CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Nonresidential Outdoor Lighting Power Allowance

Measure Number: 2016-NR-LTG6-F

Nonresidential Lighting

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team September 2014

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Document Information

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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 Nonresidential Outdoor Lighting Power Allowances (LPA). The report contains pertinent information that justifies the code change including:

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

Scope of Code Change Proposal

Nonresidential Outdoor LPA will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

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

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

Measure Description

The Nonresidential Outdoor LPA measure intends to replace pulse start Metal Halide (PSMH) light sources with LED as the basis for the calculation of Lighting Power Allowances (LPA) for all exterior applications where it is technically feasible to do so.

Section 2 of this report provides detailed information about the code change proposal including: ***Section 2.2 Summary of Changes to Code Documents (page 5)*** 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 (page 5)
- Table 6: Sections of Standards Impacted by Proposed Code Change (page 5)

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.

The following documents will be modified by the proposed change:

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

Subsection 140.6(a)3: Will have the exception for ATM lighting removed.

Table 140.6-C: Will add an allowance for ATM lighting in parking garages.

SECTION 140.7 – REQUIREMENTS FOR OUTDOOR LIGHTING

EXCEPTION 6 and 8 to Subsection 140.7(a): The edits will remove an exception for ATM lighting, lighting for tunnels, and lighting for bridges.

Subsection 140.7(d)1A: The edits will add bridge(s) and tunnel(s) to the general hardscape lighting allowance calculation instructions.

Tables 140.7-A & B: The tables will be modified with new LPA values to reduce energy consumption by using LED light sources as the new baseline for calculations. Further, language will be added to establish an LPA for ATM locations, and bridges and tunnels will be included in the allowance list.

Market Analysis and Regulatory Impact Assessment

The industry as a whole is participating in the change to LED light sources. Manufacturers are actively funding R&D efforts for the LED market, putting most of their R&D funds into LED product development. (TRC 2014) As a result, manufacturers are already supporting this change and are working to be well positioned for this market shift.

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

(CARB 2010b Figures 7a and 10a). The specific code change proposal presented in this report is not expected to have an appreciable impact on investments in California.

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

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the Nonresidential Outdoor Lighting Power Allowance measure.

Table 2: Estimated First Year Energy Savings

	First Year Statewide Savings			TDV Dollar Savings ($ Millions)
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	
TOTAL	125	N/A	N/A	207

Section 4.7.1 discusses the methodology and Section 5.1.1 shows the results for the per unit energy impact analysis.

Cost-effectiveness

Results 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). 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.

The cost effectiveness of each part of this measure is not possible to represent in a single, simple table. However, the general Hardscape cost effectiveness is shown, as this is expected to be the largest component of the measure as a whole. For a detailed description of the Cost-effectiveness Methodology and more details on the other portions of this measure, see Section 4.7 of this report.

Table 3: Per Unit Cost-effectiveness Summary – General Hardscape by Lighting Zone

Lighting Zone	Benefit: TDV Energy Cost Savings (2017 PV$/sf)	Cost: Total Incremental First Cost and Maintenance Cost (2017 PV$)	Change in Lifecycle Cost (2017 PV$/sf)	Planned Benefit to Cost (B/C) Ratio
LZ1	0.31	None or Lower	0.31	Infinite
LZ2	0.42	None or Lower	0.42	Infinite
LZ3	1.15	None or Lower	1.15	Infinite
LZ4	1.51	None or Lower	1.51	Infinite

Section 4.7 discusses the methodology and Section 5.2 shows the results of the Cost Effectiveness Analysis

Greenhouse Gas and Water Related Impacts

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

Greenhouse Gas Impacts

Table 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 4.9.1 on page 30 of this report.

Table 4: Estimated Statewide Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions ($MTCO_2e/yr$)
TOTAL	44,000

Section 4.9.1 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 positive impacts that may occur at power plants due to reduced energy consumption.

Acceptance Testing

The proposed measure is not expected to have any impacts on acceptance testing.

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 for the Nonresidential Outdoor Lighting Power Allowances. The report contains pertinent information that justifies the code change.

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

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

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

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

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

2. MEASURE DESCRIPTION

2.1 Measure Overview

2.1.1 Measure Description

The Outdoor Lighting Power Allowance (LPA) values in Title 24 are subject to change as new technologies (in particular, light source technologies that increase lamp efficacy) become available to the market. As a result, the LPA values have continued to slowly move downward over time in response to these technological advancements, most recently for Pulse-Start Metal Halide (PSMH) technology.

LED light source technology is advancing rapidly, and the raw lamp efficacy of LED light sources are rapidly improving beyond that of both PSMH (the current baseline standard), and High Pressure Sodium (HPS) light sources. The lumen package efficacy is anticipated to exceed PSMH and HPS in several years. Further, the efficiency of LED luminaires is typically significantly higher than either PSMH or HPS luminaires. LED luminaires will exceed combined HID source luminaire efficacy sometime in late 2014 or 2015. (DOE 2013) Finally, LED luminaires can deliver light more uniformly to the target area, which will result in further savings opportunities.

In addition, LED light source technology has a variety of operational advantages over either PSMH or HPS, including:

- much longer life expectancy (in some cases beyond 100,000 hours)
- better lumen maintenance at a given age of operation
- very good dimming efficacy curves
- a large range of dimming capability (down to 10% in most cases)
- rapid level changes that accommodates sensor integration
- instant re-strike for On-Off-On switching capability
- preservation of source color characteristics over full dimming range

As a result, LED is rapidly claiming a large portion of the exterior lighting market, and the market adoption of LED is anticipated to accelerate as the cost of LED products continues to decrease.

This measure intends to replace PSMH light sources with LED as the basis for the calculation of Lighting Power Allowances (LPA) for all exterior applications where it is technically feasible to do so.

At no point in this LPA adjustment will the lighting design criteria be changed. This basis of design has been established by the Illumination Engineering Society (IES) in a variety of sources and mapped as part of the previous Title 24 Outdoor Lighting Case Studies (CASE 2007). This matrix of design criteria was reviewed to ensure that no specific recommendations have changed, and therefore, no changes are needed to the illuminance criterion that establishes the LPA values.

Further, two specific applications have been identified that require attention. There currently is no allowance mechanism for lighting associated with ATM locations in Outdoor Lighting. This lighting is currently exempted from the code through an exception in 140.7(a). ASHRAE 90.1-2013 includes an allowance for this, and it is possible to establish a reasonable allowance for ATM locations and insert this allowance as a line-item into the tables of LPA values.

The other application requires some clarification in the language, but will require no additional LPA values established. This is lighting for tunnels and other covered pathways that would not normally be interpreted as Non-Sales Canopy applications. In this circumstance, the proposal is to add language including them in the Non-Sales Canopy category.

2.1.2 Measure History

Outdoor lighting was first introduced into Title 24 in the 2005 code cycle. At that time, the outdoor lighting realm was predominately based upon probe-start Metal Halide (MH) and HPS light sources for large area lighting, fluorescent and compact fluorescent for smaller lumen package products, and very small amounts of other light source types under certain circumstances.

While HPS light sources are commonly used for roadway applications, when a white light source is desired (as is common for retail applications), MH lamps have been the only viable option for many years. This established MH as the de facto baseline technology for most Lighting Power Allowance (LPA) calculations because it is approximately 15% less efficacious than HPS under comparable circumstances. As a result, MH has been used as the light source technology for the simulations used to generate the LPA values established in Tables 140.7-A and 140.7-B.

Due to the enactment of the Energy Independence and Security Act (EISA) in 2007, MH lamps and ballasts were removed as a new luminaire option, so the MH lamp baseline shifted to PSMH lamps. These were employed in Title 24-2013, but the changes were subtle due to certain lamp and design interactions that reduced their apparent impact.

In approximately 2008, LED light sources started to become available, offering an alternative to MH or PSMH as a white light source. As LED technology has advanced, the quality of the light, the cost of the luminaires, the efficacy of the LED chips, and the rated life of the LED chips have all improved significantly.

A study by the US-DOE found that LED chips have improved in efficacy at a rate of approximately 10% per year recently, and this efficacy improvement is projected to continue for the next five years or more before slowing down. (DOE 2013) At the same time, the cost per kilolumen of the LED package has decreased by approximately 30% in 2012, another 50% is expected through 2015, and another 50% (to 25% of today’s cost) by 2018 (DOE 2013).

In the past, while LED technology has been a viable alternative to MH sources, it was at a cost premium that was hard to justify with the associated energy savings. In almost all metrics, (availability, cost of initial purchase, efficacy, and ongoing maintenance cost), this premium will be eliminated for most applications in time for the next cycle of Title 24 to take effect (currently scheduled for Jan. 1, 2017).

As a result, by 2017, LED light sources will have become the white light source of choice for almost all outdoor lighting applications, and will be both a major advancement in energy efficiency, and also a very cost effective design solution for the building industry to employ.

Using LED as a baseline is anticipated to result in an approximately 40% reduction in the LPA values in Tables 140.7-A & B. The full impact of a switch to LED as the basis of design is not a simple efficacy gain comparison for the general lighting applications; the LED products produce better illumination with better uniformity and lower waste from “spill light” than similar MH products due to more carefully directed light distribution. As a result, the impact is greater than a simple luminaire efficacy calculation may predict.

This measure provides a methodology to calculate the anticipated cost and efficacy implications of LED lighting products in advance of the timeframe of the Standard effective date. This is necessary because LED technology is advancing at a very rapid pace. The most appropriate LPA values are calculated based on reasonable predictions of where LED efficacy will be at the time of adoption, not on current performance of LED lighting products, which would place the LPA values approximately three years behind the LED efficacy curve.

This measure is proposed because the lighting market is rapidly advancing, and most of the current LPA values in Section 140.6 have not been reviewed and reduced since the 2008 revisions. In the future, the prevalence of LED in the market will make the LPA values easily achievable if they remain at current levels, causing Title 24 to lose savings opportunities due to inaction.

The move towards LED in the lighting industry is a fundamental shift towards electronics. However, this move is happening independent of codes and standards development. It is important that Title 24 keep in stride with this shift if it is to remain relevant as an energy code that challenges the building industry to higher levels of performance.

At this time, the shift to LED as the baseline is designated for Nonresidential Outdoor lighting only, and no other portions of Title 24.

2.1.3 Existing Standards

Nonresidential Outdoor LPA is regulated in Section 140.7 of the Standards. This measure will not change the regulation infrastructure, but will change the values that are established as the permissible performance for outdoor lighting applications in Tables 140.7-A & B.

2.1.4 Alignment with Zero Net Energy Goals

The Statewide CASE Team and the CEC are committed to achieving California’s zero-net-energy (ZNE) goal. This measure will help achieve ZNE goals by reducing the connected power and energy consumption of outdoor lighting associated with new construction. This measure will also set the foundation for future revisions that will help ensure ZNE goals are achieved. In particular, this measure could lead directly to the following changes in the 2019 and 2022 revision cycles:

- Possible further reductions in outdoor LPA values in Tables 140.7-A and 140.7-B as the LED technology advances.
- As an enabling technology, LED will permit more advanced lighting controls and controls strategies to be employed, saving on hours of operation.

2.1.5 Relationship to Other Title 24 Measures

This measure does not specifically overlap with any other current measure directly. However, there is a Nonresidential Outdoor Lighting Controls measure that will be impacted by the LPA values that are established in this CASE.

2.2 Summary of Changes to Code Documents

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

2.2.1 Catalogue of Proposed Changes

Scope

Table 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	No	No	No	No	No

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)
10-114	Determination of Outdoor Lighting Zones and Administrative Rules for Use	M	E
140.6	Prescriptive Requirements for Indoor Lighting	Ps	E
140.7	Requirements for Outdoor Lighting	Ps	E

Appendices

The proposed code change is not anticipated to modify any sections of the appendices.

Nonresidential Alternative Calculation Method (ACM) Reference Manual

The proposed code change is not anticipated to modify the Nonresidential Alternative Calculation Method References.

Simulation Engine Adaptations

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

2.2.2 Standards Change Summary

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

Changes in Mandatory Requirements

The changes focus on Tables 10-114-A, where the Lighting Zone definitions are described, and add the new Lighting Zone 0 into the table.

TABLE 10-114-A – LIGHTING ZONE CHARACTERISTICS AND RULES FOR AMENDMENTS BY LOCAL JURISDICTIONS

The edits will add the description of Lighting Zone 0 to the table, and more accurately describe the ambient illumination using terminology that correlates with the Illumination Engineering Society.

Changes in Prescriptive Requirements

There is a change in Section 140.6 (Indoor Lighting) to address ATM machines in Parking Garage situations.

The changes focus on Tables 140.7-A & B, where the LPA values for outdoor lighting are presented. All of these values are reduced based on the calculations of light source technology improvements.

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

Subsection 140.6(a)3: Will have the exception for ATM lighting removed.

Table 140.6-C: Will add an allowance for ATM lighting in parking garages.

SECTION 140.7 – REQUIREMENTS FOR OUTDOOR LIGHTING

EXCEPTION 6 and 8 to Subsection 140.7(a): The edits will remove an exception for ATM lighting, lighting for tunnels, and lighting for bridges.

Subsection 140.7(d)1A: The edits will add bridge(s) and tunnel(s) to the general hardscape lighting allowance calculation instructions.

Tables 140.7-A & B: The tables will be modified with new LPA values to reduce energy consumption by using LED light sources as the new baseline for calculations. Further, language will be added to establish an LPA for ATM locations, and bridges and tunnels will be included in the allowance list.

2.2.3 Standards Reference Appendices Change Summary

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

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

The proposed code change will not modify the ACM Reference Manuals.

2.2.5 Compliance Forms Change Summary

The proposed code change will not modify the Compliance Forms.

2.2.6 Simulation Engine Adaptations

The simulation engine is not anticipated to be affected by this measure.

2.2.7 Other Areas Affected

There are anticipated to be no other areas affected by this measure.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

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

2.3.2 Code Implementation

The code compliance methods currently employed by designers and builders will remain the same with this new measure. Title 24 is currently regulating LPA for Outdoor Lighting in a manner that is compatible with the changes intended with this measure. The building industry is accustomed to using the LPA limits approach that has been established in the previous versions of Title 24, and this measure maintains this infrastructure.

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

This measure makes no changes in the inspection process.

There is no anticipated resistance to this measure from the building industry beyond the normal reluctance to lower LPA values. However, this change reflects a significant change in the lighting LPA values associated with a new technology that is considerably higher in efficacy than the previous baseline technology (PSMH). As a result, there is a need to educate the stakeholders so they understand the impacts of the measure, how the changes were calculated, and what the impacts will be on the lighting industry in the State.

While the impacts are intended to be minimized through the naturally occurring shift to LED technology, there will be some that may cause hesitancy within the stakeholders. Statewide CASE Team effort is required to make the stakeholders comfortable with the new paradigm associated with designing based on LED light sources.

2.3.3 Acceptance Testing

There are no new acceptance testing burdens created by this measure.

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 overall concept of this proposal. The details and final analysis results of this proposal have not been fully presented to stakeholders due to the compressed CEC schedule, and a further complication with potential revision to the lighting design criteria that should be applied for the measure (IES RP-20).

The issues that have been addressed to date during development of the code change proposal are summarized below.

The IES is in the process of producing a new Recommended Practice (RP-20) that addresses parking lot and parking garage lighting design criteria. This may apply to the general hardscape lighting criteria that should be applied in the LPA calculations. At this point, the new document is not available for review and has not been approved, so it is impossible to gauge precisely what the impact of the new design criteria will be, but preliminary reports indicate that it will considerably increase light levels to meet the new criteria.

Since the document is not finalized, and because the Title 24 update process must continue on its schedule to meet the CEC's deadlines for the public process, the Statewide CASE Team has not made changes to the design criteria. However, if the new IES document does increase the energy consumption required to meet the criteria, the recommendation of the Statewide CASE Team may be to disregard the new RP-20 document and consider different sources for design criteria.

This issue is complicated by the lack of a public comment period associated with the development of this Recommended Practice (RP) document. Some RP documents and committees follow ANSI standards and include a comment period while others (RP-20 included) do not. It is the opinion of the Statewide CASE Team that this process is flawed, and that the IES must make corrective action to address this inconsistency. These documents are being presented to the building industry as the primary design 'standard', and while not legally binding, the criteria established by these documents are considered by many to be the metric for 'good practice'. As a result, there is strong pressure to accommodate the criteria established in the documents.

Unfortunately, the criteria also have the result that they impact the energy consumption of lighting systems throughout the United States, and energy codes that are moving towards lower energy consumption may be negatively affected by a change in criteria that was implemented without full consideration of the wide-ranging impacts of the changes by the small group of people on the committee. Documents produced by the IES that impact energy consumption should go through a rigorous review to ensure that the science is correct and the design criteria is reasonable to balance the need for energy efficiency and the potential benefits and drawbacks associated with increased light levels driven by a desire for higher visual performance.

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 stakeholder meeting the utility team sponsored in 2014. Some of the resources the Statewide CASE Team used to complete this task include:

- Interviews with manufacturers on outlook of technology development going forward.
- Interviews with specifiers and sales representatives and previous research on market penetration of current technology advancements.
- Review of recent market research and further interviews with market research authors and sources of ongoing projections on modifications of the market outlook.
- Modeling of current and projected impacts of trends in technology advancements on market pricing, market share, efficacy, energy savings opportunities, cost effectiveness.

3.1 Market Structure

Multiple manufacturers are producing LED lighting products for outdoor applications, including parking lot lighting, pedestrian poles, bollards, building-mounted area lights, and canopy lights. There are no concerns regarding availability of products as there are currently many available from many manufacturers.

Further, LED has become the only light source that is receiving substantial market research and development money, from both the Federal Government (through DOE research support), and independently by manufacturers working on the implementation of LED in their product lines.

3.2 Market Availability and Current Practices

The industry as a whole is anticipating the change to LED light sources. Manufacturers are actively funding R&D efforts for the LED market, putting most of their R&D funds into LED product development. (TRC 2014) As a result, manufacturers are already anticipating this change and are working to be well positioned for this market shift.

This shift is occurring rapidly in the industry, with the most rapid move to LED occurring in lighting products that are small, low wattage, with directional light distributions, and in outdoor lighting products. These categories are the most naturally-suited for LED light sources and have shown the earliest adoption of the design standard. LED has almost completely taken the market share of some types of outdoor lighting products, and many manufacturers expect this to be mostly complete in all outdoor lighting product categories by 2017 (TRC 2014).

3.3 Useful Life, Persistence, and Maintenance

The useful life of LED luminaires exceeds the 15 year measure duration considerably, and is expected to persist longer than incumbent lighting solutions in most cases. Maintenance with LED lighting products is expected to be decreased because the long life of the LED chips will remove the need for the normal lamp failure maintenance that is regularly associated with PSMH and other incumbent sources.

The methodology the Statewide CASE Team used to determine the costs associated with incremental maintenance costs, relative to existing conditions, is presented in Section 4.8.1. The incremental maintenance costs of the proposed code change are presented in Section 5.2.1.

3.4 Market Impacts and Economic Assessments

3.4.1 Impact on Builders

No substantial impacts are anticipated.

3.4.2 Impact on Building Designers

No substantial impacts are anticipated.

3.4.3 Impact on Occupational Safety and Health

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

3.4.4 Impact on Building Owners and Occupants

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

3.4.5 Impact on Retailers (including manufacturers and distributors)

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

3.4.6 Impact on Energy Consultants

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

3.4.7 Impact on Building Inspectors

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

3.4.8 Impact on Statewide Employment

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

3.5 Economic Impacts

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

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

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).

This measure is not anticipated to have a large economic impact on the industry because it functions as a reduction in LPA allowances in the current code infrastructure. In most cases, the greatest impact will be a change in the light source technology of luminaires that are specified. There may be a reduction in the amounts of lighting equipment specified as well, but the varying methods of compliance with the reduced LPA values does not dictate that reduces equipment specifications will occur. In most cases, the wattage of the equipment specified will be reduced, but the quantities nay not be greatly impacted.

3.5.1 Creation or Elimination of Jobs

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

3.5.2 Creation or Elimination of Businesses within California

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation (as described above) estimates that this scenario would result in 0.6% additional GSP in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Table ES-2). We expect that higher GSP will drive additional business creation in California. In particular, local

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

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

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).[3]

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

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

Table 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

3.5.3 Competitive Advantages or Disadvantages for Businesses within California

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

3.5.4 Increase or Decrease of Investments in the State of California

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

3.5.5 Incentives for Innovation in Products, Materials, or Processes

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

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

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

3.5.6.1 Cost of Enforcement

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

Cost to the State

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

Cost to Local Governments

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

3.5.6.2 Impacts on Specific Persons

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

- Migrant Workers
- Persons by age
- Persons by race

- Persons by religion
- Commuters

Renters will typically benefit from lower energy bills if they pay energy bills directly.

4. Methodology

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

4.1 Existing Conditions

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

There is an existing Title 24 standard that covers the building system in question, so the existing conditions assume a building complies with the 2013 Title 24 Standards, which primarily uses PSMH as the light source technology baseline for the LPA calculations. Refer to Section 2.2 and 2.3 for more information on the standard practice of design in the industry.

4.2 Proposed Conditions

The proposed conditions are defined as the design conditions that will comply with the proposed code changes. Specifically, the proposed changes will reduce the LPA for Nonresidential Outdoor Lighting based on meeting the same (or currently relevant) design criteria using LED light sources wherever technically feasible.

4.3 Calculation Methodology

There are two different lighting calculations represented in the results, and the method used is dependent on the application. In situations where the performance criterion (other than 'average illuminance') is the primary basis for the calculations, a full set of simulations have been performed to produce the resultant recommendations. This is due to the fact that these conditions are primarily driven by lighting (and visual) performance requirements rather than the amount of light in the space. This is a much more time consuming set of calculations, and involves the application of a variety of different lighting products and design scenarios to test the various variables to ensure reasonable possibility to achieve the target design criteria.

The second method is an efficacy adjustment of the typical luminaires that are applied to the lighting application. This method applies to all of the conditions where the criteria is driven more by the amount of light than a specific geometry-based criterion (like 'minimum vertical illuminance', for example). In these cases, the incumbent light sources, including compact fluorescent (CFL), linear fluorescent, and PSMH, were compared to comparable output LED products available now and adjusted for efficacy in 2017, to produce an LPA reduction for that application. These are all special applications, and will be layered on top of the general allowances. Table 8, Table 9, and Table 10 show a sample of the analysis that was conducted to produce the recommendations.

Table 8: Sample of Calculations for Building Entrance Baseline Scenario

Building Entrance Calculations NO CANOPY T-24 2016

Per DOE, 141% increase in luminaire LPW by January 2017

Area

2008 Basis of Design											Weighting				Weighted LPW			
Wattage	Lamp Type	Ballast	Luminaire	Initial Lamp Lumens	Maintained Lamp Lumens	System Watts	Initial Luminaire Lumens	Maintained Luminaire Lumens	LLD	LPW	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
18	CFL	Electronic	Type 'A'	1,150	990	20	802	690	0.861	35	0.20	0.10	0.05	0.00	7	3	2	0
26	CFL	Electronic	Type 'A'	1,800	1,548	28	1,193	1,026	0.860	37	0.25	0.15	0.05	0.05	9	5	2	2
32	CFL	Electronic	Type 'A'	2,400	2,064	35	1,674	1,440	0.860	41	0.25	0.20	0.15	0.10	10	8	6	4
42	CFL	Electronic	Type 'A'	3,200	2,752	46	2,232	1,920	0.860	42	0.15	0.25	0.25	0.10	6	10	10	4
50	MH	Pulse Start	Type 'B'	3,450	1,600	67	2,905	1,347	0.464	20	0.10	0.15	0.15	0.05	2	3	3	1
70	MH	Pulse Start	Type 'B'	5,600	3,300	92	4,715	2,778	0.589	30	0.05	0.10	0.20	0.10	2	3	6	3
100	MH	Pulse Start	Type 'B'	8,500	4,675	129	7,157	3,936	0.550	31	0.00	0.05	0.10	0.30	0	2	3	9
150	MH	Pulse Start	Type 'B'	14,000	11,000	190	11,998	9,427	0.786	50	0.00	0.00	0.05	0.30	0	0	2	15
											1.00	1.00	1.00	1.00	**36**	**35**	**35**	**38**

Wall Pack

2008 Basis of Design											Weighting				Weighted LPW			
Wattage	Lamp Type	Ballast	Luminaire	Initial Lamp Lumens	Maintained Lamp Lumens	System Watts	Initial Luminaire Lumens	Maintained Luminaire Lumens	LLD	LPW	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
18	CFL	Electronic	Type 'A'	1,150	990	20	802	690	0.861	35	0.20	0.10	0.05	0.00	7	3	2	0
26	CFL	Electronic	Type 'A'	1,800	1,548	28	1,193	1,026	0.860	37	0.25	0.15	0.05	0.05	9	5	2	2
32	CFL	Electronic	Type 'A'	2,400	2,064	35	1,674	1,440	0.860	41	0.25	0.20	0.15	0.10	10	8	6	4
42	CFL	Electronic	Type 'A'	3,200	2,752	46	2,232	1,920	0.860	42	0.15	0.25	0.25	0.10	6	10	10	4
50	MH	Pulse Start	Type 'C'	3,450	1,600	67	1,578	732	0.464	11	0.10	0.15	0.15	0.05	1	2	2	1
70	MH	Pulse Start	Type 'C'	5,600	3,300	92	2,561	1,509	0.589	16	0.05	0.10	0.20	0.10	1	2	3	2
100	MH	Pulse Start	Type 'C'	8,500	4,675	129	3,887	2,138	0.550	17	0.00	0.05	0.10	0.30	0	1	2	5
150	MH	Pulse Start	Type 'C'	14,000	11,000	190	6,401	5,029	0.786	26	0.00	0.00	0.05	0.30	0	0	1	8
											1.00	1.00	1.00	1.00	**35**	**32**	**28**	**25**
											AVERAGE:				**35**	**33**	**31**	**32**

An example of this calculation is given for the 18 Watt CFL (first row of the area table) in Table 8. The weighted lumens per watt (LPW) for LZ 3 is given by:

Weighted LPW = Maintained Luminaire Lumens x Weighting Factor / Input Watts

Weighted LPW (LZ3) = 690 x 0.05 / 20 = 1.7 (rounded to 2 in the table for space reasons).

The weighted LPW values are added up for all other lamps types to provide an average weighted value of LPW for all lamps types that might be used for a given application in a given Lighting Zone.

A similar calculation is conducted in Table 9 for LED light sources. Table 9 includes the system lumens per watt (luminous efficacy) for LED systems in 2014 and the projected lumens per watt for 2017. Appendix B provides the rationale behind the projections of increasing luminous efficacy over the next 3 years. In Table 9, the column labelled “LPW” refers to the luminous efficacy of LED lighting system in 2017. The “LPW diff” column indicates the difference between the luminous efficacies for the first row of luminaires in Table 8 with the first row of luminaires in Table 9.

Table 9: Sample of Calculations for Building Entrance LED Scenario

Building Entrance Calculations NO CANOPY T-24 2016 LED Results

Area

Luminaire	Initial Luminaire Lumens	Maintained Luminaire Lumens	LLD	2014 Fixture Watts	2017 Fixture Watts	LPW	LPW Diff.	Percentage Increase	Weighting LZ1	Weighting LZ2	Weighting LZ3	Weighting LZ4	Weighted LPW LZ1	Weighted LPW LZ2	Weighted LPW LZ3	Weighted LPW LZ4
LED Type 'A'	1,110	852	0.768	30	21	40	6	16%	0.20	0.10	0.05	0.00	8	4	2	0
LED Type 'A'	1,110	852	0.768	30	21	40	3	9%	0.25	0.15	0.05	0.05	10	6	2	2
LED Type 'B'	1,674	1,172	0.700	27	19	61	20	49%	0.25	0.20	0.15	0.10	15	12	9	6
LED Type 'B'	2,059	1,441	0.700	27	19	75	34	80%	0.15	0.25	0.25	0.10	11	19	19	8
LED Type 'C'	3,139	2,969	0.946	34	24	122	102	507%	0.10	0.15	0.15	0.05	12	18	18	6
LED Type 'C'	4,709	4,455	0.946	51	36	124	93	309%	0.05	0.10	0.20	0.10	6	12	25	12
LED Type 'C'	6,727	6,364	0.946	77	55	117	86	282%	0.00	0.05	0.10	0.30	0	6	12	35
LED Type 'C'	12,552	11,874	0.946	139	99	120	71	143%	0.00	0.00	0.05	0.30	0	0	6	36
									1.00	1.00	1.00	1.00	**63**	**78**	**93**	**105**

Wall Pack

Luminaire	Initial Luminaire Lumens	Maintained Luminaire Lumens	LLD	2014 Fixture Watts	2017 Fixture Watts	LPW	LPW Diff.	Percentage Increase	Weighting LZ1	Weighting LZ2	Weighting LZ3	Weighting LZ4	Weighted LPW LZ1	Weighted LPW LZ2	Weighted LPW LZ3	Weighted LPW LZ4
LED Type 'D'	734	514	0.700	9	6	81	47	136%	0.20	0.10	0.05	0.00	24	16	8	0
LED Type 'D'	1,278	895	0.700	16	11	78	41	112%	0.25	0.15	0.05	0.05	19	12	4	4
LED Type 'E'	1,927	1,709	0.887	24	17	100	59	144%	0.25	0.20	0.15	0.10	25	20	15	10
LED Type 'F'	2,712	2,406	0.887	27	19	126	84	201%	0.15	0.25	0.25	0.10	19	31	31	13
LED Type 'E'	1,927	1,709	0.887	24	17	100	89	819%	0.10	0.15	0.15	0.05	10	15	15	5
LED Type 'F'	2,712	2,406	0.887	27	19	126	109	666%	0.05	0.10	0.20	0.10	6	13	25	13
LED Type 'E'	3,839	3,405	0.887	47	33	102	86	516%	0.00	0.05	0.10	0.30	0	5	10	31
LED Type 'G'	6,587	6,231	0.946	74	53	118	92	346%	0.00	0.00	0.05	0.30	0	0	6	35
									1.00	1.00	1.00	1.00	**104**	**112**	**115**	**110**
									AVERAGE:				**84**	**95**	**104**	**108**

Note that the range of typical luminaires that were modeled provides a range of design solutions that may be found in typical installations. However, there is a wattage suitability issue to these luminaires that is being addressed by the weighting factors that are found to the right side of the tables.

The weighting factors account for the lighting zones where these products are mostly likely to be employed, based on the design criteria that was established for the respective Lighting Zones. Higher wattage luminaires are weighted more heavily toward LZ3 and LZ4, where they are much more likely to be specified.

The weighting produces an adjustment where multiple luminaire types and wattages are factored into the calculations to ensure that a representative sampling of the available luminaire stock is considered.

Table 10: Sample of Calculation of Building Entrance Efficacy Adjustments

Building Entrances NO CANOPY Recommendations

		LZ1	**LZ2**	**LZ3**	**LZ4**	
2013	Allowance	30	60	90	90	W
	LPW	35	33	31	32	lm/W
2016	LPW	84	95	104	108	lm/W
	Change	13	21	27	26	Limit of Reduction
	Proposed	**15**	**25**	**35**	**45**	**W**

In all of these calculation sheets, the limits of the *possible* adjustment are presented (Limit of Reduction), and the *proposed* adjustment for Title 24 is also shown. In many cases the reductions are not nearly as aggressive as the LED light source calculations find to be technically possible. As this is the first opportunity to base Title 24 requirements on LED light sources, the Statewide CASE Team used a conservative approach. This approach provides a less significant reduction than may ultimately be possible, but the lighting design industry must become comfortable with the changing paradigm that LEDs represent before more aggressive LPA reductions can be implemented.

As an example in Table 10, Lighting Zone 3 currently has a lighting power allowance of 90 Watts per entrance. From our lighting model we estimate that this corresponds to an overall lighting system luminous efficacy of 31 lumens per Watt as shown above; the details how this 31 lm/W was calculated is shown in Table 8. The actual value is 31.4, rounded to 31 for space purposes. As shown in Table 10, the proposed system efficacy for LED entrance lighting systems is 104 lumens per watt for LZ3 (103.8 rounded to 104). From this information we can calculate the overall lumens per entrance delivered by CFLs or metal halide lighting using the current LPA and from this calculate the minimum amount of watts to provide the same amount for lumens by an LED system.

Current Lumens (LZ3) = Current Allowance [Watts] x Current System Efficacy [lm/W]

Current Allowed Lumens (LZ3) = 90 W x 31.4 lm/W = 2826 lumens

Minimum Proposed Watts (LZ3) = Current Allowed Lumens / Proposed System Efficacy

Minimum Proposed Watts (LZ3) = 2826 Lumens / 103.8 Lm/W = 27.2 Watts per entrance

Though 27.2 Watts per entrance is the lowest possible wattage allowance that could be proposed, this proposal is conservative and allows higher lighting wattage allowances. In this case the proposed lighting power allowance for LZ3 is 35 lumens per watt – 30% higher than the minimum wattage that could be technically justified, but still achieving a reduction of 62% of lighting power as compared to the current allowance of 90 Watts per entrance.

Appendix C contains these calculations for all outdoor lighting applications evaluated.

4.4 Prototype Building Sites

This measure applies only to exterior lighting conditions, so the CEC building prototypes are not applicable. Instead, the Statewide CASE Team established nine building site prototypes to model representative site conditions; varying from an efficient (square) site with a simple building footprint and hardscape layout to more complex, less ideal site conditions. These prototypes enabled the Statewide CASE Team to compare LPA values in practical lighting layout conditions that represent the reasonable spectrum of conditions that may be encountered during a design project.

Further details on these sites are available in Appendix D.

Table 11 presents the details of the prototype sites used in the analysis.

Table 11: Prototype Sites used for Energy Impact Analysis

	Possible Occupancy Type	Hardscape Area (Square Feet)	Hardscape Perimeter (Feet)	Perimeter to Area %	Notes
Prototype A	Office / Retail	501,626	6,794	1.4%	Long skinny site, big building
Prototype B	Retail	471,726	5,131	1.1%	Square site, irregular building
Prototype C	Retail	42,828	3,052	7.1%	Irregular site, campus buildings
Prototype D	Retail	28,500	960	3.4%	Long skinny site, small building
Prototype E	Retail / Office / Industrial	21,000	760	3.6%	Square site, small square building
Prototype F	Retail / Office / Industrial	61,798	1,940	3.1%	Irregular site, long square building
Prototype G	Retail / Office / Industrial	21,797	1,408	6.5%	Long skinny site, irregular building
Prototype H	Retail / Office / Industrial	11,040	1,042	9.4%	Square site, large square building
Prototype J	Retail / Office / Industrial	34,735	2,593	7.5%	Irregular site, large irregular building

Additionally, one idealized site was calculated, which represents the best possible conditions likely to occur in normal nonresidential properties. This is a relatively large square site, with no building. These characteristics make it likely to produce as efficient a site as possible for lighting purposes.

Table 12: Additional Ideal Prototype Site used for Energy Impact Analysis

	Possible Occupancy Type	Hardscape Area (Square Feet)	Hardscape Perimeter (Feet)	Perimeter to Area %	Notes
Prototype K	Parking	250,000	2,000	0.8%	Ideal square site

The Statewide CASE Team developed a basic lighting and electrical layout to use with three additional sites to conduct cost effectiveness calculations. This is a much more detailed calculation of the lighting and electrical design necessary to meet the design criteria. The sites vary in size and complexity to represent the range of conditions that are typically found on sites. This provided the information needed for pricing exercises to estimate incremental costs.

Further details on these sites are also available in Appendix D. Table 13 below, presents the details of the three prototype sites used for cost evaluation analysis.

Table 13: Prototype Sites used for Cost Impact Analysis

	Site Description	Site Hardscape Area (Square Feet)	Hardscape Perimeter (Feet)	Perimeter to Area Percentage	Notes
Prototype Large	Large parking (only)	195,119	1,896	1.0%	'Efficient' site conditions
Prototype Medium	Med. parking with building	34,480	982	2.9%	Typical small retail location
Prototype Small	Small parking with building	14,622	588	4.0%	Typical small gas station

4.5 Climate Dependent

This lighting measure is not climate dependent in its specific direct energy impacts, but is climate dependent when considering the impacts of the reductions in TDV.

4.6 Time Dependent Valuation

The TDV (Time Dependent Valuation) of savings is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during different times of the day and year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV 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 (CE 2014). The TDV energy impacts are presented in Section 5.1 of this report, and the statewide TDV cost impacts are presented in Section 5.2.

4.7 Energy Impacts Methodology

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

This analysis defined the effective wattage allowance that accommodates a reasonable cross-section of the sites that may occur in the State. The effective wattage allowance combines the Initial Wattage Allowance, the Area Wattage Allowance, and the Linear Wattage Allowance into a single value that can characterize the impacts in a single, per square foot value, and can be scaled up for statewide calculations.

The Statewide CASE Team estimated the energy impact calculation by first estimating the Outdoor LPA values for component applications, and then extrapolating the estimates to the entire state through CEC building construction forecasts with a translation for the square footage of hardscape associated with typical nonresidential construction.

Appendix E contains seven lighting schedules that are weighted and applied to each of the lighting applications evaluated. Thus each lighting application has a differing number of full load hours that accounts for the different schedules for how long lights are on and, for hardscape areas which have bi-level motion controlled lighting, the hours which some of the lights are dimmed down due to no movement in the surrounding area.

4.7.1 Per Unit Energy Impacts Methodology

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

The energy savings for this measure will result from reductions in LPA allowances. Therefore, the primary basis for calculating energy savings is a spreadsheet-based analysis that takes into account a variety of variables:

- Reductions in LPA values within Tables 140.7 A & B
- Impacted area of LPA reduction (for some situations where the area is not explicitly defined)
- Occupancy and use profiles for various outdoor applications
- Prototype sites employed for effective wattage/square foot reduction calculations.

Analysis Tools

The analysis is completed using the outdoor lighting application types, and predicted through the TDV calculation based on energy use curves sourced through the ACM and industry knowledge of typical hours of operation for nonresidential buildings in conjunction with the assumptions listed below.

Key Assumptions

CEC provided a number of key assumptions to be used in the energy impacts analysis (CEC 2014). Some of the assumptions included in CEC's Lifecycle Cost Methodology Guidelines (LCC Methodology) include hours of operation, weather data, and prototype building design. 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 presented in Table 14.

Table 14: Key assumptions for per unit Energy Impacts Analysis

Parameter	Assumption	Source	Notes
Light source efficacy projections	LED products are rapidly improving	(DOE 2013) and manufacturer interviews	The efficacy increase is modeled in the supporting documents in Appendix B.

4.7.2 Statewide Energy Impacts Methodology

Outdoor nonresidential construction is not included in the construction forecasts, so the impact of the various lighting measures must be predicted based on other metrics that rely on indoor construction square footage as the basis of measurement. Assumptions for how the individual line items of the measure are calculated to the statewide impacts are presented below.

Translation of Lighting Zones to Statewide Impacts

The definition of the Lighting Zones is tied to the US Census (2010), and is related to the classification of land mass designated as Urban or Rural, which is the demarcation line between Lighting Zone 2 (rural) and Lighting Zone 3 (urban).

Table 15: Lighting Zone Area and Likely Construction Activity within the Respective Lighting Zones in the State

Lighting Zone	Percent of Land Mass (Source: 2010 US Census)	Percent of Construction Activity (Estimate)
LZ0	9	0
LZ1	1	0.1
LZ2	85	90
LZ3	5	9.9
LZ4	0	0

Note that the Census data only provides information on land mass in LZ0, LZ1, and LZ2 as a single group, and similarly, LZ3 and LZ4 as another group. However, LZ4 has not been employed in the state by any jurisdiction, and LZ2 represents the preponderance of the state outside designated State and National parks, so the breakdown is a reasonable cross-section for statewide impacts. The percent of construction activity column is employed in the statewide estimates.

Translation of Individual Line Items to Statewide Impacts

Since the outdoor hardscape is not estimated as part of the construction forecasts, statewide impacts must be completed by making proxies with reasonable estimates of the relationship of the line item to the potential gross square footage of indoor spaces associated with the measure.

In effect, the estimates relate the unit of the measure (square foot of hardscape, for example), with an equivalent unit of gross interior space, which can then be projected using the constructions forecasts.

Assumptions regarding how the individual line items of the measure are calculated to the statewide impacts are presented in Table 16 below.

Table 16: Proxy Assumptions for Statewide Impacts Estimate Calculations for Specific Applications

Assumptions for Statewide Estimates - Specific Applications										
		Applied to % of Building S.F. in Category								
Lighting Allowance	Assumptions	Office, LG & SM	Retail	Restaurant	Food (Grocery)	Warehouse, Ref & NR	Hotel	School	College	Other
Building Entrances or Exits	**1 door per 5000 sf of building interior** (20 occupants per door, 250 occ/sf)	100%	100%	100%	100%	100%	100%	100%	100%	100%
Primary Entrances to Senior Care Facilities, Police Stations, Hospitals, Fire Stations, and Emergency Vehicle Facilities	**1 per 5000 SF of gross building area** (1 primary entrance per building)									5%
Drive Up Windows	**1 per 500 SF of gross building area** (2 locations per building; 1000 sf building)			50%						
Vehicle Service Station Uncovered Fuel Dispenser	**1 per 100 sf of gross building area** (1 fuel dispenser face per 25 sf of station building interior)									0.1%
Automated Teller Machines	**Assume 400W MH luminaire as typical standard practice, switch to 250W limit for first location**									1%
Outdoor Sales Frontage	**1.6 LF per sf of gross building area** (1 display parking space per 10 sf of building interior)									2.5%
Hardscape Ornamental Lighting	**0.1 SF per SF of gross building area**	50%	50%	50%	25%		50%	25%	25%	5%
Building Facades	**30/4*sqrt of building area / 2 (number of floors)** (25% of applicable facades are lit)	25%	50%	50%			50%	25%	25%	5%
Outdoor Sales Lots	**22.4 SF of sales lot per sf of gross building area** (1 display parking space per 10 sf of building interior)									3%
Vehicle Service Station Hardscape	**13.4 SF per SF of gross building area** (1 fuel dispenser per 25 sf of station building interior sf)									5%
Vehicle Service Station Canopies	**8.6 SF of canopy per SF of gross building area** (1 fuel dispenser face per 25 sf of station									5%
Sales Canopies	**0.1 SF of canopy per SF of gross building area**									5%
Non-sales Canopies	**0.1 SF per SF of gross building area**	25%	25%	25%	25%		25%	25%	25%	5%
Guard Stations	**0.00043 sf per SF of gross building area** (1 guard station per 500,000 sf of total construction)	100%				100%	100%	100%	100%	100%
Student Pick-up/Drop-off zone	**0.0173 sf per SF of gross building area** (1 drop off per 50,000 sf of total							100%	100%	5%
Outdoor Dining	**1 sf per 5 sf of gross building area** (20% of typical building sf)		25%	75%	25%					
Special Security Lighting for Retail Parking and Pedestrian Hardscape	**1 SF per 100 SF gross building SF** (1% of hardscape)		100%	100%	100%					50%

Most measure line items only apply to certain building types (retail or small office, for example), and this is taken into account as well.

The general hardscape values are based in part on the requirements for parking spaces in building development codes in the Los Angeles, San Diego and Bay areas. These requirements produce a net impact of approximately one square foot of hardscape for each square foot of gross building area developed. An urban development may have much less than this (relying on on-street parking, for example), but suburban sites are much more likely to have higher values, and the majority of construction is estimated to be in the lower density regions of the State as they still have available room for new construction.

For more detailed information on this, refer to Appendix G at the end of the report. Table 17 below provides information on the assumptions used to determine the impact of each individual line item of the measure (excluding general hardscape) upon the statewide construction forecasts.

Table 17: Proxy Assumptions for Statewide Impacts Estimate Calculations for General Hardscape

Assumptions for Statewide Estimates - General Hardscape		
General Hardscape	**Assumptions**	**Area Multipliers for Construction S.F.**
for Large Office, Small Office, Food, Restaurant, College	1 parking space per 250 sf of gross building area	1
for Hotel, Retail, School, Other	1 parking space per 360 sf of gross building area	0.7
for NR Warehouse, Ref. Warehouse	1 parking space per 830 sf of gross building area	0.3

First Year Statewide Impacts

The Statewide CASE Team estimated statewide impacts for the first year of construction complying with the 2016 Title 24 Standards by multiplying per unit savings estimates by statewide construction forecasts that have been translated to estimate associated outdoor hardscape area.

There are several aspects of the statewide estimates that add complexity to the calculation. These are:

1. Construction estimates of the square footage of outdoor hardscape are not included in statewide construction forecasts, and therefore must be estimated by the use of a proxy.
2. The construction forecasts do not predict construction activity based on the Lighting Zones, as defined in Title 24, and therefore another translation must be performed to predict the statewide impacts based on the area of each individual Lighting Zone, and modified by anticipated construction activity weighted for each Lighting Zone.
3. The actual amount of lighting employed on the hardscape is not clearly known. There is evidence that it may be somewhat less than a fully lighted condition in some cases (RLW 2002). The Statewide CASE Team analysis adjusted the full allowance downward to accommodate sites that are not fully lighted.

The CEC Demand Analysis Office provided the Statewide CASE Team with the nonresidential new construction forecast for 2017, broken out by building type and forecast climate zones (FCZ). The Statewide CASE Team translated this data to building climate zones (BCZ) using the same weighting of FCZ to BCZ as the previous code update cycle (2013), as presented in

Table 19. The projected nonresidential new construction forecast is presented in Table 20. Table 18 provides a definition of the various space types used in the forecast.

Table 18: Description of Space Types used in the Nonresidential New Construction Forecast

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

Table 19. Translation from FCZ to BCZ

Source: CEC Demand Analysis Office

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

Table 20: Estimated New Nonresidential Construction in 2017 by Climate Zone and Building Type (Million Square Feet)

Source: CEC Demand Analysis Office

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

4.8 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 2014). The Statewide CASE Team followed these guidelines when developing the Cost-effectiveness Analysis for this measure. CEC's guidance dictated which costs were included in the analysis. Incremental equipment and maintenance costs over the 15 year period of analysis were included. The TDV energy cost savings from electricity savings were considered. Each of these components is discussed in more detail below.

Design costs were not included.

4.8.1 Incremental Cost Methodology

The Statewide CASE Team estimated the incremental cost of LED lighting products based on current costs (sourced from sales representatives for manufacturers) and reductions in the cost per kilolumen of LED light source technology as detailed in a report to the DOE from Navigant (Navigant 2012). These estimates are reinforced using cost projections from another DOE study that provided cost estimates of actual luminaire product categories (DOE 2013).

The Statewide CASE Team estimated costs for non-volatile products (poles, foundations, etc.) based on a mix of manufacturer's sales representative price quotes and general pricing experience through multiple construction projects. Costs for commodity items and labor (conductors, conduit, trenching, installation or equipment, etc.) are based on RS Means estimates collected during June 2014.

The Statewide CASE Team compared prices for three installation scenarios, which are the detailed project installation cost comparison examples described in Appendix F below.

Incremental Construction Cost Methodology

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

For the general hardscape allowance, the Statewide CASE Team designed a lighting system to meet criteria for the same site conditions using an incumbent light source technology (PSMH) and the new baseline (LED). These two systems are optimized to efficiently meet lighting design criteria, the electrical needs of the system, and physical issues (pole heights, foundations, etc.).

Finally, the Statewide CASE Team estimated costs for the two systems using projected costs of LED in 2017 and current costs for PSMH products. This approach was applied to three different sites to produce a reasonable estimate of the impact on a variety of site conditions. The cost difference between these scenarios provides the incremental cost of this measure.

For the specific lighting allowances in Table 140.7-B, the LED light source is unlikely to be able to substantially change the designs because there are other factors that determine the equipment locations and quantities. In these circumstances, a luminaire cannot be compared directly with other system changes being considered (an incumbent technology luminaire compared to an LED luminaire with no impacts on wiring, etc.). This simplifies the calculations, but may slightly underestimate the positive impacts of the reduced wattage of the luminaires. Key assumptions used to derive cost are presented in Table 21.

Table 21: Key Assumptions for per unit Incremental Construction Cost

Parameter	Assumption	Source	Notes
Product Cost projections	LED costs are dropping rapidly	(DOE 2013) and manufacturer interviews for confirmation	The cost of lighting products in 2017 is modeled in the supporting documents in Appendix B.

Incremental Maintenance Cost Methodology

Maintenance costs associated with LED lighting products are generally a reduction from the incumbent technology. The LCC analysis uses a 15 year life cycle, during which no maintenance is expected for any of the LED lighting equipment because the products are still within their life expectancy at that time (approximately 65,000 hours of operation). As a result, the maintenance impacts result in savings related to the elimination of typical cyclic maintenance associated with the lighting equipment (primarily lamp and ballast replacement with failure). This varies by lamp type and wattage, so the Statewide CASE Team used a reasonable cross-section of incumbent lamps to calculate maintenance costs for incumbent and LED systems.

4.8.2 Cost Savings Methodology

Energy Cost Savings Methodology

The PV of the energy savings were calculated using the method described in the LCC Methodology (CEC 2014). 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 15 year period of analysis. This measure is not climate sensitive, so the hourly energy cost savings were calculated using the population-weighted TDV values.

Other Cost Savings Methodology

Other than maintenance cost savings, this measure does not have any non-energy cost savings.

4.8.3 Cost-effectiveness Methodology

The Statewide CASE Team calculated the cost-effectiveness using the LCC Methodology (CEC 2014). 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, the measure is cost-effective, meaning that the present value of TDV energy savings is greater than the cost premium.

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.

4.9 Environmental Impacts Methodology

4.9.1 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).

4.9.2 Water Use Impacts Methodology

There are no impacts on water use or water quality.

4.9.3 Material Impacts Methodology (Optional)

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

4.9.4 Other Impacts Methodology

There are no other impacts from the proposed code change.

5. ANALYSIS AND RESULTS

Results from the energy, demand, cost, and environmental impacts analyses are presented in this section. The reduction in LPA values is approximately 40% for the general allowances applied to the general hardscape.

5.1 Energy Impacts Results

Lighting Recommendations Table

Table 22 below, represents the complete set of recommendations of the LPA values for the outdoor lighting applications in Section 140.7. All of the values represented in Tables 140.7-A and 140.7-B are included below.

Table 22: Outdoor Lighting LPA Recommendations Table

			2013				2016 Proposed			
Allowance		Units	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
General Hardscape Allowance	**Area Wattage Allowance (AWA)**	W/s	0.035	0.045	0.090	0.115	0.020	0.030	0.040	0.050
	Linear Wattage Allowance (LWA)	W/lf	0.25	0.45	0.60	0.85	0.15	0.25	0.35	0.45
	Initial Wattage Allowance (IWA)	W	340	510	770	1030	340	450	520	640
Allowance per Application	**Building Entrances or Exits**	W	30	60	90	90	15	25	35	45
	Primary Entrances to Senior Care Facilities, Police Stations, Hospitals, Fire Stations, and Emergency Vehicle Facilities.	W	45	80	120	130	20	40	60	80
	Drive Up Windows	W	40	75	125	200	30	40	60	100
	Vehicle Service Station Uncovered Fuel Dispenser.	W	120	175	185	330	80	100	140	160
	Automated Teller Machines	W	Not Included				250 W for first ATM plus 70 W per add'l ATM			
Allowance per Unit Length	**Outdoor Sales Frontage**	W/lf	No allowance	22.5	36	45	No allowance	15	25	30
Allowance per Hardscape Area	**Hardscape Ornamental Lighting**	W/sf	No allowance	0.020	0.040	0.060	No allowance	0.015	0.030	0.045
Allowance per Specific Area	**Building Facades**	W/sf	No allowance	0.18	0.35	0.50	No allowance	0.15	0.25	0.35
	Outdoor Sales Lots	W/sf	0.164	0.555	0.758	1.285	0.100	0.250	0.500	1.000
	Vehicle Service Station Hardscape	W/sf	0.014	0.155	0.308	0.485	0.010	0.100	0.150	0.200
	Vehicle Service Station Canopies	W/sf	0.514	1.005	1.300	2.200	0.400	0.700	0.900	1.200
	Sales Canopies	W/sf	No allowance	0.655	0.908	1.135	No allowance	0.500	0.800	1.000
	Non-sales Canopies	W/sf	0.084	0.205	0.408	0.585	0.080	0.160	0.300	0.400
	Guard Stations	W/sf	0.154	0.355	0.708	0.985	0.100	0.300	0.500	0.750
	Student Pick-up/Drop-off zone	W/sf	No allowance	0.15	0.45	No allowance	No allowance	0.10	0.25	No allowance
	Outdoor Dining	W/sf	0.014	0.135	0.240	0.400	0.010	0.100	0.150	0.200
	Special Security Lighting for Retail Parking and Pedestrian Hardscape	W/sf	0.007	0.009	0.019	No allowance	0.005	0.007	0.012	No allowance

Table 23, below, represents the complete set of recommendations of the LPA values for the outdoor lighting applications in Section 140.7 and the percentage reduction for the LPA values based on this recommendation. All of the values represented in Tables 140.7-A and 140.7-B are included below.

Table 23: Outdoor Lighting LPA Recommendations Reduction Percentage Table

Allowance		Units	2016 Proposed & Reduction Percentage							
			Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4	LZ1 Reduced By:	LZ2 Reduced By:	LZ3 Reduced By:	LZ3 Reduced By:
General Hardscape Allowance	Area Wattage Allowance (AWA)	W/s	0.020	0.030	0.040	0.050	43%	33%	56%	57%
	Linear Wattage Allowance (LWA)	W/lf	0.15	0.25	0.35	0.45	40%	44%	42%	47%
	Initial Wattage Allowance (IWA)	W	340	450	520	640	No Change	12%	32%	38%
Allowance per Application	**Building Entrances or Exits**.	W	15	25	35	45	50%	58%	61%	50%
	Primary Entrances to Senior Care Facilities, Police Stations, Hospitals, Fire Stations, and Emergency Vehicle Facilities.	W	20	40	60	80	56%	50%	50%	38%
	Drive Up Windows.	W	30	40	60	100	25%	47%	52%	50%
	Vehicle Service Station Uncovered Fuel Dispenser.	W	80	100	140	160	33%	43%	24%	52%
	Automated Teller Machines.	W	250 W for first ATM plus 70 W per add'l ATM				New Allowance			
Allowance per Unit Length	**Outdoor Sales Frontage**.	W/lf	No allowance	15	25	30	No Change	33%	31%	33%
Allowance per Hardscape Area	**Hardscape Ornamental Lighting**.	W/sf	No allowance	0.015	0.030	0.045	No Change	25%	25%	25%
Allowance per Specific Area	**Building Facades.**	W/sf	No allowance	0.15	0.25	0.35	No Change	17%	29%	30%
	Outdoor Sales Lots.	W/sf	0.100	0.250	0.500	1.000	39%	55%	34%	22%
	Vehicle Service Station Hardscape.	W/sf	0.010	0.100	0.150	0.200	29%	35%	51%	59%
	Vehicle Service Station Canopies.	W/sf	0.400	0.700	0.900	1.200	22%	30%	31%	45%
	Sales Canopies.	W/sf	No allowance	0.500	0.800	1.000	No Change	24%	12%	12%
	Non-sales Canopies.	W/sf	0.080	0.160	0.300	0.400	5%	22%	26%	32%
	Guard Stations.	W/sf	0.100	0.300	0.500	0.750	35%	15%	29%	24%
	Student Pick-up/Drop-off zone.	W/sf	No allowance	0.10	0.25	No allowance	No Change	33%	44%	No Change
	Outdoor Dining.	W/sf	0.010	0.100	0.150	0.200	29%	26%	38%	50%
	Special Security Lighting for Retail Parking and Pedestrian Hardscape.	W/sf	0.005	0.007	0.012	No allowance	29%	22%	37%	No Change

5.1.1 Per Unit Energy Impacts Results

Table 24 below provides information on the per unit results for a comparison of the general hardscape lighting for ten different prototypical sites, comparing the results from an incumbent technology approach to an LED light source approach.

The sites include nine different site layouts, with a range of sizes and building complexity. One additional site is included that represents an 'ideal' site; the most efficient site that can be produced in a rectangular shape. For more details on the sites, refer to Appendix D at the end of the report.

This analysis establishes an effective wattage allowance that accommodates a reasonable cross-section of the sites that may occur in the State. The effective wattage allowance combines the Initial Wattage Allowance, the Area Wattage Allowance, and the Linear Wattage Allowance values found in Table 140.7-A of the Code into a single value that can characterize the impacts in a per square foot value of hardscape and can be scaled up for statewide calculations.

Table 24: Effective Energy Impacts per Square Foot of General Hardscape

Lighting Zone	Per Unit Lighting Power Density		
	Average of Prototypes, 2013 Standard	Average of Prototypes, Proposed 2016 Values	Power Density Reduction (W/sf)
LZ1	0.046	0.027	0.019
LZ2	0.065	0.041	0.024
LZ3	0.116	0.055	0.061
LZ4	0.152	0.070	0.083

Note that the Lighting Zone is not the same as a Climate Zone. Lighting Zones are related primarily to population density, and are tied to the 2010 US Census. The correlation of Lighting Zones to Climates Zones and the resulting statewide impacts will be made in the next section.

Per unit energy and demand impacts for the general hardscape of the proposed measure are presented in Table 25. Per unit savings for the first year are expected to be 0.12 kilowatt-hours per year per square foot (kWh/yr-sqft) in Lighting Zone 2 (the most prevalent zone in the state). These are off-peak loads, so peak demand is not anticipated to be affected.

The Statewide CASE Team estimates that the TDV electricity over the 15 year period of analysis will be $ 0.42 per square foot in Lighting Zone 2. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

This measure is not anticipated to produce any peak energy demand savings, based on the nature of the nighttime operation of outdoor lighting systems. Therefore demand savings in this measure are assigned the 'N/A' designation.

Table 25: Energy Impacts per Square Foot – General Hardscape

Lighting Zone	Per Unit First Year Savings[1]			Per Unit TDV Savings[2]
	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Savings[4] (2017 $)
LZ1	0.09	N/A	N/A	.31
LZ2	0.12	N/A	N/A	.42
LZ3	0.34	N/A	N/A	1.15
LZ4	0.44	N/A	N/A	1.51

1. Savings from one square foot for the first year the site is in operation.
2. TDV energy savings for one square foot over the 15 year period of analysis.
3. Site electricity savings. Does not include TDV of electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity.

The energy impacts per unit for the specific applications found in Table 140.7-B of the Code are presented for Lighting Zones 1 – 4 in Table 26, Table 27, Table 28 and Table 29, respectively.

Table 26: Energy Impacts per Unit – Other Line Items LZ1

Lighting Application	Per Unit First Year Savings[1]				Per Unit TDV Savings[2]
	Units	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings[4] (2017 $/unit)
Building Entrances	Each	81	N/A	N/A	121
Primary Entrances	Each	137	N/A	N/A	467
Drive Up Windows	Each	52	N/A	N/A	83
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	385	N/A	N/A	577
ATM Machine	Each	406	N/A	N/A	530
Outdoor Sales Frontage	Per linear foot	N/A	N/A	N/A	N/A
Hardscape Ornamental Lighting	Per Square Foot	N/A	N/A	N/A	N/A
Building Facades	Per Square Foot	N/A	N/A	N/A	N/A
Outdoor Sales Lots	Per Square Foot	0.54	N/A	N/A	0.81
Vehicle Service Station Hardscape	Per Square Foot	0.042	N/A	N/A	0.06
Vehicle Service Station Canopies	Per Square Foot	0.79	N/A	N/A	2.43
Sales Canopies	Per Square Foot	N/A	N/A	N/A	N/A
Non-sales Canopies	Per Square Foot	0.14	N/A	N/A	0.21
Guard Stations	Each	.43	N/A	N/A	0.64
Student Pick-up/Drop-off Zone	Each	N/A	N/A	N/A	N/A
Outdoor Dining	Per Square Foot	0.02	N/A	N/A	0.03
Special Security Lighting for Retail	Per Square Foot	0.02	N/A	N/A	0.03

1. Savings from one unit for the first year the site is in operation.
2. TDV energy savings for one unit over the 15 year period of analysis.
3. Site electricity savings. Does not include TDV of electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity.

Table 27: Energy Impacts per Unit – Other Line Items LZ2

Lighting Application	Per Unit First Year Savings[1]				Per Unit TDV Savings[2]
	Units	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings[4] (2017 $/unit)
Building Entrances	Each	182	N/A	N/A	273
Primary Entrances	Each	257	N/A	N/A	385
Drive Up Windows	Each	95	N/A	N/A	152
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	575	N/A	N/A	863
ATM Machine	Each	406	N/A	N/A	530
Outdoor Sales Frontage	Per linear foot	30	N/A	N/A	38.49
Hardscape Ornamental Lighting	Per Square Foot	0.01	N/A	N/A	0.01
Building Facades	Per Square Foot	0.49	N/A	N/A	0.74
Outdoor Sales Lots	Per Square Foot	1.9	N/A	N/A	2.78
Vehicle Service Station Hardscape	Per Square Foot	0.48	N/A	N/A	0.72
Vehicle Service Station Canopies	Per Square Foot	3.1	N/A	N/A	4.65
Sales Canopies	Per Square Foot	1.5	N/A	N/A	2.21
Non-sales Canopies	Per Square Foot	0.35	N/A	N/A	0.53
Guard Stations	Each	1.0	N/A	N/A	1.56
Student Pick-up/Drop-off Zone	Each	0.16	N/A	N/A	0.26
Outdoor Dining	Per Square Foot	0.19	N/A	N/A	0.31
Special Security Lighting for Retail	Per Square Foot	0.26	N/A	N/A	0.04

1. Savings from one unit for the first year the site is in operation.
2. TDV energy savings for one unit over the 15 year period of analysis.
3. Site electricity savings. Does not include TDV of electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity.

Table 28: Energy Impacts per Unit – Other Line Items LZ3

Lighting Application	Per Unit First Year Savings[1]				Per Unit TDV Savings[2]
	Units	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings[4] (2017 $/unit)
Building Entrances	Each	294	N/A	N/A	441
Primary Entrances	Each	402	N/A	N/A	603
Drive Up Windows	Each	155	N/A	N/A	246
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	623	N/A	N/A	934
ATM Machine	Each	406	N/A	N/A	530
Outdoor Sales Frontage	Per linear foot	46	N/A	N/A	59.67
Hardscape Ornamental Lighting	Per Square Foot	0.19	N/A	N/A	0.03
Building Facades	Per Square Foot	0.97	N/A	N/A	1.45
Outdoor Sales Lots	Per Square Foot	2.4	N/A	N/A	3.62
Vehicle Service Station Hardscape	Per Square Foot	0.97	N/A	N/A	1.45
Vehicle Service Station Canopies	Per Square Foot	3.9	N/A	N/A	5.85
Sales Canopies	Per Square Foot	2.1	N/A	N/A	3.22
Non-sales Canopies	Per Square Foot	0.76	N/A	N/A	1.13
Guard Stations	Each	2.2	N/A	N/A	3.29
Student Pick-up/Drop-off Zone	Each	0.50	N/A	N/A	3.62
Outdoor Dining	Per Square Foot	0.34	N/A	N/A	0.55
Special Security Lighting for Retail	Per Square Foot	0.059	N/A	N/A	0.09

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

Table 29: Energy Impacts per Unit – Other Line Items LZ4

Lighting Application	Per Unit First Year Savings[1]				Per Unit TDV Savings[2]
	Units	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings[4] (2017 $/unit)
Building Entrances	Each	298	N/A	N/A	447
Primary Entrances	Each	107	N/A	N/A	658
Drive Up Windows	Each	254	N/A	N/A	403
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	1,127	N/A	N/A	1,689
ATM Machine	Each	406	N/A	N/A	530
Outdoor Sales Frontage	Per linear foot	52	N/A	N/A	67.76
Hardscape Ornamental Lighting	Per Square Foot	0.03	N/A	N/A	0.04
Building Facades	Per Square Foot	1.4	N/A	N/A	2.11
Outdoor Sales Lots	Per Square Foot	4.1	N/A	N/A	6.09
Vehicle Service Station Hardscape	Per Square Foot	1.54	N/A	N/A	2.31
Vehicle Service Station Canopies	Per Square Foot	6.6	N/A	N/A	9.93
Sales Canopies	Per Square Foot	2.6	N/A	N/A	3.91
Non-sales Canopies	Per Square Foot	1.2	N/A	N/A	1.73
Guard Stations	Each	3.1	N/A	N/A	4.62
Student Pick-up/Drop-off Zone	Each	N/A	N/A	N/A	N/A
Outdoor Dining	Per Square Foot	0.57	N/A	N/A	0.91
Special Security Lighting for Retail	Per Square Foot	N/A	N/A	N/A	N/A

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

5.1.2 Statewide Energy Impacts Results

First Year Statewide Energy Impacts

The statewide energy impacts of the proposed measure are presented in Table 30. 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 125 GWh. These are primarily off-peak loads, so there is no expected peak demand savings. Since these light sources are outdoors there are no interaction effects with air conditioning or heating loads.

Table 30: Statewide Energy Impacts

	First Year Statewide Savings[1]			TDV Savings[2]
	Electricity Savings[3] (GWh)	Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Cost Savings[4] (Million $)
TOTAL	125	N/A	N/A	207

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 4.7 of this report.

5.2 Cost-effectiveness Results

5.2.1 Incremental Cost Results

Incremental Construction Cost Results

As shown in Appendix F, by 2017, many of the proposed lighting systems are likely to cost less than the incumbent PSMH lighting systems. This is considering cost forecasts for LED products, which estimate an approximate 30% reduction in luminaire costs by 2017 (DOE 2013).

Incremental Maintenance Cost Results

The maintenance requirements associated with the code change proposal, relative to existing conditions, are described qualitatively in Section 3.3 of this report.

For the sake of the calculations, luminaire maintenance is not being considered in the comparative analysis. The incumbent systems all have higher maintenance costs compared to LED, and the very long life of LED makes them effectively last for the full duration of the 15 year life cycle without requiring maintenance. This produces a conservative life cycle comparison analysis, but the cost effectiveness is sufficiently high to be satisfactory even with this conservative position.

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 32. This measure is not climate zone dependent, so the information is presented as an average for the State. The energy and energy cost savings per unit per lighting zone is presented in Section 5.1.1. Table 32 contains the per unit energy cost savings averaged across all climate zones according to the weighting described in Table 31 below.

Table 31: Lighting Zone Area Weighting Factors

Lighting Zone	Energy Impact Weight (%)
LZ0	0
LZ1	0.1
LZ2	90
LZ3	9.9
LZ4	0

Note that Lighting Zone 0 (LZ0) is not currently defined in the existing Title 24 Building Standards. The Statewide CASE Team proposes an addition to the code to keep it aligned with the IES lighting zone definitions. LZ0 is specifically intended for undeveloped spaces in parks, and therefore has no substantial energy impact on the statewide values.

Table 32: Weighted TDV Energy Cost Savings Over 15 Years - Per Unit

Climate Zone	Units	TDV Electricity Cost Savings (2017 PV $)	TDV Natural Gas Cost Savings (2017 PV $)	Total TDV Energy Cost Savings (2017 PV $)
General Hardscape	Per Square Foot	0.44	N/A	0.44
Building Entrances	Each	289.69	N/A	289.69
Primary Entrances	Each	406.92	N/A	406.92
Drive Up Windows	Each	160.78	N/A	160.78
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	870.14	N/A	870.14
ATM Machine	Each	476.84	N/A	476.84
Outdoor Sales Frontage	Per linear foot	40.54	N/A	40.54
Hardscape Ornamental Lighting	Per Square Foot	0.01	N/A	0.01
Building Facades	Per Square Foot	0.81	N/A	0.81
Outdoor Sales Lots	Per Square Foot	2.86	N/A	2.86
Vehicle Service Station Hardscape	Per Square Foot	0.79	N/A	0.79
Vehicle Service Station Canopies	Per Square Foot	4.77	N/A	4.77
Sales Canopies	Per Square Foot	2.30	N/A	2.30
Non-sales Canopies	Per Square Foot	0.59	N/A	0.59
Guard Stations	Each	1.73	N/A	1.73
Student Pick-up/Drop-off Zone	Each	0.60	N/A	0.60
Outdoor Dining	Per Square Foot	0.33	N/A	0.33
Special Security Lighting for Retail	Per Square Foot	0.04	N/A	0.04

Other Cost Savings Results

Many of the proposed lighting systems are likely to cost less than the incumbent PSMH lighting systems. This is especially true when considering cost forecasts for LED products, which estimate an approximate 30% reduction in luminaire costs by 2017 (DOE 2013). Refer to Appendix F at the end of the report for a comparison of the General Hardscape Costing exercise. However, this analysis conservatively assumes zero cost difference between the existing and proposed conditions.

5.2.3 Cost-effectiveness Results

Results for per unit lifecycle cost-effectiveness analyses are presented below in Table 33 through Table 36.

Table 33: Cost-effectiveness Summary[1] – Lighting Zone 1

Climate Zone	Units	Benefit: TDV Energy Cost Savings[2] (2017 PV$)	Cost: Total Incremental Cost[3] (2017 PV$)	Change in Lifecycle Cost[4] (2017 PV$)	Benefit to Cost Ratio[5]
General Hardscape	Per Square Foot	0.31	Lower	-0.31	Infinite
Building Entrances	Each	121.80	Lower	-121.8	Infinite
Primary Entrances	Each	467.13	40.78	-426.35	11.5
Drive Up Windows	Each	82.50	68.91	-13.59	1.2
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	577.54	306.04	-271.5	1.9
ATM Machine	Each	592.82	288.00	-304.82	1.8
Outdoor Sales Frontage	Per linear foot	N/A	N/A	N/A	N/A
Hardscape Ornamental Lighting	Per Square Foot	N/A	N/A	N/A	N/A
Building Facades	Per Square Foot	N/A	N/A	N/A	N/A
Outdoor Sales Lots	Per Square Foot	0.81	0.22	-0.59	3.7
Vehicle Service Station Hardscape	Per Square Foot	0.06	0.05	-0.01	1.4
Vehicle Service Station Canopies	Per Square Foot	2.43	0.83	-1.6	2.9
Sales Canopies	Per Square Foot	N/A	N/A	N/A	N/A
Non-sales Canopies	Per Square Foot	0.21	0.19	-0.02	1.1
Guard Stations	Each	0.64	0.24	-0.4	2.7
Student Pick-up/Drop-off Zone	Each	N/A	N/A	N/A	N/A
Outdoor Dining	Per Square Foot	0.03	0.01	-0.02	4.1
Special Security Lighting for Retail	Per Square Foot	0.03	0.02	-0.01	1.5

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; ΔTDV$ = ΔTDV$E + ΔTDV$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; ΔLCC = ΔC – ΔTDV$
5. The benefit to cost ratio is the TDV energy costs savings divided by the total incremental costs; B/C = ΔTDV$ ÷ ΔC. The measure is cost effective if the B/C ratio is greater than 1.0.

Table 34: Cost-effectiveness Summary[1] – Lighting Zone 2

Climate Zone	Units	Benefit: TDV Energy Cost Savings[2] (2017 PV$)	Cost: Total Incremental Cost[3] (2017 PV$)	Change in Lifecycle Cost[4] (2017 PV$)	Benefit to Cost Ratio[5]
General Hardscape	Per Square Foot	0.42	Lower	-0.42	Infinite
Building Entrances	Each	273.20	Lower	-273.2	Infinite
Primary Entrances	Each	385.25	102.14	-283.11	3.8
Drive Up Windows	Each	151.51	104.20	-47.31	1.5
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	863.34	290.21	-573.13	3.0
ATM Machine	Each	592.82	288.00	-304.82	1.8
Outdoor Sales Frontage	Per linear foot	38.49	5.19	-33.3	7.4
Hardscape Ornamental Lighting	Per Square Foot	N/A	N/A	N/A	N/A
Building Facades	Per Square Foot	0.74	Lower	-0.74	Infinite
Outdoor Sales Lots	Per Square Foot	2.78	0.16	-2.62	17.9
Vehicle Service Station Hardscape	Per Square Foot	0.72	0.47	-0.25	1.5
Vehicle Service Station Canopies	Per Square Foot	4.65	1.80	-2.85	2.6
Sales Canopies	Per Square Foot	2.21	1.44	-0.77	1.5
Non-sales Canopies	Per Square Foot	0.53	0.53	0	1.0
Guard Stations	Each	1.56	0.57	-0.99	2.7
Student Pick-up/Drop-off Zone	Each	0.26	0.12	-0.14	2.3
Outdoor Dining	Per Square Foot	0.31	0.07	-0.24	4.1
Special Security Lighting for Retail	Per Square Foot	0.04	0.02	-0.02	1.7

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.

Table 35: Cost-effectiveness Summary[1] – Lighting Zone 3

Climate Zone	Units	Benefit: TDV Energy Cost Savings[2] (2017 PV$)	Cost: Total Incremental Cost[3] (2017 PV$)	Change in Lifecycle Cost[4] (2017 PV$)	Benefit to Cost Ratio[5]
General Hardscape	Per Square Foot	1.15	Lower	-1.15	Infinite
Building Entrances	Each	441.32	Lower	-441.32	Infinite
Primary Entrances	Each	603.32	132.97	-470.35	4.5
Drive Up Windows	Each	245.83	209.93	-35.9	1.2
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	934.90	176.74	-758.16	5.3
ATM Machine	Each	592.82	288.00	-304.82	1.8
Outdoor Sales Frontage	Per linear foot	59.67	Lower	-59.67	Infinite
Hardscape Ornamental Lighting	Per Square Foot	N/A	N/A	N/A	N/A
Building Facades	Per Square Foot	1.45	Lower	-1.45	Infinite
Outdoor Sales Lots	Per Square Foot	3.62	0.08	-3.54	42.8
Vehicle Service Station Hardscape	Per Square Foot	1.45	0.75	-0.7	1.9
Vehicle Service Station Canopies	Per Square Foot	5.85	3.17	-2.68	1.8
Sales Canopies	Per Square Foot	3.22	2.49	-0.73	1.3
Non-sales Canopies	Per Square Foot	1.13	0.90	-0.23	1.3
Guard Stations	Each	3.29	1.12	-2.17	2.9
Student Pick-up/Drop-off Zone	Each	3.62	0.08	-3.54	42.8
Outdoor Dining	Per Square Foot	0.55	0.13	-0.42	4.1
Special Security Lighting for Retail	Per Square Foot	0.09	0.05	-0.04	1.7

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.

Table 36: Cost-effectiveness Summary[1] – Lighting Zone 4

Climate Zone	Units	Benefit: TDV Energy Cost Savings[2] (2017 PV$)	Cost: Total Incremental Cost[3] (2017 PV$)	Change in Lifecycle Cost[4] (2017 PV$)	Benefit to Cost Ratio[5]
General Hardscape	Per Square Foot	1.51	Lower	-1.51	Infinite
Building Entrances	Each	446.56	Lower	-446.56	Infinite
Primary Entrances	Each	657.69	206.96	-450.73	3.2
Drive Up Windows	Each	403.41	292.84	-110.57	1.4
Vehicle Service Uncovered Fuel Dispenser	Each Pump Face	1,689.44	151.12	-1538.32	11.2
ATM Machine	Each	592.82	288.00	-304.82	1.8
Outdoor Sales Frontage	Per linear foot	67.76	Lower	-67.76	Infinite
Hardscape Ornamental Lighting	Per Square Foot	N/A	N/A	N/A	N/A
Building Facades	Per Square Foot	2.11	Lower	-2.11	Infinite
Outdoor Sales Lots	Per Square Foot	6.09	Lower	-6.09	Infinite
Vehicle Service Station Hardscape	Per Square Foot	2.31	1.18	-1.13	2.0
Vehicle Service Station Canopies	Per Square Foot	9.93	4.19	-5.74	2.4
Sales Canopies	Per Square Foot	3.91	3.72	-0.19	1.0
Non-sales Canopies	Per Square Foot	1.73	1.52	-0.21	1.1
Guard Stations	Each	4.62	1.85	-2.77	2.5
Student Pick-up/Drop-off Zone	Each	N/A	N/A	N/A	N/A
Outdoor Dining	Per Square Foot	0.91	0.21	-0.7	4.4
Special Security Lighting for Retail	Per Square Foot	N/A	N/A	N/A	N/A

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; ΔTDV$ = ΔTDV$E + ΔTDV$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; ΔLCC = ΔC – ΔTDV$
5. The benefit to cost ratio is the TDV energy costs savings divided by the total incremental costs; B/C = ΔTDV$ ÷ ΔC. The measure is cost effective if the B/C ratio is greater than 1.0.

Given data regarding the new construction forecast for 2017, the Statewide CASE Team estimates that that lifecycle cost savings (over 15 years) of all buildings constructed during the first year the 2016 Standards are in effect will be $227 million.

5.3 Environmental Impacts Results

5.3.1 Greenhouse Gas Emissions Results

Table 37 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year the 2016 Standards are in effect the proposed measure will result in avoided GHG emissions. The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) for each hour of the year and thus included in the Cost-effectiveness Analysis presented in this report.

Table 37: Statewide Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions[1] ($MTCO_2e/yr$)
TOTAL	44,000

1. First year savings from buildings built in 2017; assumes 353 $MTCO_2e/GWh$.
2. Monetary value of carbon is included in cost effectiveness analysis; assumes $/ $MTCO_2e$ consistent with 2016 TDV.

5.3.2 Water Use and Water Quality Impacts

Impacts on water use and water quality are presented in Table 38.

Table 38: 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

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

5.3.4 Other Impacts Results

There are no other impacts anticipated from this measure.

6. PROPOSED LANGUAGE

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

6.1 Standards

Section 100.1 will be modified to add LZ0 to the definition of Outdoor Lighting Zone.

Table 10-114 A will be modified to add LZ0 to the table and redefine the Lighting Zone ambient illumination description to align with the IES definitions.

Table 130.2-A and –B will be modified to add LZ0 to the tables.

Section 140.7(a) will be modified to remove the exception for ATM lighting and also to remove tunnels and bridges from exceptions.

Tables 140.7-A and 140.7-B will be revised with new LPA values for all of the items within the table and an additional section regarding ATM Machine Lighting.

Section 140.6(a)3 will be revised to remove ATM lighting from the exception.

Table 140.6-C will be revised to add a note to the Parking Garage allowance for a specific ATM allowance.

Section 100.1 Definitions and Rules of Construction will be modified in the following manner:

OUTDOOR LIGHTING ZONE is a geographic area designated by the California Energy Commission in accordance with Part 1, Section 10-114, that determines requirements for outdoor lighting, including lighting power densities and specific control, equipment or performance requirements. Lighting zones are numbered LZ0, LZ1, LZ2, LZ3 and LZ4.

Table 130.2-A will be modified in the following manner:

TABLE 130.2-A Uplight Ratings (Maximum Zonal Lumens)

Secondary Solid Angle	Maximum Zonal Lumens per Outdoor Lighting Zone				
	LZ 0	~~O~~LZ 1	~~O~~LZ 2	~~O~~LZ 3	OLZ 4
Uplight High (UH) 100 to 180 degrees	0	10	50	500	1,000
Uplight Low (UL) 90 to <100 degrees	0	10	50	500	1,000

Table 130.2-B will be modified in the following manner:

TABLE 130.2-B Glare Ratings (Maximum Zonal Lumens)

Glare Rating for Asymmetrical Luminaire Types (Type 1, Type II, Type III, Type IV)					
Secondary Solid Angle	Maximum Zonal Lumens per Outdoor Lighting Zone				
	LZ 0	~~O~~LZ 1	~~O~~LZ 2	~~O~~LZ 3	~~O~~LZ 4
Forward Very High (FVH) 80 to 90 degrees	10	100	225	500	750
Backlight Very High (BVH) 80 to 90 degrees	10	100	225	500	750

Forward High (FH) 60 to <80 degrees	660	1,800	5,000	7,500	12,000
Backlight High (BH) 60 to <80 degrees	110	500	1,000	2,500	5,000
Glare Rating for Quadrilateral Symmetrical Luminaire Types (Type V, Type V Square)					
Secondary Solid Angle	**Maximum Zonal Lumens per Outdoor Lighting Zone**				
	LZ 0	~~O~~LZ 1	~~O~~LZ 2	OLZ 3	~~O~~LZ 4
Forward Very High (FVH) 80 to 90 degrees	10	100	225	500	750
Backlight Very High (BVH) 80 to 90 degrees	10	100	225	500	750
Forward High (FH) 60 to <80 degrees	660	1,800	5,000	7,500	12,000
Backlight High (BH) 60 to <80 degrees	660	1,800	5,000	7,500	12,000

Table 10-114-A will be modified in the following manner:

TABLE 10-114-A LIGHTING ZONE CHARACTERISTICS AND RULES FOR AMENDMENTS BY LOCAL JURISDICTIONS

Zone	Ambient Illumination	State wide Default Location	Moving Up to Higher Zones	Moving Down to Lower Zones
LZ0	Very Low	Undeveloped areas of government designated parks, recreation areas, and wildlife preserves.	Undeveloped portions of government designated park, recreation area, wildlife preserve, can be designated as LZ1 or LZ2 if they are contained within a higher zone.	Not applicable.
LZ1	~~Dark~~ Low	Developed portions of government designated parks, recreation areas, and wildlife preserves. Those that are wholly contained within a higher lighting zone may be considered by the local government as part of that lighting zone.	Developed portions of a government designated park, recreation area, wildlife preserve, ~~or portions thereof,~~ can be designated as LZ2 or LZ3 if they are contained within such a zone.	Not applicable.
LZ2	~~Low~~ Moderate	Rural areas, as defined by the 2010 U.S. Census.	Special districts within a default LZ2 zone may be designated as LZ3 or LZ4 by a local jurisdiction. Examples include special commercial districts or areas with special security considerations located within a rural area.	Special districts and government designated parks within a default LZ2 zone maybe designated as LZ1 by the local jurisdiction for lower illumination standards, without any size limits.
LZ3	~~Medium~~ Moderately High	Urban areas, as defined by the 2010 U.S. Census.	Special districts within a default LZ3 may be designated as a LZ4 by local jurisdiction for high intensity nighttime use, such as entertainment or commercial districts or areas with special security considerations requiring very high light levels.	Special districts and government designated parks within a default LZ3 zone may be designated as LZ1 or LZ2 by the local jurisdiction, without any size limits.
LZ4	High	None.	Not applicable.	Not applicable.

Section 140.7(a) will be modified in the following manner:

(a) An outdoor lighting installation complies with this section if it meets the requirements in Subsections (b) and (c), and the actual outdoor lighting power installed is no greater than the allowed outdoor lighting power calculated under Subsection (d). The allowed outdoor lighting shall be calculated according to Outdoor Lighting Zone in Title 24, Part 1, Section 10-114.

EXCEPTIONS to Section 140.7(a): When more than 50 percent of the light from a luminaire falls within one or more of the following applications, the lighting power for that luminaire shall be exempt from Section 140.7:

1. Temporary outdoor lighting.
2. Lighting required and regulated by the Federal Aviation Administration, and the Coast Guard.
3. Lighting for public streets, roadways, highways, and traffic signage lighting, including lighting for driveway entrances occurring in the public right-of-way.
4. Lighting for sports and athletic fields, and children's playgrounds.
5. Lighting for industrial sites, including but not limited to, rail yards, maritime shipyards and docks, piers and marinas, chemical and petroleum processing plants, and aviation facilities.

~~6. Lighting specifically for Automated Teller Machines as required by California Financial Code Section 13040, or required by law through a local ordinance.~~

~~7~~6. Lighting of public monuments.

~~8~~7. Lighting of signs complying with the requirements of Sections 130.3 and 140.8.

~~9~~8. Lighting of ~~tunnels, bridges,~~ stairs, wheelchair elevator lifts for American with Disabilities Act (ADA) compliance, and ramps that are other than parking garage ramps.

~~10~~9. Landscape lighting.

~~11~~10. In theme parks: outdoor lighting only for themes and special effects.

~~12~~11. Lighting for outdoor theatrical and other outdoor live performances, provided that these lighting systems are additions to area lighting systems and are controlled by a multiscene or theatrical cross-fade control station accessible only to authorized operators.

~~13~~12. Outdoor lighting systems for qualified historic buildings, as defined in the California Historic Building Code (Title 24, Part 8), if they consist solely of historic lighting components or replicas of historic lighting components. If lighting systems for qualified historic buildings contain some historic lighting components or replicas of historic components, combined with other lighting components, only those historic or historic replica components are exempt. All other outdoor lighting systems for qualified historic buildings shall comply with Section 140.7.

Section 140.7(d)1A will be modified in the following manner:

1. **General Hardscape Lighting Allowance.** Determine the general hardscape lighting power allowances as follows:

A. The general hardscape area of a site shall include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridges(s), tunnel(s), and other improved area(s) that are illuminated. In plan view of the site, determine the illuminated hardscape area, which is defined as any hardscape area that is within a square pattern around each luminaire or pole that is ten times the luminaire mounting height with the luminaire in the middle of the pattern, less any areas that are within a building, beyond the hardscape area, beyond property lines, or obstructed by a structure. The illuminated hardscape area shall include portions of planters and landscaped areas that are within the lighting application and are less than or equal to 10 feet wide in the short dimensions and are enclosed by hardscape or other improvement on at least three sides. Multiply the illuminated hardscape area by the Area Wattage Allowance (AWA) from TABLE 140.7-A for the appropriate Lighting Zone.

Table 140.7-A will be modified in the following manner:

TABLE 140.7-A GENERAL HARDSCAPE LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Area Wattage Allowance (AWA)	*See Note #1 Below*	~~0.035~~ 0.020 W/ft²	~~0.045~~ 0.030 W/ft²	~~0.090~~ 0.040 W/ft²	~~0.115~~ 0.050 W/ft²
Linear Wattage Allowance (LWA)		~~0.25~~ 0.15 W/lf	~~0.45~~ 0.25 W/lf	~~0.60~~ 0.35 W/lf	~~0.85~~ 0.45 W/lf
Initial Wattage Allowance (IWA)		340 W	~~510~~ 450 W	~~770~~ 520 W	~~1030~~ 640 W

Note #1: Lighting Zone 0: *Continuous lighting is explicitly prohibited in Lighting Zone 0. Therefore, a single luminaire of 15 Watts or less may be installed at the entrance to a parking area, trail head, fee payment kiosk, outhouse, or toilet facility, as required to provide safe navigation of the site infrastructure. Luminaires shall be meet the maximum zonal lumen limits of LZ0 for Uplight and Glare in Tables 130.2-A and 130.2-B to comply with this zone.*

Table 140.7-B will be modified in the following manner:

TABLE 140.7-B ADDITIONAL LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS All area and distance measurements in plan view unless otherwise noted.

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate.					
Building Entrances or Exits. Allowance per door. Luminaires qualifying for this allowance shall be within 20 feet of the door.	*See Note #1 Below*	~~30~~ 15 watts	~~60~~ 25 watts	~~90~~ 35 watts	~~90~~ 45 watts
Primary Entrances to Senior Care Facilities, Police Stations, Hospitals, Fire Stations, and Emergency Vehicle Facilities. Allowance per primary entrance(s) only. Primary entrances shall provide access for the general public and shall not be used exclusively for staff or service personnel. This allowance shall be in addition to the building entrance or exit allowance above. Luminaires qualifying for this allowance shall be within 100 feet of the primary entrance.	No Allowance	~~45~~ 20 watts	~~80~~ 40 watts	~~120~~ 60 watts	~~130~~ 80 watts
Drive Up Windows. Allowance per customer service location. Luminaires qualifying for this allowance shall be within 2 mounting heights of the sill of the window.	No Allowance	~~40~~ 30 watts	~~75~~ 40 watts	~~125~~ 60 watts	~~200~~ 100 watts
Vehicle Service Station Uncovered Fuel Dispenser. Allowance per fueling dispenser. Luminaires qualifying for this allowance shall be within 2 mounting heights of the dispenser.	No Allowance	~~120~~ 80 watts	~~175~~ 100 watts	~~185~~ 140 watts	~~330~~ 160 watts
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	No Allowance	250 watts for first ATM machine, 70 watts for each additional ATM machine			
WATTAGE ALLOWANCE PER UNIT LENGTH (w/linear ft). May be used for one or two frontage side(s) per site.					
Outdoor Sales Frontage. Allowance for frontage immediately adjacent to the principal viewing location(s) and unobstructed for its viewing length. A corner sales lot may include two adjacent sides provided that a different principal viewing location exists for each side. Luminaires qualifying for this allowance shall be located between the principal viewing location and the frontage outdoor sales area.	No Allowance	No Allowance	~~22.5~~ 15 W/linear ft	~~36~~ 25 W/linear ft	~~45~~ 30 W/linear ft
WATTAGE ALLOWANCE PER HARDSCAPE AREA (W/ft²). May be used for any illuminated hardscape area on the site.					
Hardscape Ornamental Lighting. Allowance for the total site illuminated hardscape area. Luminaires qualifying for this allowance shall be rated for 100 watts or less as determined in accordance with Section 130.0(d), and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	No Allowance	No Allowance	~~0.02~~ 0.015 W/ft²	~~0.04~~ 0.03 W/ft²	~~0.06~~ 0.045 W/ft²
WATTAGE ALLOWANCE PER SPECIFIC AREA (W/ft²). Use as appropriate provided that none of the following specific applications shall be used for the same area.					
Building Facades. Only areas of building façade that are illuminated shall qualify for this allowance. Luminaires qualifying for this allowance shall be aimed at the façade and shall be capable of illuminating it without obstruction or interference by permanent building features or other objects.	No Allowance	No Allowance	~~0.18~~ 0.15 W/ft²	~~0.35~~ 0.25 W/ft²	~~0.50~~ 0.35 W/ft²

Outdoor Sales Lots. Allowance for uncovered sales lots used exclusively for the display of vehicles or other merchandise for sale. Driveways, parking lots or other non-sales areas shall be considered hardscape areas even if these areas are completely surrounded by sales lot on all sides. Luminaires qualifying for this allowance shall be within 5 mounting heights of the sales lot area.	No Allowance	~~0.164~~ 0.100 W/ft²	~~0.555~~ 0.250 W/ft²	~~0.758~~ 0.500 W/ft²	~~1.285~~ 1.000 W/ft²
Vehicle Service Station Hardscape. Allowance for the total illuminated hardscape area less area of buildings, under canopies, off property, or obstructed by signs or structures. Luminaires qualifying for this allowance shall be illuminating the hardscape area and shall not be within a building, below a canopy, beyond property lines, or obstructed by a sign or other structure.	No Allowance	~~0.014~~ 0.010 W/ft²	~~0.155~~ 0.100 W/ft²	~~0.308~~ 0.150 W/ft²	~~0.485~~ 0.200 W/ft²
Vehicle Service Station Canopies. Allowance for the total area within the drip line of the canopy. Luminaires qualifying for this allowance shall be located under the canopy.	No Allowance	~~0.514~~ 0.400 W/ft²	~~1.005~~ 0.700 W/ft²	~~1.300~~ 0.900 W/ft²	~~2.200~~ 1.200 W/ft²
Sales Canopies. Allowance for the total area within the drip line of the canopy. Luminaires qualifying for this allowance shall be located under the canopy.	No Allowance	No Allowance	~~0.655~~ 0.500 W/ft²	~~0.908~~ 0.800 W/ft²	~~1.135~~ 1.000 W/ft²
Non-sales Canopies and Tunnels. Allowance for the total area within the drip line of the canopy or inside the tunnel. Luminaires qualifying for this allowance shall be located under the canopy or tunnel.	No Allowance	~~0.084~~ 0.080 W/ft²	~~0.205~~ 0.160 W/ft²	~~0.408~~ 0.300 W/ft²	~~0.585~~ 0.400 W/ft²
Guard Stations. Allowance up to 1,000 square feet per vehicle lane. Guard stations provide access to secure areas controlled by security personnel who stop and may inspect vehicles and vehicle occupants, including identification, documentation, vehicle license plates, and vehicle contents. Qualifying luminaires shall be within 2 mounting heights of a vehicle lane or the guardhouse.	No Allowance	~~0.154~~ 0.100 W/ft²	~~0.355~~ 0.300 W/ft²	~~0.708~~ 0.500 W/ft²	~~0.985~~ 0.750 W/ft²
Lighting Application	**Lighting Zone 0**	**Lighting Zone 1**	**Lighting Zone 2**	**Lighting Zone 3**	**Lighting Zone 4**
Student Pick-up/Drop-off zone. Allowance for the area of the student pick-up/drop-off zone, with or without canopy, for preschool through 12th grade school campuses. A student pick-up/drop off zone is a curbside, controlled traffic area on a school campus where students are picked-up and dropped off from vehicles. The allowed area shall be the smaller of the actual width or 25 feet, times the smaller of the actual length or 250 feet. Qualifying luminaires shall be within 2 mounting heights of the student pick-up/drop-off zone.	No Allowance	No Allowance	~~0.12~~ 0.10 W/ft²	~~0.45~~ 0.25 W/ft²	No Allowance
Outdoor Dining. Allowance for the total illuminated hardscape of outdoor dining. Outdoor dining areas are hardscape areas used to serve and consume food and beverages. Qualifying luminaires shall be within 2 mounting heights of the hardscape area of outdoor dining.	No Allowance	~~0.014~~ 0.010 W/ft²	~~0.135~~ 0.100 W/ft²	~~0.240~~ 0.150 W/ft²	~~0.400~~ 0.200 W/ft²
Special Security Lighting for Retail Parking and Pedestrian Hardscape. This additional allowance is for illuminated retail parking and pedestrian hardscape identified as having special security needs. This allowance shall be in addition to the building entrance or exit allowance.	No Allowance	~~0.007~~ 0.005 W/ft²	~~0.009~~ 0.007 W/ft²	~~0.019~~ 0.012 W/ft²	No Allowance

Note #1: Lighting Zone 0: *A single luminaire of 15 Watts or less may be installed at the entrance to a parking area, trail head, fee payment kiosk, outhouse, or toilet facility, as required to provide safe navigation of the site infrastructure. Luminaires shall be meet the maximum zonal lumen limits of LZ0 for Uplight and Glare in Tables 130.2-A and 130.2-B to comply with this zone.*

Section 140.6(a)3T will be modified in the following manner:

~~T. Lighting for automatic teller machines that are located inside parking garages.~~

Table 140.6(a)3T will be modified in the following manner:

TABLE 140.6-C AREA CATEGORY METHOD - LIGHTING POWER DENSITY VALUES (WATTS/FT²)

PRIMARY FUNCTION AREA	ALLOWED LIGHTING POWER (W/ft²)	PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER (W/ft²)
Auditorium Area	1.5 [3]	Library Area	Reading areas	1.2 [3]
Auto Repair Area	0.9 [2]		Stack areas	1.5 [3]
Beauty Salon Area	1.7	Lobby Area	Hotel lobby	1.1 [3]
Civic Meeting Place Area	1.3 [3]		Main entry lobby	1.5 [3]

Classroom, Lecture, Training, Vocational Areas	1.2 [5]	Locker/Dressing Room	0.8
Commercial and Industrial Storage Areas (conditioned and unconditioned)	0.6	Lounge Area	1.1 [3]
Commercial and Industrial Storage Areas (refrigerated)	0.7	Malls and Atria	1.2 [3]
Convention, Conference, Multipurpose and Meeting Center Areas	1.4 [3]	Medical and Clinical Care Area	1.2
Corridor, Restroom, Stair, and Support Areas	0.6	Office Area: > 250 square feet	0.75
Dining Area	1.1 [3]	Office Area: ≤ 250 square feet	1.0
Electrical, Mechanical, Telephone Rooms	0.7 [2]	Parking Garage Area: Parking Area[10]	0.14
Exercise Center, Gymnasium Areas	1.0	Parking Garage Area: Dedicated Ramps	0.3
Exhibit, Museum Areas	2.0	Parking Garage Area: Daylight Adaptation Zones [9]	0.6
Financial Transaction Area	1.2 [3]	Religious Worship Area	1.5 [3]
General Commercial and Industrial Work Areas: Low bay	0.9 [2]	Retail Merchandise Sales, Wholesale Showroom Areas	1.2 [6 and 7]
General Commercial and Industrial Work Areas: High bay	1.0 [2]		
General Commercial and Industrial Work Areas: Precision	1.2 [4]	Theater Area: Motion picture	0.9 [3]
Grocery Sales Area	1.2 [6 and 7]	Theater Area: Performance	1.4 [3]
Hotel Function Area	1.5 [3]	Transportation Function Area	1.2
Kitchen, Food Preparation Areas	1.6	Videoconferencing Studio	1.2 [8]
Laboratory Area, Scientific	1.4 [1]	Waiting Area	1.1 [3]
Laundry Area	0.9	All other areas	0.6

Footnotes for this table are listed below.

FOOTNOTES FOR TABLE 140.6-C:

See Section 140.6(c)2 for an explanation of additional lighting power available for specialized task work, ornamental, precision, accent, display, decorative, and white boards and chalk boards, in accordance with the footnotes in this table. The smallest of the added lighting power listed in each footnote below, or the actual design wattage, may be added to the allowed lighting power only when using the Area Category Method of compliance.

Footnote number	Type of lighting system allowed	Maximum allowed added lighting power. (W/ft^2 of task area unless otherwise noted)
1	Specialized task work	0.2 W/ft^2
2	Specialized task work	0.5 W/ft^2
3	Ornamental lighting as defined in Section 100.1 and in accordance with Section 140.6.(c)2.	0.5 W/ft^2
4	Precision commercial and industrial work	1.0 W/ft^2
5	Per linear foot of white board or chalk board.	5.5 W per linear foot
6	Accent, display and feature lighting - luminaires shall be adjustable or directional	0.3 W/ft^2
7	Decorative lighting - primary function shall be decorative and shall be in addition to general illumination.	0.2 W/ft^2
8	Additional Videoconferencing Studio lighting complying with all of the requirements in Section 140.6(c)2Gvii.	1.5 W/ft^2
9	Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage	
10	Additional allowance for ATM locations in Parking Garages. Allowance per ATM	200 watts for first ATM location, 50 watts for each additional ATM location in a group.

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

There are no proposed changes to the compliance manuals.

6.5 Compliance Forms

There are no proposed changes to the compliance forms.

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.[4] When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The Statewide CASE Team used data from CARB's analysis to inform the air quality analysis presented in this report.

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

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

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

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

APPENDIX B: OUTDOOR LIGHTING CALCULATIONS METHODOLOGY

General Hardscape Area Lighting Calculations Rationale

There are a number of issues that make the change to LED as the basis of design more difficult than a simple recalculation of the LPA values based on the efficacy of the LED lamps compared to PSMH lamps. Each of these items will be addressed individually. These factors include:

- The efficacy of the LED products is increasing at a rate of approximately 10% per year.
- The luminaire efficacy (the light source efficacy times the luminaire efficiency) produces a very different result than the raw lamp efficacy.
- LED lumen maintenance is not as straightforward as incumbent technology.
- The light distribution from LED products designed for outdoor hardscape lighting is very different than for incumbent PSMH products.
- The lighting design criteria for parking lots and other outdoor hardscape spaces dictates the LPA results in a manner that is sometimes non-intuitive.

LED Efficacy is Rapidly Improving

LED technology is being pushed rapidly towards higher efficacy values with every new generation of chips introduced to market. The current rate of improvement is in the range of 10% per annum, and this rate of improvement is expected to be maintained for the near future (at least for the next five years or so). Some LED products are improving faster, in particular 'warm' LED chips, which are generally preferred by many in the industry for aesthetic reasons.

They are also strongly preferred by some specifiers because they typically have a lower amount of light in the blue end of the spectrum where there is considerable concern regarding the interruption of human and other species circadian rhythms as a result of melatonin disruption caused by nighttime exposure to light sources rich in blue wavelengths.

As a result, the 'warm' LED chips (generally color temperatures lower than approximately 4100K) are considered preferable for outdoor specifications.

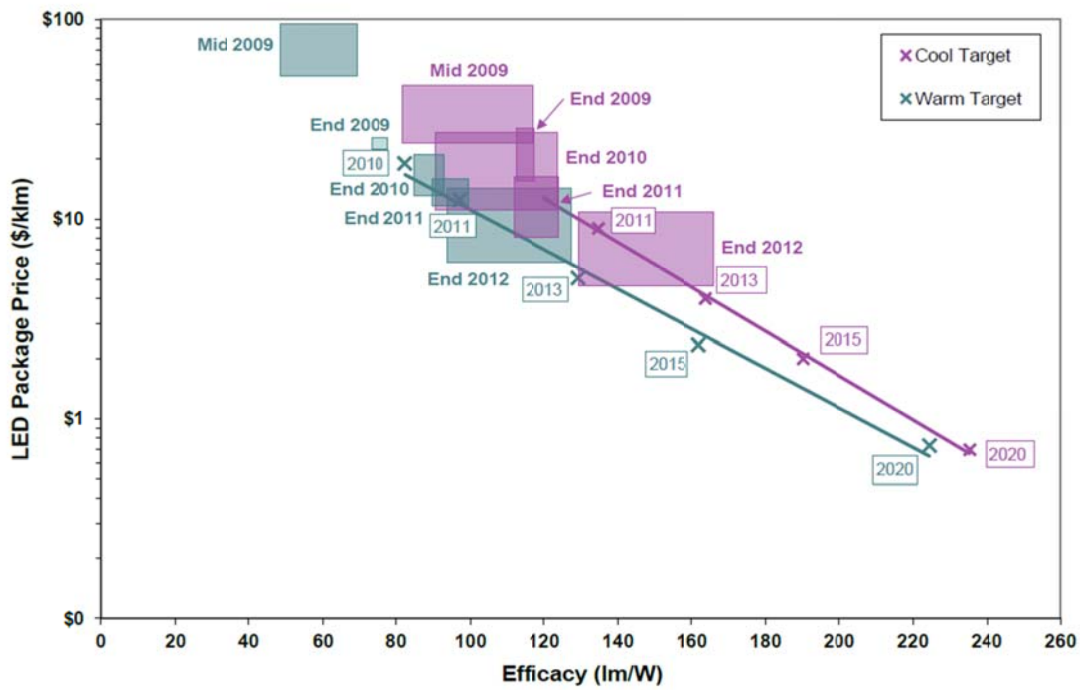
Because the LED chips are improving so rapidly, it is important to set the LPA values based on the performance of the chips that will be available at the time of implementation of the 2106 Title 24 Standards. To set the values based on current (2014) chip efficacy values would result in a table of LPA values that are obsolete by approximately 30% by 2017. As a result, it is important to predict the efficacy of the available lighting equipment in 2017 and establish values based on that expectation of efficacy.

Since the Standards will be in effect for three years (from January 1, 2017 until implementation of the 2019 Title 24 Standards on January 1, 2020), the LPA values will be approximately 30% too high by the end of the expected effective period of the 2016 Standards, even though the LPA values are current at the beginning. This makes it important that the LPA values be continually evaluated and updated at each code cycle to ensure that the values continue to effectively work toward the overall goals of Title 24; to achieve the highest cost effective energy efficiency standards in the United States, and to work toward an achievable Zero Net Energy Goal in 2030 for Nonresidential buildings.

The DOE has produced several LED chip tracking reports in the past, and this information is cited as the primary resource for the projections of LED efficacy as we move forward in time. (DOE 2013)

Figure 1 below, provides a graphic of the projections of LED efficacy for both 'cool' and 'warm' LEDs.

Figure 1: Diagram of LED Chip Efficacy Projections



The information on the graph can be translated into the projections shown in Figure 2, year by year, so that the values can be placed at the appropriate point in time for the Title 24 Standards implementation timeframe.

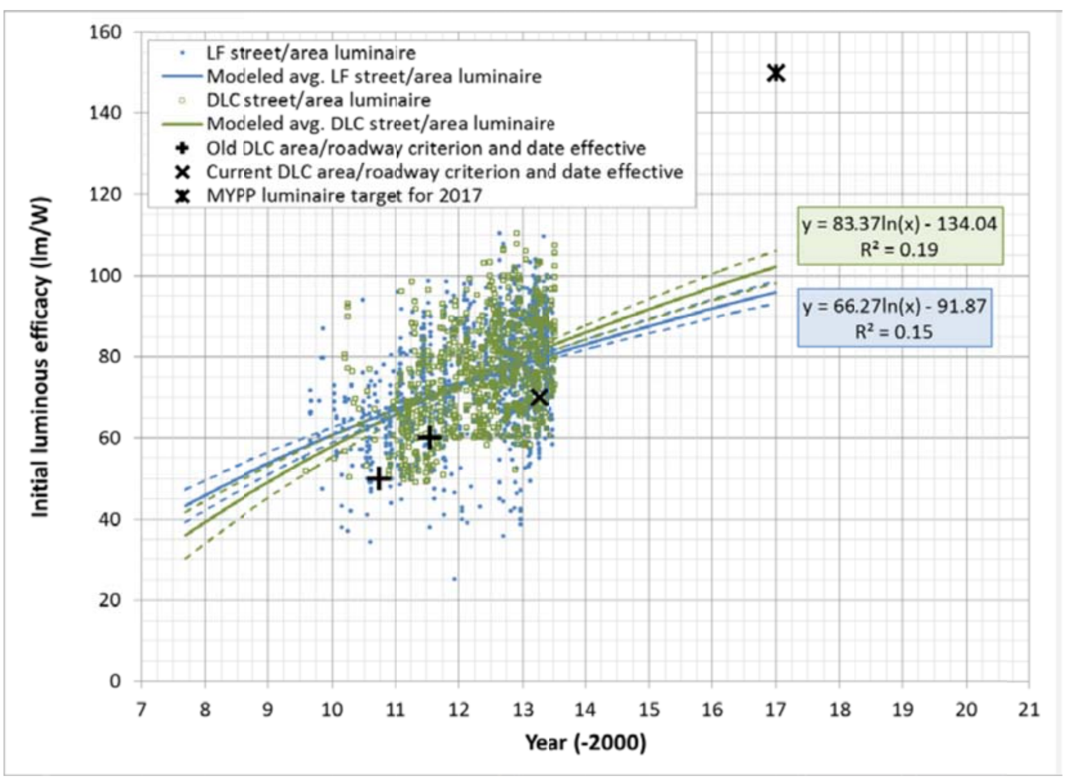
Figure 2: LED Chip Efficacy and Price Projections

Metric	2012	2013	2015	2020	Goal
Cool-White Efficacy (lm/W)	150	164	190	235	266
Cool-White Price ($/klm)	6	4	2	0.7	0.5
Warm-White Efficacy (lm/W)	113	129	162	224	266
Warm-White Price ($/klm)	7.9	5.1	2.3	0.7	0.5

Note: Projections for cool-white packages assume CCT=4746-7040 K and CRI >70, while projections for warm-white packages assume CCT=2580-3710 K and CRI >80. All efficacy projections assume that packages are measured at 25 °C with a drive current density of 35 A/cm^2.

Further, the DOE produced a report in 2013 that provides information on the efficacy of luminaires. The data contained in this report deviates from the chip tracking reports because the luminaires have other variables that impact the total efficacy of the lighting equipment, including the quality of the optical materials used to redirect the light, driver losses, chip board losses, heat rejection, and other factors that all have the possibility to improve with time independent of the LED chip efficacy improvements. Figure 3 below, provides information from the DOE report on specific luminaires, which helps to reinforce the projections that have been made to the year 2017 (PNNL 2013).

Figure 3: Roadway and Area Luminaire Efficacy Projections with 95% Confidence Bands.



As a result, the luminaire efficacy of the products used in the calculations has been adjusted upwards to reflect the 2017 performance of LED products.

Luminaire efficacy is Different from Lamp Efficacy

The introduction of LED light sources in the lighting industry has caused the industry to reset its expectations for the way light is produced and controlled from a luminaire. With incumbent technology (HPS, PSMH, CFL, incandescent, etc.) the light is emitted from the lamp, redirected by reflectors in the luminaire, and delivered to the task location as efficiently as possible. Light from many lamp types is produced in all directions, so a considerable amount of resources is spent to redirect the light that is going in the opposite direction from that desired back toward the task area. This sometimes requires two bounces off a reflector, and then through a coverglass.

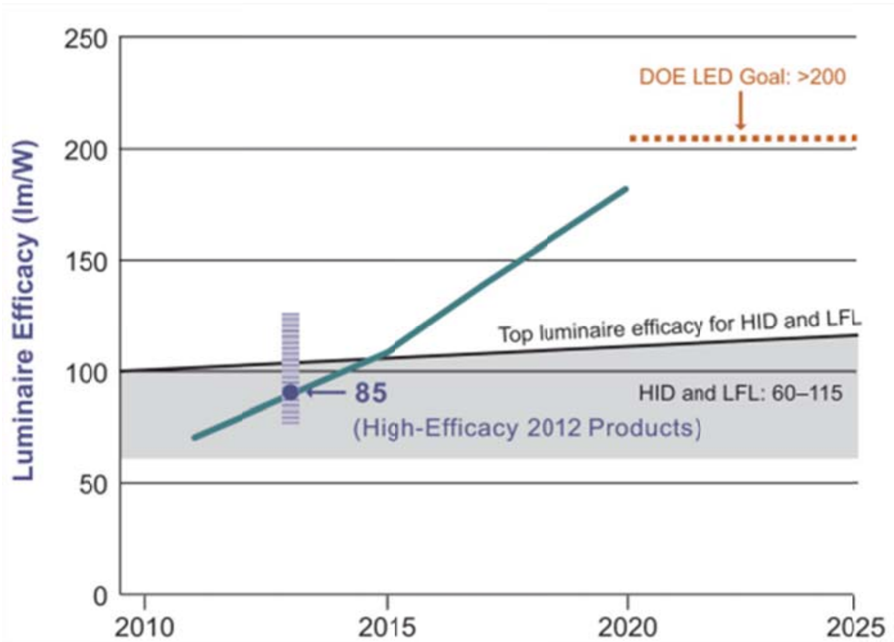
The resultant luminaire efficiency (the percentage of light output compared to the bare lamp output) is often in the 70% range, with many sources as low as about 50%, and very few as high as 80%.

As a result, a comparison of lamp efficacy between PSMH and LED will yield a false picture of the actual performance of the respective light sources. Previously, these differences were minimal when comparing MH to PSMH, for example, because both systems had the same optical limitations to deal with.

While LED lamp efficacy is not expected to exceed PSMH or even CFL lamp efficacy for several more years, the information provided through LED market research indicates that when accounting for the losses associated with the luminaires, LED is now equal to, or better than almost all other light sources available on the market in high quality luminaire products (DOE 2013).

Figure 4 below, provides the DOE projection for LED luminaire efficacy compared to HID and linear fluorescent products, and shows the clear improvement of LED in time, and that projected point where the LED luminaires will have the highest efficacy, which appears to happen in late 2014 or early 2015.

Figure 4: LED Luminaire Efficacy Projections Compared To 'Best in Class' HID and LFL Products



APPENDIX C: OUTDOOR LIGHTING LPA CALCULATIONS RESULTS

General Hardscape Calculations Results

Figure 5: General Hardscape Possible LPA Calculation Results LZ1-1

LZ1 Parking Lot Maximum Spacing Calculations T-24 2016									
							Average:	0.017	
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 0.2fc minimum, 20:1 max:min (vertical illuminance not considered)					
Lamp	2017 Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Max:Min	W/sf
15 Foot Poles									
001	146	1	T3	60	120	2.45	0.30	19.67	0.02028
001	146	1	T4	60	105	2.94	0.47	16.62	0.02317
001	146	1	T5	60	105	1.81	0.31	9.97	0.02317
002	113	1	T3	60	100	1.64	0.20	19.55	0.01883
002	113	1	T4	60	100	1.65	0.28	15.04	0.01883
002	113	1	T5	60	105	1.26	0.20	15.00	0.01794
003	197	1	T3	60	85	3.10	0.44	14.50	0.03863
003	197	1	T4	60	85	3.00	0.43	14.40	0.03863
003	197	1	T5	60	100	1.95	0.34	14.00	0.03283
004	155	1	T3	120	100	1.61	0.33	18.97	0.01292
004	155	1	T4	120	60	2.56	0.45	18.42	0.02153
004	155	1	T5	120	105	0.92	0.21	16.71	0.0123
001	146	2	T3	60	110	3.32	0.56	15.13	0.04424
001	146	2	T4	60	105	3.60	0.61	17.44	0.04635
002	113	2	T3	60	100	2.66	0.38	18.89	0.03767
002	113	2	T4	60	100	2.53	0.46	17.89	0.03767
003	197	2	T3	60	85	5.00	0.85	14.08	0.07725
003	197	2	T4	60	85	4.85	0.82	14.16	0.07725
004	155	2	T3	120	100	1.94	0.37	19.00	0.01292
004	155	2	T4	120	75	2.40	0.46	19.70	0.01722
20 Foot Poles									
001	146	1	T3	60	155	1.93	0.21	18.43	0.0157
001	146	1	T4	60	145	2.03	0.27	17.74	0.01678
001	146	1	T5	60	140	1.28	0.25	8.60	0.01738
002	113	1	T3	60	120	1.35	0.42	5.26	0.01569
002	113	1	T4	60	125	1.27	0.27	9.37	0.01507
002	113	1	T5	60	135	0.93	0.21	9.76	0.01395
003	197	1	T3	60	110	2.32	0.27	13.19	0.02985
003	197	1	T4	60	115	2.20	0.20	17.60	0.02855
003	197	1	T5	60	125	1.58	0.27	12.04	0.02627
004	155	1	T3	120	165	0.94	0.21	19.71	0.00783
004	155	1	T4	120	90	1.97	0.27	19.74	0.01435
004	155	1	T5	120	145	0.69	0.20	10.05	0.00891
001	146	2	T3	60	150	2.40	0.34	16.24	0.03244
001	146	2	T4	120	140	1.29	0.30	17.57	0.01738
002	113	2	T3	60	130	2.01	0.22	17.95	0.02897
002	113	2	T4	120	120	1.07	0.37	13.32	0.01569
003	197	2	T3	60	120	3.40	0.34	19.15	0.05472
003	197	2	T4	60	120	3.30	0.33	19.12	0.05472
004	155	2	T3	120	170	1.13	0.22	19.05	0.0152
004	155	2	T4	120	100	1.88	0.29	18.07	0.02583

Figure 6: General Hardscape Possible LPA Calculation Results LZ1-2

LZ1 Parking Lot Maximum Spacing Calculations T-24 2016									
								Average:	0.017
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 0.2fc minimum, 20:1 max:min (vertical illuminance not considered)					
Lamp	2017 Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Max:Min	W/sf
25 Foot Poles									
001	146	1	T3	60	185	1.57	0.23	12.26	0.01315
001	146	1	T4	60	180	1.45	0.24	12.58	0.01352
001	146	1	T5	60	170	0.95	0.23	6.09	0.01431
002	113	1	T3	60	155	1.03	0.23	7.70	0.01215
002	113	1	T4	60	150	0.94	0.22	7.64	0.01256
002	113	1	T5	60	165	0.68	0.21	6.57	0.01141
003	197	1	T3	60	140	1.79	0.33	8.82	0.02345
003	197	1	T4	60	140	1.74	0.32	8.81	0.02345
003	197	1	T5	60	155	1.17	0.20	11.30	0.02118
004	155	1	T3	120	190	0.83	0.20	13.10	0.0068
004	155	1	T4	120	115	1.57	0.20	19.65	0.01123
004	155	1	T5	120	170	0.57	0.20	6.95	0.0076
001	146	2	T3	60	195	1.85	0.23	19.22	0.02496
001	146	2	T4	120	170	1.07	0.22	16.86	0.01431
002	113	2	T3	60	165	1.57	0.21	14.48	0.02283
002	113	2	T4	120	150	0.85	0.21	15.19	0.01256
003	197	2	T3	60	145	2.83	0.32	15.34	0.04529
003	197	2	T4	120	140	1.42	0.24	17.04	0.02345
004	155	2	T3	120	210	0.91	0.22	12.91	0.0123
004	155	2	T4	120	130	1.43	0.21	18.29	0.01987
30 Foot Poles									
001	146	1	T3	60	220	1.22	0.21	10.43	0.01106
001	146	1	T4	60	210	1.13	0.21	11.05	0.01159
001	146	1	T5	60	200	0.72	0.22	4.64	0.01217
002	113	1	T3	60	185	0.80	0.20	6.80	0.01018
002	113	1	T4	60	175	0.79	0.21	6.71	0.01076
002	113	1	T5	60	190	0.52	0.23	4.30	0.00991
003	197	1	T3	60	170	1.40	0.21	10.71	0.01931
003	197	1	T4	60	170	1.36	0.20	10.38	0.01931
003	197	1	T5	60	180	0.89	0.26	6.27	0.01824
004	155	1	T3	120	210	0.74	0.21	10.19	0.00615
004	155	1	T4	120	130	1.31	0.21	14.48	0.00994
004	155	1	T5	120	190	0.50	0.20	4.80	0.0068
001	146	2	T3	60	230	1.44	0.20	16.85	0.02116
001	146	2	T4	120	200	0.91	0.21	13.43	0.01217
002	113	2	T3	60	190	1.27	0.22	10.82	0.01982
002	113	2	T4	120	175	0.74	0.22	9.95	0.01076
003	197	2	T3	60	180	2.15	0.23	16.61	0.03648
003	197	2	T4	120	165	1.22	0.23	12.78	0.0199
004	155	2	T3	120	245	0.78	0.21	11.81	0.01054
004	155	2	T4	120	150	1.21	0.20	15.70	0.01722

Figure 7: General Hardscape Possible LPA Calculation Results LZ1-3

LZ1 Parking Lot Maximum Spacing Calculations T-24 2016									
								Average:	0.017
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 0.2fc minimum, 20:1 max:min (vertical illuminance not considered)					
Lamp	2017 Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Max:Min	W/sf
35 Foot Poles									
001	146	1	T3	60	250	0.99	0.20	8.90	0.00973
001	146	1	T4	60	235	0.92	0.21	8.95	0.01035
001	146	1	T5	60	225	0.56	0.21	3.76	0.01081
002	113	1	T3	60	205	0.66	0.25	4.56	0.00919
002	113	1	T4	60	195	0.65	0.22	5.32	0.00966
002	113	1	T5	60	220	0.41	0.20	3.80	0.00856
003	197	1	T3	60	195	1.15	0.20	9.55	0.01684
003	197	1	T4	60	195	1.12	0.20	9.30	0.01684
003	197	1	T5	60	205	0.73	0.25	5.20	0.01602
004	155	1	T3	120	230	0.66	0.21	7.52	0.00562
004	155	1	T4	120	150	1.09	0.20	12.30	0.00861
004	155	1	T5	120	205	0.45	0.21	3.67	0.0063
001	146	2	T3	60	260	1.19	0.20	13.80	0.01872
001	146	2	T4	120	225	0.82	0.21	10.81	0.01081
002	113	2	T3	60	220	1.03	0.20	9.80	0.01712
002	113	2	T4	120	200	0.62	0.24	6.71	0.00942
003	197	2	T3	60	200	1.83	0.27	11.85	0.03283
003	197	2	T4	120	185	1.09	0.27	8.26	0.01775
004	155	2	T3	120	270	0.64	0.20	8.45	0.00957
004	155	2	T4	120	160	1.09	0.20	13.7	0.01615

Figure 8: General Hardscape Possible LPA Calculation Results LZ2-1

LZ2 Parking Lot Maximum Spacing Calculations T-24 2016										
									Average:	0.018
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 .2fc minimum horizontal, .1fc minimum vertical at center, 20:1 max:min						
Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
20 Foot Poles										
001	146	1	T3	60	155	1.93	0.21	0.13	18.43	0.0157
001	146	1	T4	60	145	2.03	0.27	0.13	17.74	0.01678
001	146	1	T5	60	125	1.42	0.54	0.10	3.98	0.01947
002	113	1	T3	60	115	1.43	0.49	0.13	4.57	0.01638
002	113	1	T4	60	115	1.38	0.52	0.12	4.87	0.01638
002	113	1	T5	60	115	1.08	0.63	0.12	3.25	0.01638
003	197	1	T3	60	110	2.32	0.27	0.10	13.19	0.02985
003	197	1	T4	60	105	2.40	0.59	0.13	5.97	0.03127
003	197	1	T5	60	110	1.83	0.94	0.13	3.39	0.02985
004	155	1	T3	120	165	0.94	0.21	0.15	19.71	0.00783
004	155	1	T4	120	90	1.97	0.27	0.67	19.74	0.01435
004	155	1	T5	120	145	0.69	0.20	0.18	10.05	0.00891
001	146	2	T3	60	150	2.40	0.34	0.23	16.24	0.03244
001	146	2	T4	120	140	1.29	0.30	0.20	17.57	0.01738
002	113	2	T3	60	125	2.14	0.35	0.10	11.29	0.03013
002	113	2	T4	120	120	1.07	0.37	0.11	13.32	0.01569
003	197	2	T3	60	115	3.64	0.40	0.12	17.00	0.0571
003	197	2	T4	60	115	3.54	0.39	0.12	16.90	0.0571
004	155	2	T3	120	170	1.13	0.22	0.18	19.05	0.0152
004	155	2	T4	120	100	1.88	0.29	0.69	18.07	0.02583
25 Foot Poles										
001	146	1	T3	60	185	1.57	0.23	0.10	12.26	0.01315
001	146	1	T4	60	165	1.62	0.41	0.12	7.66	0.01475
001	146	1	T5	60	155	1.07	0.44	0.10	3.18	0.0157
002	113	1	T3	60	140	1.12	0.59	0.12	2.95	0.01345
002	113	1	T4	60	135	1.07	0.54	0.11	3.19	0.01395
002	113	1	T5	60	145	0.77	0.46	0.11	3.00	0.01299
003	197	1	T3	60	130	1.93	0.54	0.11	5.39	0.02526
003	197	1	T4	60	130	1.87	0.53	0.11	5.32	0.02526
003	197	1	T5	60	135	1.33	0.74	0.11	3.05	0.02432
004	155	1	T3	120	190	0.73	0.20	0.18	13.10	0.0068
004	155	1	T4	120	115	1.57	0.20	0.82	19.65	0.01123
004	155	1	T5	120	170	0.57	0.20	0.18	6.95	0.0076
001	146	2	T3	60	195	1.85	0.23	0.11	19.22	0.02496
001	146	2	T4	120	170	1.07	0.22	0.23	16.86	0.01431
002	113	2	T3	60	150	1.80	0.46	0.11	6.54	0.02511
002	113	2	T4	120	150	0.85	0.21	0.12	15.19	0.01256
003	197	2	T3	60	140	2.88	0.56	0.10	8.71	0.0469
003	197	2	T4	120	125	1.57	0.41	0.11	9.98	0.02627
004	155	2	T3	120	210	0.91	0.22	0.16	12.91	0.0123
004	155	2	T4	120	130	1.43	0.21	0.66	18.29	0.01987

Figure 9: General Hardscape Possible LPA Calculation Results LZ2-2

LZ2 Parking Lot Maximum Spacing Calculations T-24 2016										
									Average:	0.018
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 .2fc minimum horizontal, .1fc minimum vertical at center, 20:1 max:min						
Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
30 Foot Poles										
001	146	1	T3	60	205	1.32	0.33	0.12	6.76	0.01187
001	146	1	T4	60	195	1.25	0.41	0.11	5.66	0.01248
001	146	1	T5	60	175	0.82	0.47	0.11	2.23	0.0139
002	113	1	T3	60	165	0.89	0.55	0.11	2.47	0.01141
002	113	1	T4	60	155	0.86	0.52	0.11	2.71	0.01215
002	113	1	T5	60	170	0.59	0.35	0.11	2.83	0.01108
003	197	1	T3	60	150	1.59	0.72	0.10	3.13	0.02189
003	197	1	T4	60	145	1.61	0.91	0.14	2.40	0.02264
003	197	1	T5	60	160	1.00	0.60	0.13	2.72	0.02052
004	155	1	T3	120	210	0.74	0.21	0.21	10.19	0.00615
004	155	1	T4	120	130	1.31	0.21	0.79	14.48	0.00994
004	155	1	T5	120	190	0.50	0.20	0.17	4.80	0.0068
001	146	2	T3	60	210	1.58	0.36	0.12	9.39	0.02317
001	146	2	T4	120	200	0.91	0.21	0.19	13.43	0.01217
002	113	2	T3	60	170	1.41	0.67	0.12	3.55	0.02216
002	113	2	T4	120	175	0.74	0.22	0.11	9.95	0.01076
003	197	2	T3	60	160	2.42	0.73	0.11	5.23	0.04104
003	197	2	T4	120	165	1.22	0.23	0.10	12.78	0.0199
004	155	2	T3	120	245	0.78	0.21	0.14	11.81	0.01054
004	155	2	T4	120	150	1.21	0.2	0.55	15.7	0.01722
35 Foot Poles										
001	146	1	T3	60	230	1.07	0.34	0.11	5.24	0.01058
001	146	1	T4	60	210	1.01	0.42	0.11	4.48	0.01159
001	146	1	T5	60	200	0.63	0.42	0.10	1.83	0.01217
002	113	1	T3	60	185	0.73	0.53	0.11	2.15	0.01018
002	113	1	T4	60	175	0.70	0.46	0.11	2.54	0.01076
002	113	1	T5	60	195	0.47	0.28	0.10	2.75	0.00966
003	197	1	T3	60	170	1.30	0.76	0.14	2.51	0.01931
003	197	1	T4	60	170	1.26	0.74	0.13	2.50	0.01931
003	197	1	T5	60	185	0.80	0.48	0.10	2.71	0.01775
004	155	1	T3	120	230	0.66	0.21	0.22	7.52	0.00562
004	155	1	T4	120	150	1.09	0.20	0.65	12.30	0.00861
004	155	1	T5	120	205	0.45	0.21	0.16	3.67	0.0063
001	146	2	T3	60	235	1.33	0.38	0.11	7.26	0.02071
001	146	2	T4	120	225	0.82	0.21	0.18	10.81	0.01081
002	113	2	T3	60	190	1.19	0.70	0.13	2.81	0.01982
002	113	2	T4	120	200	0.62	0.24	0.11	6.71	0.00942
003	197	2	T3	60	175	2.11	0.93	0.14	3.47	0.03752
003	197	2	T4	120	185	1.09	0.27	0.14	8.26	0.01775
004	155	2	T3	120	270	0.68	0.20	0.14	8.45	0.00957
004	155	2	T4	120	160	1.09	0.22	0.54	11.86	0.01615

Figure 10: General Hardscape Possible LPA Calculation Results LZ3-1

LZ3 Parking Lot Maximum Spacing Calculations T-24 2016

Average: 0.019

Yellow is the limiting factor

Maximum Spacing to meet IESNA RP-20 Enhanced Security Guidelines

.5fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min

Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
20 Foot Poles										
001	146	1	T3	60	135	2.21	0.58	0.27	6.67	0.01802
001	146	1	T4	60	125	2.34	0.73	0.28	6.56	0.01947
001	146	1	T5	60	115	1.57	0.85	0.27	2.53	0.02116
002	113	1	T3	60	105	1.56	1.05	0.36	2.13	0.01794
002	113	1	T4	60	100	1.54	1.11	0.33	2.28	0.01883
002	113	1	T5	60	105	1.18	0.81	0.31	2.53	0.01794
003	197	1	T3	60	95	2.72	1.61	0.26	2.26	0.03456
003	197	1	T4	60	95	2.64	1.56	0.25	2.26	0.03456
003	197	1	T5	60	95	2.05	1.38	0.31	2.36	0.03456
004	155	1	T3	120	115	1.42	0.51	0.45	9.82	0.01123
004	155	1	T4	120	70	2.48	0.50	0.92	10.80	0.01845
004	155	1	T5	120	90	1.07	0.50	0.39	3.88	0.01435
005	187	1	T3	60	140	3.19	0.62	0.32	9.69	0.02226
005	187	1	T4	120	115	2.07	0.53	0.56	10.75	0.01355
005	187	1	T5	60	105	2.88	1.19	0.27	3.60	0.02968
001	146	2	T3	60	140	2.57	0.59	0.32	9.37	0.03476
001	146	2	T4	120	120	1.50	0.52	0.29	10.15	0.02028
002	113	2	T3	60	110	2.38	1.26	0.31	3.13	0.03424
002	113	2	T4	60	110	2.21	0.99	0.25	5.29	0.03424
003	197	2	T3	60	100	4.08	2.16	0.28	3.01	0.06567
003	197	2	T4	60	100	3.96	2.10	0.28	3.01	0.06567
004	155	1	T3	120	120	1.58	0.54	0.51	7.83	0.01076
004	155	1	T4	120	75	2.55	0.55	0.93	11.85	0.01722
005	187	1	T3	60	145	4.01	0.64	0.29	14.25	0.02149
005	187	1	T4	120	120	2.36	0.54	0.55	14.24	0.01299
25 Foot Poles										
001	146	1	T3	60	160	1.77	0.61	0.27	4.46	0.01521
001	146	1	T4	60	150	1.74	0.69	0.28	4.39	0.01622
001	146	1	T5	60	140	1.16	0.73	0.27	1.92	0.01738
002	113	1	T3	60	130	1.20	0.90	0.26	1.93	0.01449
002	113	1	T4	60	120	1.18	0.86	0.29	1.97	0.01569
002	113	1	T5	60	130	0.84	0.59	0.32	2.31	0.01449
003	197	1	T3	60	120	2.09	1.26	0.25	2.31	0.02736
003	197	1	T4	60	115	2.13	1.49	0.35	1.91	0.02855
003	197	1	T5	60	125	1.38	0.93	0.29	2.41	0.02627
004	155	1	T3	120	145	1.11	0.50	0.45	5.98	0.00891
004	155	1	T4	120	75	2.18	0.51	1.29	7.31	0.01722
004	155	1	T5	120	120	0.80	0.51	0.50	2.80	0.01076
005	187	1	T3	60	195	2.57	0.54	0.28	10.15	0.01598
005	187	1	T4	120	135	1.76	0.52	0.70	7.42	0.01154
005	187	1	T5	120	130	1.16	0.55	0.26	4.58	0.01199
001	146	2	T3	60	165	2.17	0.63	0.27	7.02	0.02949
001	146	2	T4	120	145	1.28	0.54	0.41	7.17	0.01678
002	113	2	T3	60	135	1.91	1.17	0.28	2.60	0.0279
002	113	2	T4	120	135	0.96	0.52	0.25	6.13	0.01395
003	197	2	T3	60	130	3.10	0.89	0.29	5.48	0.05051
003	197	2	T4	60	125	3.17	1.29	0.25	3.70	0.05253
004	155	1	T3	120	150	1.26	0.52	0.47	5.52	0.00861
004	155	1	T4	120	85	2.18	0.51	1.20	8.49	0.0152
005	187	1	T3	120	150	1.91	0.50	0.26	11.20	0.01039
005	187	1	T4	120	140	2.03	0.55	0.63	10.33	0.01113

Figure 11: General Hardscape Possible LPA Calculation Results LZ3-2

LZ3 Parking Lot Maximum Spacing Calculations T-24 2016

Average: 0.019

Yellow is the limiting factor

Maximum Spacing to meet IESNA RP-20 Enhanced Security Guidelines

.5fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min

Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
30 Foot Poles										
001	146	1	T3	60	185	1.46	0.59	0.26	3.78	0.01315
001	146	1	T4	60	170	1.39	0.69	0.26	3.36	0.01431
001	146	1	T5	60	160	0.89	0.68	0.27	1.50	0.01521
002	113	1	T3	60	150	0.97	0.74	0.31	1.82	0.01256
002	113	1	T4	60	140	0.93	0.65	0.27	2.12	0.01345
002	113	1	T5	60	145	0.69	0.52	0.34	1.94	0.01299
003	197	1	T3	60	140	1.70	1.26	0.27	1.79	0.02345
003	197	1	T4	60	140	1.65	1.22	0.26	1.79	0.02345
003	197	1	T5	60	145	1.12	0.75	0.30	2.19	0.02264
004	155	1	T3	120	165	0.95	0.51	0.44	4.71	0.00783
004	155	1	T4	120	80	2.02	0.54	1.47	5.93	0.01615
004	155	1	T5	120	135	0.69	0.51	0.47	2.04	0.00957
005	187	1	T3	60	195	2.17	0.54	0.27	8.37	0.01598
005	187	1	T4	120	145	1.51	0.54	0.61	5.28	0.01075
005	187	1	T5	120	150	1.00	0.50	0.35	3.62	0.01039
001	146	2	T3	60	190	1.74	0.64	0.25	5.28	0.02561
001	146	2	T4	120	165	1.12	0.51	0.49	5.63	0.01475
002	113	2	T3	60	155	1.57	1.04	0.32	2.32	0.0243
002	113	2	T4	120	140	0.90	0.51	0.56	4.31	0.01345
003	197	2	T3	60	140	2.76	1.99	0.38	1.92	0.0469
003	197	2	T4	120	135	1.48	0.80	0.30	3.68	0.02432
004	155	1	T3	120	175	1.08	0.52	0.43	4.81	0.00738
004	155	1	T4	120	95	1.89	0.51	1.34	6.98	0.0136
005	187	1	T3	120	190	1.50	0.52	0.27	7.83	0.0082
005	187	1	T4	120	160	1.75	0.59	0.54	7.53	0.00974
35 Foot Poles										
001	146	1	T3	60	205	1.21	0.61	0.25	2.93	0.01187
001	146	1	T4	60	185	1.16	0.71	0.28	2.65	0.01315
001	146	1	T5	60	175	0.72	0.66	0.28	1.20	0.0139
002	113	1	T3	60	170	0.79	0.60	0.27	1.90	0.01108
002	113	1	T4	60	155	0.79	0.54	0.29	2.17	0.01215
002	113	1	T5	60	145	0.63	0.51	0.30	1.53	0.01299
003	197	1	T3	60	160	1.38	1.12	0.28	1.71	0.02052
003	197	1	T4	60	160	1.34	1.09	0.27	1.70	0.02052
003	197	1	T5	60	165	0.90	0.61	0.29	2.13	0.0199
004	155	1	T3	120	165	0.92	0.51	0.51	3.35	0.00783
004	155	1	T4	120	90	1.72	0.53	1.49	5.00	0.01435
004	155	1	T5	120	135	0.66	0.50	0.53	1.66	0.00957
005	187	1	T3	120	190	1.18	0.53	0.47	3.58	0.0082
005	187	1	T4	120	175	1.29	0.54	0.48	4.31	0.0089
005	187	1	T5	120	165	0.91	0.51	0.42	2.80	0.00944
001	146	2	T3	60	205	1.52	0.74	0.28	3.73	0.02374
001	146	2	T4	120	180	1.00	0.54	0.53	4.13	0.01352
002	113	2	T3	60	175	1.30	0.90	0.30	2.19	0.02152
002	113	2	T4	120	150	0.83	0.52	0.60	3.12	0.01256
003	197	2	T3	60	165	2.23	1.45	0.29	2.23	0.0398
003	197	2	T4	120	175	1.15	0.50	0.25	4.46	0.01876
004	155	1	T3	120	200	0.91	0.51	0.38	3.35	0.00646
004	155	1	T4	120	105	1.62	0.53	1.4	5.34	0.0123
005	187	1	T3	120	210	1.35	0.52	0.35	5.98	0.00742
005	187	1	T4	120	185	1.51	0.51	0.39	7.57	0.00842

Figure 12: General Hardscape Possible LPA Calculation Results LZ3-3

LZ3 Parking Lot Maximum Spacing Calculations T-24 2016										
									Average:	0.019
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 Enhanced Security Guidelines .5fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min						
Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
40 Foot Poles										
001	146	1	T3	120	195	0.75	0.51	0.49	1.98	0.00624
001	146	1	T4	120	185	0.76	0.52	0.55	2.19	0.00658
001	146	1	T5	120	115	0.73	0.51	0.85	1.78	0.01058
002	113	1	T3	120	120	0.65	0.52	0.55	1.42	0.00785
002	113	1	T4	120	110	0.68	0.53	0.50	1.62	0.00856
002	113	1	T5	120	70	0.63	0.51	0.3	1.41	0.01345
003	197	1	T3	120	180	0.71	0.56	0.42	1.70	0.00912
003	197	1	T4	120	180	0.67	0.54	0.41	1.70	0.00912
003	197	1	T5	120	150	0.63	0.52	0.60	1.56	0.01094
004	155	1	T3	120	155	0.90	0.51	0.62	2.88	0.00833
004	155	1	T4	120	100	1.747	0.53	1.36	4.53	0.01292
004	155	1	T5	120	120	0.7	0.51	0.79	1.90	0.01076
005	187	1	T3	120	205	1.09	0.53	0.52	3.08	0.0076
005	187	1	T4	120	195	1.11	0.52	0.40	3.67	0.00799
005	187	1	T5	120	190	0.82	0.52	0.43	2.15	0.0082
001	146	2	T3	120	115	0.85	0.51	0.39	3.39	0.02116
001	146	2	T4	120	200	0.89	0.50	0.46	3.60	0.01217
002	113	2	T3	120	185	0.71	0.51	0.53	2.12	0.01018
002	113	2	T4	120	160	0.75	0.52	0.50	2.46	0.01177
003	197	2	T3	120	195	1.06	0.51	0.29	3.49	0.01684
003	197	2	T4	120	195	1.02	0.50	0.25	3.44	0.01684
004	155	1	T3	120	220	0.81	0.51	0.35	2.96	0.00587
004	155	1	T4	120	115	1.41	0.52	1.29	4.88	0.01123
005	187	1	T3	120	230	1.22	0.51	0.36	4.88	0.00678
005	187	1	T4	120	205	1.31	0.51	0.34	6.27	0.0076

Figure 13: General Hardscape Possible LPA Calculation Results LZ4-1

LZ4 Parking Lot Maximum Spacing Calculations T-24 2016										
									Average:	0.020
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 Enhanced Security Guidelines 1.0fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min						
Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
30 Foot Poles										
001	146	1	T3	60	160	1.67	1.07	0.59	2.06	0.01521
001	146	1	T4	60	150	1.58	1.04	0.58	2.24	0.01622
001	146	1	T5	60	110	1.29	1.02	1.17	1.72	0.02212
002	113	1	T3	60	120	1.21	1.08	0.87	1.26	0.01569
002	113	1	T4	60	110	1.18	1.06	0.79	1.31	0.01712
002	113	1	T5	60	80	1.14	1.02	0.71	1.25	0.02354
003	197	1	T3	60	140	1.70	1.26	0.27	1.79	0.02345
003	197	1	T4	60	140	1.65	1.22	0.26	1.79	0.02345
003	197	1	T5	60	125	1.29	1.05	0.77	1.57	0.02627
004	155	1	T3	120	100	1.47	1.04	1.04	2.20	0.01292
004	155	1	T4	60	105	2.30	1.02	1.04	4.84	0.0246
004	155	1	T5	60	110	1.35	1.01	0.75	1.68	0.02348
005	187	1	T3	120	140	1.60	1.01	0.53	2.46	0.01113
005	187	1	T4	120	130	1.76	1.13	1.47	2.46	0.01199
005	187	1	T5	120	125	1.21	1.00	0.89	1.89	0.01247
001	146	2	T3	60	170	1.95	1.03	0.48	3.29	0.02863
001	146	2	T4	120	125	1.43	1.07	1.09	2.66	0.01947
002	113	2	T3	60	155	1.07	1.04	0.32	2.32	0.0243
002	113	2	T4	60	130	1.64	1.02	0.60	2.44	0.02897
003	197	2	T3	60	140	2.76	1.99	0.38	1.92	0.0469
003	197	2	T4	120	80	2.44	1.15	0.63	3.69	0.04104
004	155	1	T3	120	125	1.45	1.06	0.88	2.42	0.01033
004	155	1	T4	120	110	2.28	1.02	0.89	4.74	0.01174
005	187	1	T3	120	150	1.89	1.01	0.58	4.04	0.01039
005	187	1	T4	120	140	2.00	1.06	1.13	4.20	0.01113
35 Foot Poles										
001	146	1	T3	60	175	1.41	1.06	0.58	1.70	0.0139
001	146	1	T4	60	160	1.33	1.03	0.52	1.83	0.01521
001	146	1	T5	60	90	1.27	1.11	0.92	1.24	0.02704
002	113	1	T3	60	100	1.31	1.10	0.71	1.35	0.01883
002	113	1	T4	60	100	1.18	1.00	0.58	1.38	0.01883
002	113	1	T5	60	70	1.04	1.01	0.56	1.05	0.0269
003	197	1	T3	60	160	1.38	1.12	0.28	1.71	0.02052
003	197	1	T4	60	160	1.34	1.09	0.27	1.70	0.02052
003	197	1	T5	60	125	1.17	1.00	0.60	1.32	0.02627
004	155	1	T3	60	160	1.43	1.00	0.50	2.85	0.01615
004	155	1	T4	60	110	1.79	1.02	0.72	3.65	0.02348
004	155	1	T5	60	80	1.50	1.05	1.23	1.83	0.03229
005	187	1	T3	120	160	1.39	1.07	0.78	1.80	0.00974
005	187	1	T4	120	150	1.48	1.01	1.04	2.28	0.01039
005	187	1	T5	120	125	1.19	1.05	1.39	1.66	0.01247
001	146	2	T3	60	190	1.62	1.01	0.43	2.74	0.02561
001	146	2	T4	120	135	1.33	1.01	1.10	2.28	0.01802
002	113	2	T3	60	165	1.38	1.01	0.46	1.96	0.02283
002	113	2	T4	60	135	1.50	1.08	0.61	1.84	0.0279
003	197	2	T3	60	165	2.23	1.45	0.29	2.23	0.0398
003	197	2	T4	120	100	1.96	1.11	1.41	2.66	0.03283
004	155	1	T3	120	135	1.30	1.01	0.88	1.87	0.00957
004	155	1	T4	120	115	1.88	1.04	0.63	3.97	0.01123
005	187	1	T3	120	170	1.66	1.03	0.75	3.04	0.00917
005	187	1	T4	120	155	1.79	1.11	0.95	3.49	0.01005

Figure 14: General Hardscape Possible LPA Calculation Results LZ4-2

LZ4 Parking Lot Maximum Spacing Calculations T-24 2016										
									Average:	0.020
Yellow is the limiting factor				Maximum Spacing to meet IESNA RP-20 Enhanced Security Guidelines 1.0fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min						
Lamp	Luminaire Wattage	# of Heads	Photometric Type	Grid Dimensions		Avg. fc	Min. fc	Vert. fc	Max:Min	W/sf
40 Foot Poles										
001	146	1	T3	60	185	1.21	1.02	0.54	1.42	0.01315
001	146	1	T4	120	80	1.42	1.05	1.05	1.58	0.01521
001	146	1	T5	60	80	1.07	1.03	0.58	1.07	0.03042
002	113	1	T3	60	100	1.15	1.04	0.51	1.24	0.01883
002	113	1	T4	60	85	1.16	1.04	0.48	1.26	0.02216
002	113	1	T5	60	40	1.1	1.05	0.39	1.11	0.04708
003	197	1	T3	120	90	1.31	1.14	0.89	1.29	0.01824
003	197	1	T4	120	90	1.27	1.10	0.86	1.30	0.01824
003	197	1	T5	60	110	1.19	1.01	0.49	1.35	0.02985
004	155	1	T3	60	150	1.36	1.02	0.66	2.16	0.01722
004	155	1	T4	60	105	1.58	1.04	0.57	2.96	0.0246
004	155	1	T5	60	70	1.36	1.04	0.86	1.60	0.0369
005	187	1	T3	120	170	1.3	1.01	0.95	1.64	0.00917
005	187	1	T4	120	160	1.33	1.03	0.83	1.83	0.00974
005	187	1	T5	120	120	1.21	1.01	1.67	1.66	0.01299
001	146	2	T3	120	145	1.22	1.00	1.07	1.76	0.01678
001	146	2	T4	120	135	1.29	1.02	1.08	1.86	0.01802
002	113	2	T3	60	170	1.25	1.03	0.50	1.65	0.02216
002	113	2	T4	60	145	1.15	1.00	0.47	1.72	0.02598
003	197	2	T3	120	130	1.56	1.02	1.29	2.08	0.02526
003	197	2	T4	120	120	1.64	1.05	1.33	2.13	0.02736
004	155	1	T3	120	110	1.43	1.06	1.23	1.68	0.01174
004	155	1	T4	120	110	1.66	1.01	0.51	2.96	0.01174
005	187	1	T3	120	180	1.55	1.05	0.85	2.39	0.00866
005	187	1	T4	120	165	1.61	1.06	0.79	3.03	0.00944

General Hardscape Effective Power Density Calculations Results

Figure 15: General Hardscape Effective LPA Calculation Results

2016 Calculations	
	eAWA
LZ1	0.017
LZ2	0.018
LZ3	0.020
LZ4	0.021
	W/sf

2016 Proposed						
	AWA	LWA	IWA	AWA	LWA	LWA
LZ1	0.020	0.15	340	57%	60%	100%
LZ2	0.030	0.25	420	67%	56%	82%
LZ3	0.040	0.35	520	44%	58%	68%
LZ4	0.050	0.45	640	43%	53%	62%
	W/sf	W/ft	W			

2016 Proposed		
	eAWA - No IWA	eAWA - With IWA
LZ1	0.027	0.037
LZ2	0.041	0.053
LZ3	0.055	0.068
LZ4	0.070	0.089
	W/sf	W/sf

Site Description	A- Long Skinny, Big Building	B-Square, Odd Building	C- Odd, Campus Buildings	D- Long Skinny, Small Square Building	E- Square, Small Building	F- Odd, Long Square Building	G- Long Skinny, Odd Building	H- Square, Large Square Building	J- Odd, Large Odd Building	K- Perfect Square Site, No Building
Area, [sf]	501,626	471,726	42,828	28,500	21,000	61,798	21,797	11,040	34,735	250,000
Perimeter, [sf]	6,794	5,131	3,052	960	760	1,940	1,408	1,042	2,593	2,000
Perimeter to Area Ratio	1.4%	1.1%	7.1%	3.4%	3.6%	3.1%	6.5%	9.4%	7.5%	0.8%

Title 24 - 2016: No IWA

LZ1	AWA	W/sf	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	
		W	10,033	9,435	857	570	420	1,236	436	221	695	5,000	
	LWA	W/lf	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
		W	1,019	770	458	144	114	291	211	156	389	300	
	TOTAL	W	11,052	10,204	1,314	714	534	1,527	647	377	1,084	5,300	Mean
	LPD	W/sf	0.022	0.022	0.031	0.025	0.025	0.025	0.030	0.034	0.031	0.021	0.027
	%W from AWA		90.8%	92.5%	65.2%	79.8%	78.7%	80.9%	67.4%	58.6%	64.1%	94.3%	77.2%
	%W from LWA		9.2%	7.5%	34.8%	20.2%	21.3%	19.1%	32.6%	41.4%	35.9%	5.7%	22.8%

LZ2	AWA	W/sf	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
		W	15,049	14,152	1,285	855	630	1,854	654	331	1,042	7,500	
	LWA	W/lf	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
		W	1,699	1,283	763	240	190	485	352	261	648	500	
	TOTAL	W	16,747	15,435	2,048	1,095	820	2,339	1,006	592	1,690	8,000	Mean
	LPD	W/sf	0.033	0.033	0.048	0.038	0.039	0.038	0.046	0.054	0.049	0.032	0.041
	%W from AWA		89.9%	91.7%	62.7%	78.1%	76.8%	79.3%	65.0%	56.0%	61.6%	93.8%	75.5%
	%W from LWA		10.1%	8.3%	37.3%	21.9%	23.2%	20.7%	35.0%	44.0%	38.4%	6.3%	24.5%

LZ3	AWA	W/sf	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	
		W	20,065	18,869	1,713	1,140	840	2,472	872	442	1,389	10,000	
	LWA	W/lf	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	
		W	2,378	1,796	1,068	336	266	679	493	365	908	700	
	TOTAL	W	22,443	20,665	2,781	1,476	1,106	3,151	1,365	806	2,297	10,700	Mean
	LPD	W/sf	0.045	0.044	0.065	0.052	0.053	0.051	0.063	0.073	0.066	0.043	0.055
	%W from AWA		89.4%	91.3%	61.6%	77.2%	75.9%	78.5%	63.9%	54.8%	60.5%	93.5%	74.7%
	%W from LWA		10.6%	8.7%	38.4%	22.8%	24.1%	21.5%	36.1%	45.2%	39.5%	6.5%	25.3%

LZ4	AWA	W/sf	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	
		W	25,081	23,586	2,141	1,425	1,050	3,090	1,090	552	1,737	12,500	
	LWA	W/lf	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
		W	3,057	2,309	1,373	432	342	873	634	469	1,167	900	
	TOTAL	W	28,139	25,895	3,515	1,857	1,392	3,963	1,723	1,021	2,904	13,400	Mean
	LPD	W/sf	0.056	0.055	0.082	0.065	0.066	0.064	0.079	0.092	0.084	0.054	0.070
	%W from AWA		89.1%	91.1%	60.9%	76.7%	75.4%	78.0%	63.2%	54.1%	59.8%	93.3%	74.2%
	%W from LWA		10.9%	8.9%	39.1%	23.3%	24.6%	22.0%	36.8%	45.9%	40.2%	6.7%	25.8%

Title 24 - 2016: With IWA

LZ1	AWA	W/sf	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	
		W	10,033	9,435	857	570	420	1,236	436	221	695	5,000	
	LWA	W/lf	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
		W	1,019	770	458	144	114	291	211	156	389	300	
	IWA	W	340	340	340	340	340	340	340	340	340	340	
	TOTAL	W	11,392	10,544	1,654	1,054	874	1,867	987	717	1,424	5,640	Mean
	LPD	W/sf	0.023	0.022	0.039	0.037	0.042	0.030	0.045	0.065	0.041	0.023	0.037
	%W from AWA		88.1%	89.5%	51.8%	54.1%	48.1%	66.2%	44.2%	30.8%	48.8%	88.7%	61.0%
	%W from LWA		8.9%	7.3%	27.7%	13.7%	13.0%	15.6%	21.4%	21.8%	27.3%	5.3%	16.2%
	%W from IWA		3.0%	3.2%	20.6%	32.3%	38.9%	18.2%	34.4%	47.4%	23.9%	6.0%	22.8%

LZ2	AWA	W/sf	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
		W	15,049	14,152	1,285	855	630	1,854	654	331	1,042	7,500	
	LWA	W/lf	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
		W	1,699	1,283	763	240	190	485	352	261	648	500	
	IWA	W	420	420	420	420	420	420	420	420	420	420	
	TOTAL	W	17,167	15,855	2,468	1,515	1,240	2,759	1,426	1,012	2,110	8,420	Mean
	LPD	W/sf	0.034	0.034	0.058	0.053	0.059	0.045	0.065	0.092	0.061	0.034	0.053
	%W from AWA		87.7%	89.3%	52.1%	56.4%	50.8%	67.2%	45.9%	32.7%	49.4%	89.1%	62.0%
	%W from LWA		9.9%	8.1%	30.9%	15.8%	15.3%	17.6%	24.7%	25.7%	30.7%	5.9%	18.5%
	%W from IWA		2.4%	2.6%	17.0%	27.7%	33.9%	15.2%	29.5%	41.5%	19.9%	5.0%	19.5%

Figure 15: General Hardscape Effective LPA Calculation Results (continued)

LZ3	AWA	W/sf	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	
		W	25,081	23,586	2,141	1,425	1,050	3,090	1,090	552	1,737	12,500	
	LWA	W/lf	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
		W	340	257	153	48	38	97	70	52	130	100	
	IWA	W	520	520	520	520	520	520	520	520	520	520	
	TOTAL	W	25,941	24,363	2,814	1,993	1,608	3,707	1,680	1,124	2,386	13,120	Mean
	LPD	W/sf	0.052	0.052	0.066	0.070	0.077	0.060	0.077	0.102	0.069	0.052	0.068
	%W from AWA		96.7%	96.8%	76.1%	71.5%	65.3%	83.4%	64.9%	49.1%	72.8%	95.3%	77.2%
	%W from LWA		1.3%	1.1%	5.4%	2.4%	2.4%	2.6%	4.2%	4.6%	5.4%	0.8%	3.0%
	%W from IWA		2.0%	2.1%	18.5%	26.1%	32.3%	14.0%	30.9%	46.3%	21.8%	4.0%	19.8%

LZ4	AWA	W/sf	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	
		W	25,081	23,586	2,141	1,425	1,050	3,090	1,090	552	1,737	12,500	
	LWA	W/lf	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
		W	3,057	2,309	1,373	432	342	873	634	469	1,167	900	
	IWA	W	640	640	640	640	640	640	640	640	640	640	
	TOTAL	W	28,779	26,535	4,155	2,497	2,032	4,603	2,363	1,661	3,544	14,040	Mean
	LPD	W/sf	0.057	0.056	0.097	0.088	0.097	0.074	0.108	0.150	0.102	0.056	0.089
	%W from AWA		87.2%	88.9%	51.5%	57.1%	51.7%	67.1%	46.1%	33.2%	49.0%	89.0%	62.1%
	%W from LWA		10.6%	8.7%	33.1%	17.3%	16.8%	19.0%	26.8%	28.2%	32.9%	6.4%	20.0%
	%W from IWA		2.2%	2.4%	15.4%	25.6%	31.5%	13.9%	27.1%	38.5%	18.1%	4.6%	17.9%

Figure 16: General Hardscape Effective Watts Per Square Foot LPA Adjustment Results based on Nine Prototype Properties

Site Description	A- Long Skinny, Big Building	B-Square, Odd Building	C- Odd, Campus Buildings	D- Long Skinny, Small Square Building	E- Square, Small Building	F- Odd, Long Square Building	G- Long Skinny, Odd Building	H- Square, Large Square Building	J- Odd, Large Odd Building	K- Perfect Square Site, No Building	Average
Area, [sf]	501,626	471,726	42,828	28,500	21,000	61,798	21,797	11,040	34,735	250,000	
Perimeter, [sf]	6,794	5,131	3,052	960	760	1,940	1,408	1,042	2,593	2,000	
Perimeter to Area Ratio	1.4%	1.1%	7.1%	3.4%	3.6%	3.1%	6.5%	9.4%	7.5%	0.8%	
Title 24 - 2013											
LZ1	0.038	0.038	0.053	0.043	0.044	0.043	0.051	0.059	0.054	0.037	0.046
LZ2	0.051	0.050	0.077	0.060	0.061	0.059	0.074	0.087	0.079	0.049	0.065
LZ3	0.098	0.097	0.133	0.110	0.112	0.109	0.129	0.147	0.135	0.095	0.116
LZ4	0.127	0.124	0.176	0.144	0.146	0.142	0.170	0.195	0.178	0.122	0.152
Title 24 - 2016											
LZ1	0.022	0.022	0.031	0.025	0.025	0.025	0.030	0.034	0.031	0.021	0.027
LZ2	0.033	0.033	0.048	0.038	0.039	0.038	0.046	0.054	0.049	0.032	0.041
LZ3	0.045	0.044	0.065	0.052	0.053	0.051	0.063	0.073	0.066	0.043	0.055
LZ4	0.056	0.055	0.082	0.065	0.066	0.064	0.079	0.092	0.084	0.054	0.070

Building Entrances Calculations Results

Figure 17: Building Entrances Calculation Results and Recommendations

Buliding Entrances NO CANOPY Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	30	60	90	90	W
	LPW	35	33	31	32	lm/W
2016	LPW	84	95	104	108	lm/W
	Change	13	21	27	26	Limit of Reduction
	Proposed	**15**	**25**	**35**	**45**	**W**

Building Primary Entrances Calculations Results

Figure 18: Building Primary Entrances Calculation Results and Recommendations

Building Primary Entrances Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	45	80	120	130	W
	LPW	25	25	25	26	lm/W
2016	LPW	72	79	86	92	lm/W
	Change	16	25	34	36	Limit of Reduction
	Proposed	**20**	**40**	**60**	**80**	**W**

Drive-Up Windows Calculations Results

Figure 19: Drive-Up Windows Calculation Results and Recommendations

Drive-Up Windows Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	40	75	125	200	W
	LPW	29	30	32	33	lm/W
2016	LPW	88	87	89	93	lm/W
	Change	13	26	45	72	Limit of Reduction
	Proposed	**30**	**40**	**60**	**100**	**W**

Vehicle Service Station Uncovered Fuel Dispenser Calculations Results

Figure 20: Vehicle Service Station Uncovered Fuel Dispenser Calculation Results and Recommendations

Uncovered Fuel Dispensers Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	120	175	185	330	W
	LPW	27	27	26	26	lm/W
2016	LPW	85	89	93	97	lm/W
	Change	38	52	52	90	Limit of Reduction
	Proposed	**80**	**100**	**140**	**160**	**W**

ATM Calculations Results

Figure 21: ATM Calculation Results and Recommendations

ATM Recommendations

		LZ1	LZ2	LZ3	LZ4	
2016	Watts for First ATM	185	185	186	185	Limit of Reduction
	Watts for Add'l ATMs	60	60	60	60	
	Watts for First ATM	**250**	**250**	**250**	**250**	**Proposed**
	Watts for Add'l ATMs	**70**	**70**	**70**	**70**	

Outdoor Sales Frontage Calculations Results

Figure 22: Outdoor Sales Frontage Calculation Results and Recommendations

Outdoor Sales Frontage Recommendations

		LZ1	LZ2	LZ3	LZ4	
2008	Allowance		22.5	36.0	45.0	W/lf
	LPW	33	34	38	44	lm/W
2016	LPW	95	102	110	108	lm/W
	Change		7	12	18	Limit of Reduction
	Proposed		**15**	**25**	**30**	**W/lf**

Hardscape Ornamental Frontage Calculations Results

The Hardscape Ornamental allowance was not set through a calculation process originally. Therefore, this value was adjusted downward by 25% to reflect the growing use of LED lighting to replace incandescent in this category.

Building Facades Calculations Results

Figure 23: Building Facades Calculation Results and Recommendations

Building Facades Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance		0.18	0.35	0.50	W/sf
	LPW	34	36	36	36	lm/W
2016	LPW	82	86	88	90	lm/W
	Change		0.07	0.14	0.20	Limit of Reduction
	Proposed		**0.15**	**0.25**	**0.35**	**W/sf**

Outdoor Sales Lots Calculations Results

Figure 24: Outdoor Sales Lots Calculation Results and Recommendations

Outdoor Sales Lots Recommmendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.164	0.555	0.758	1.285	W/sf
	LPW	27	29	32	34	lm/W
2016	LPW	93	101	101	103	lm/W
	Change	0.049	0.160	0.243	0.419	Limit of Reduction
	Proposed	**0.100**	**0.250**	**0.500**	**1.000**	**W/sf**

Vehicle Service Station Hardscape Calculations Results

Figure 25: Vehicle Service Station Hardscape Calculation Results and Recommendations

Service Station Hardscape Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.014	0.155	0.308	0.485	W/sf
	LPW	29	28	27	27	lm/W
2016	LPW	82	83	83	83	lm/W
	Change	0.005	0.053	0.101	0.156	Limit of Reduction
	Proposed	**0.010**	**0.100**	**0.150**	**0.200**	**W**

Vehicle Service Station Canopies Calculations Results

Figure 26: Vehicle Service Station Canopies Calculation Results and Recommendations

Service Station Canopies Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.514	1.005	1.300	2.200	W/sf
	LPW	29	30	32	33	lm/W
2016	LPW	88	87	89	93	lm/W
	Change	0.169	0.344	0.467	0.787	Limit of Reduction
	Proposed	**0.400**	**0.700**	**0.900**	**1.200**	**W/sf**

Sales Canopies Calculations Results

Figure 27: Sales Canopies Calculation Results and Recommendations

Sales Canopies Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance		0.655	0.908	1.135	W/sf
	LPW	35	36	35	36	lm/W
2016	LPW	67	69	71	70	lm/W
	Change		0.341	0.449	0.579	Limit of Reduction
	Proposed		**0.500**	**0.800**	**1.000**	**W/sf**

Non-Sales Canopies Calculations Results

Figure 28: Non-Sales Canopies Calculation Results and Recommendations

Non-Sales Canopies Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.084	0.205	0.408	0.585	W/sf
	LPW	45	44	44	43	lm/W
2016	LPW	69	70	73	75	lm/W
	Change	0.054	0.130	0.247	0.336	Limit of Reduction
	Proposed	**0.080**	**0.160**	**0.300**	**0.400**	**W/sf**

Guard Station Calculations Results

Figure 29: Guard Station Calculation Results and Recommendations

Guard Station Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.154	0.355	0.708	0.985	W
	LPW	31	30	28	29	lm/W
2016	LPW	77	80	83	86	lm/W
	Change	0.062	0.133	0.240	0.329	Limit of Reduction
	Proposed	**0.100**	**0.300**	**0.500**	**0.750**	**W/sf**

Student Pick-up/Drop-off Zone Calculations Results

Figure 30: Student Pick-up/Drop-off Zone Calculation Results and Recommendations

Student Pickup/Dropoff Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance		0.15	0.45		W/sf
	LPW	29	28	27	26	lm/W
2016	LPW	96	95	94	94	lm/W
	Change		0.04	0.13		Limit of Reduction
	Proposed		**0.10**	**0.25**		**W/sf**

Outdoor Dining Calculations Results

Figure 31: Outdoor Dining Calculation Results and Recommendations

Outdoor Dining Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.014	0.135	0.240	0.400	W/sf
	LPW	7	7	8	8	lm/W
2016	LPW	74	80	84	88	lm/W
	Change	0.001	0.012	0.022	0.037	Limit of Reduction
	Proposed	**0.010**	**0.100**	**0.150**	**0.200**	**W/sf**

Special Security Lighting for Retail Calculations Results

Figure 32: Special Security Lighting for Retail Calculation Results and Recommendations

Special Security Lighting for Retail Recommendations

		LZ1	LZ2	LZ3	LZ4	
2013	Allowance	0.007	0.009	0.019		W/sf
	LPW	30	29	27	28	lm/W
2016	LPW	75	77	81	84	lm/W
	Change	0.003	0.003	0.006		Limit of Reduction
	Proposed	**0.005**	**0.007**	**0.012**		**W**

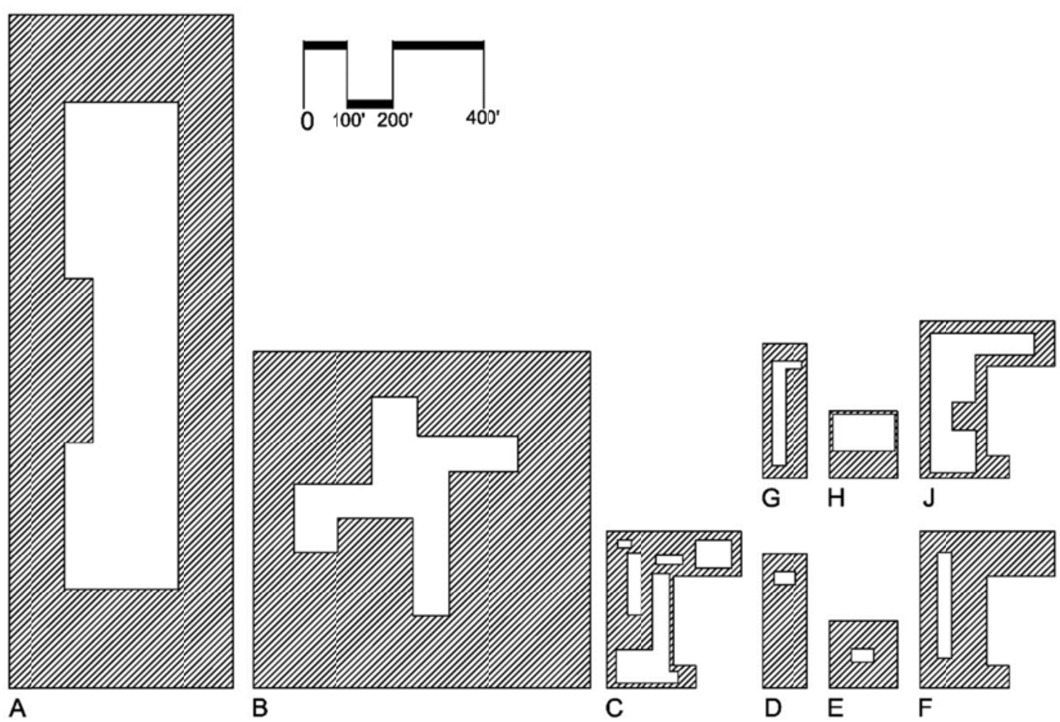
APPENDIX D: MODELS FOR GENERAL CALCULATIONS

Models for General Hardscape Allowance Calculations

The general site models used for the hardscape allowance calculations were employed to find the reasonable range of ratios in the hardscape area and perimeter. This is relevant because the way the general hardscape allowances are established, it is not possible to directly calculate the impact of a change in the allowances to a typical site without understanding what a reasonable typical site will look like.

Below in Figure 33, the general layout of the sites is represented to provide an understanding of the conditions that were anticipated in the calculations.

Figure 33: Nine Site Prototypes Used to Calculate Reasonable Site Impact Calculations



These sites vary in overall hardscape size, which impacts the influence of the Initial Wattage Allowance. Further, the sites vary in both the hardscape outside perimeter complexity, and the building complexity, which both impact ratio of the perimeter to the area of the hardscape. Rectangular sites are employed because they are most common, but the proportions are modified because that also impacts the ratio of the perimeter to area.

The site with the lowest perimeter to area percentage will be a circle with no building contained within. As a site deviates farther from that ideal site, the ratio of the perimeter to the area will increase up to a point where a very complex site will have a reasonably high percentage.

The effective site calculation for the general hardscape represents an average of the nine sites shown in Figure 33. The average of these sites is used to represent a typical site for per unit and statewide impacts calculations.

Models for Cost Effectiveness Calculations

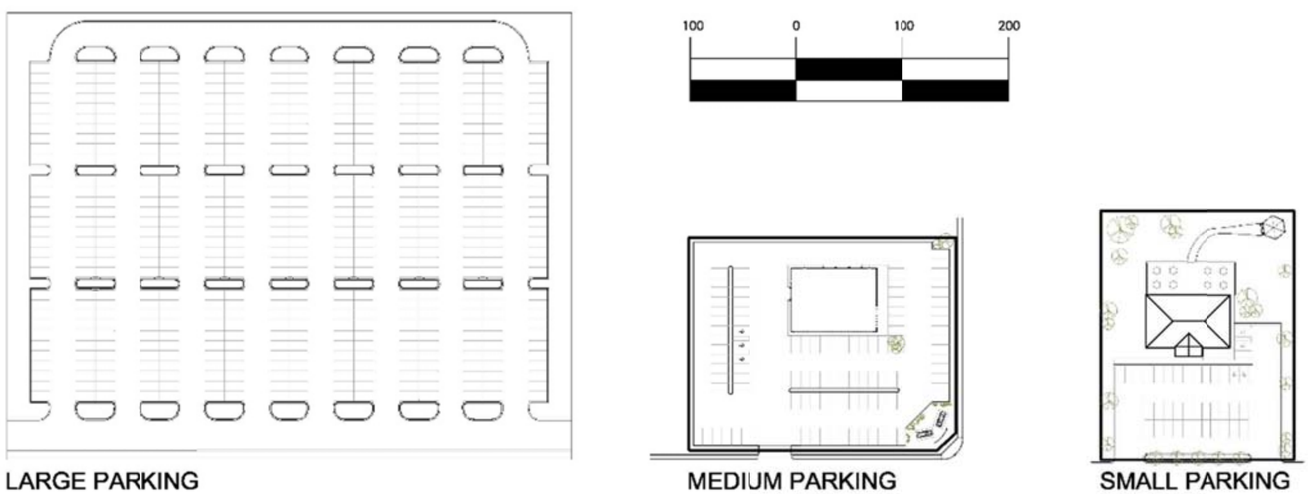
To effectively switch from a PSMH baseline to LED, the circumstances for each line item in the tables needed to be calculated so that the each item is verified to be cost effective individually.

There are two methods used to make this verification. The first is the complete design of a lighting system, which was employed for the general hardscape calculations. This approach is valid in circumstance where the LED technology is a benefit not only in terms of efficacy, but also in terms of some other aspect, like pole spacing or pole height, which will have cost implications independent of the efficacy issues.

The second is a one-for-one comparison of lighting equipment. This approach was employed for the LPA values of specific applications, like the lighting at building entrances, for example. Most of these applications are unlikely to be able to reduce the equipment quantity substantially due to the LED light improvements, so the comparison was done in this most direct manner.

Figure 34 below, provides the site geometry for three applications that were used to make costing comparisons for the general hardscape cost effectiveness calculations.

Figure 34: Three Site Prototypes Used to Calculate Cost Calculations for LED Lighting Systems



APPENDIX E: LIGHTING USE PROFILES FOR CALCULATIONS

The lighting calculations for energy consumption and TDV employ the following lighting use profiles to represent the variety of circumstances that are likely to occur in nonresidential outdoor lighting conditions.

Because the statewide estimates are built around the building types and not the specific measures (in terms of square footage projections), the use profiles for each individual measure cannot be easily applied to the whole building as a composite. Therefore, a representative use profile was developed taking into account that some lights will be turned off at different times in the night. These profiles are characteristic for the building categories and were applied to the statewide estimates only.

Overall Schedule Information

The schedules all include a formula to calculate the actual schedule based on the sunrise and sunset points, and therefore they change from day to day. However, it is possible to characterize them reasonably with winter and summer curves to understand the typical range of ours of operation that will occur.

General Hardscape Schedule Information

The general hardscape calculations for energy savings were made using three schedules. These are shown in Figure 35, Figure 36, and Figure 37. These are applied to the respective building types based on their characterization as nonresidential, hotel, or retail.

Figure 35: Nonresidential Outdoor Lighting Use Curve for General Hardscape

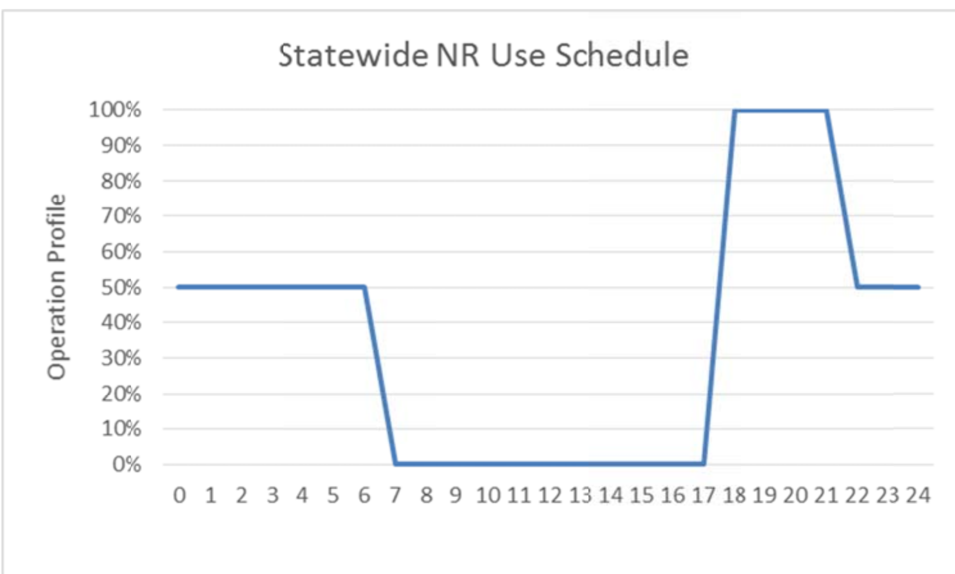


Figure 36: Hotel Outdoor Lighting Use Curve for General Hardscape

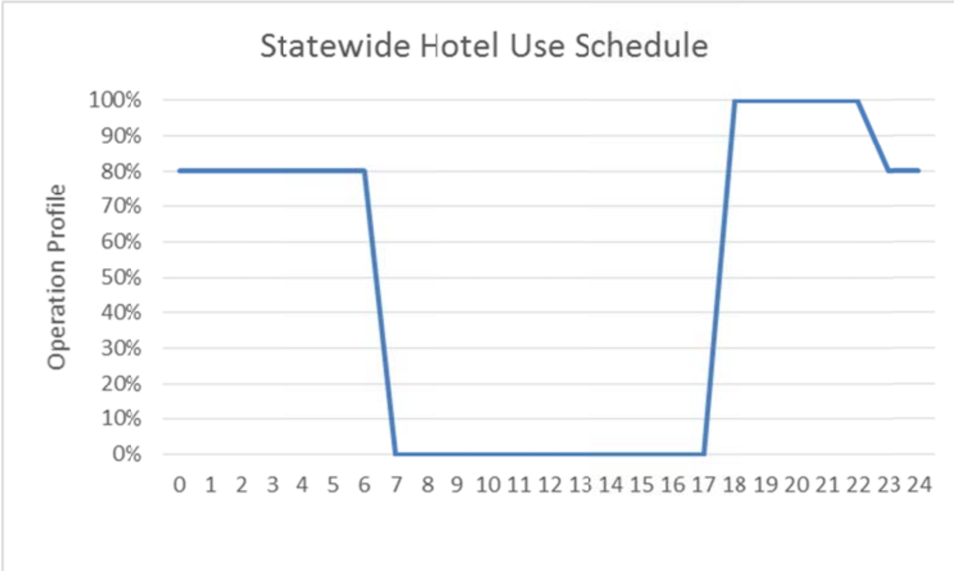


Figure 37: Retail Outdoor Lighting Use Curve for General Hardscape

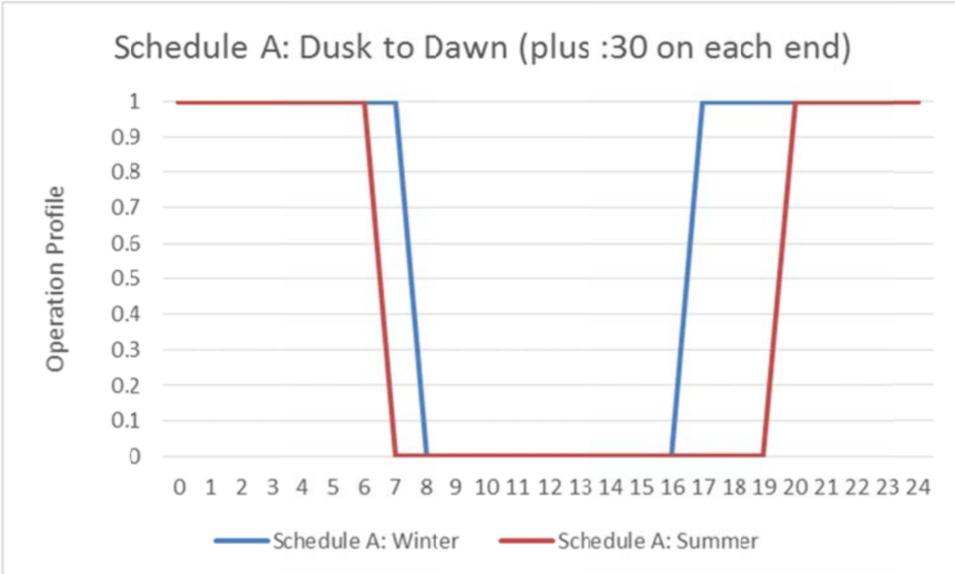
Specific Lighting Application Schedule Information

The specific applications calculations for energy savings were made using three schedules provided below in Figure 38, Figure 39, and Figure 40. Since the specific lighting applications are not representative of a large site, but more narrowly focused on a small subset of lighting on a site.

Schedule A: Dusk to Dawn

This schedule is a typical dusk to dawn operation with an additional 30 minutes on each end to represent the photocell setting for higher light levels than might be typically found at the sunset/sunrise point.

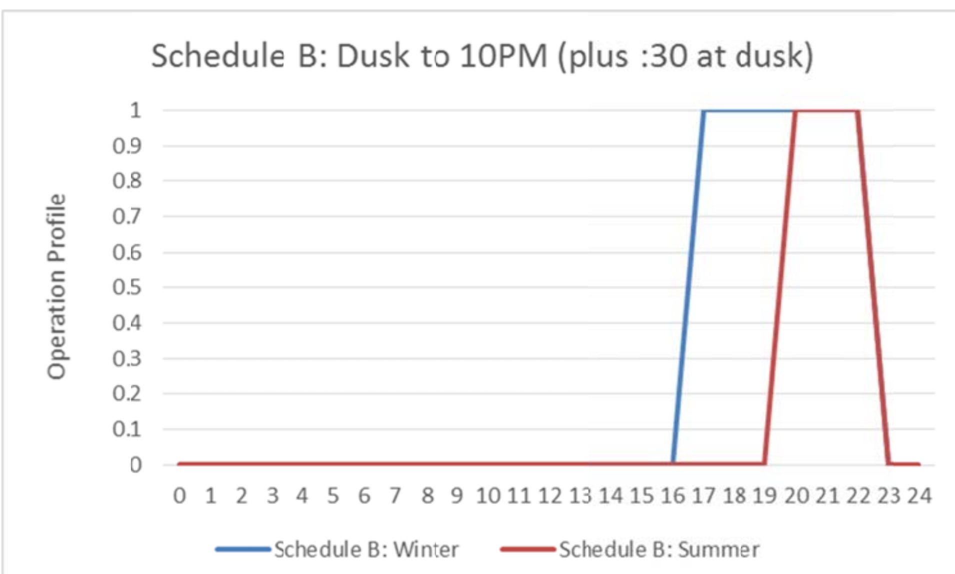
Figure 38: Schedule A: Winter and Summer Curves



Schedule B: Dusk to 10PM

This schedule is a typical dusk to 10PM operation with an additional 30 minutes on the dusk end to represent the photocell setting for higher light levels than might be typically found at the sunset point. Figure 39 represents a typical lighting system for a retail property, and often also reflects lighting for landscape and outdoor dining conditions.

Figure 39: Schedule B: Winter and Summer Curves



Schedule C: Dusk to Midnight

This schedule is a typical dusk to midnight operation with an additional 30 minutes on the dusk end to represent the photocell setting for higher light levels than might be typically found at the sunset point. Figure 40 represents a typical lighting system for a later-night retail property, some outdoor dining conditions.

Figure 40: Schedule C: Winter and Summer Curves

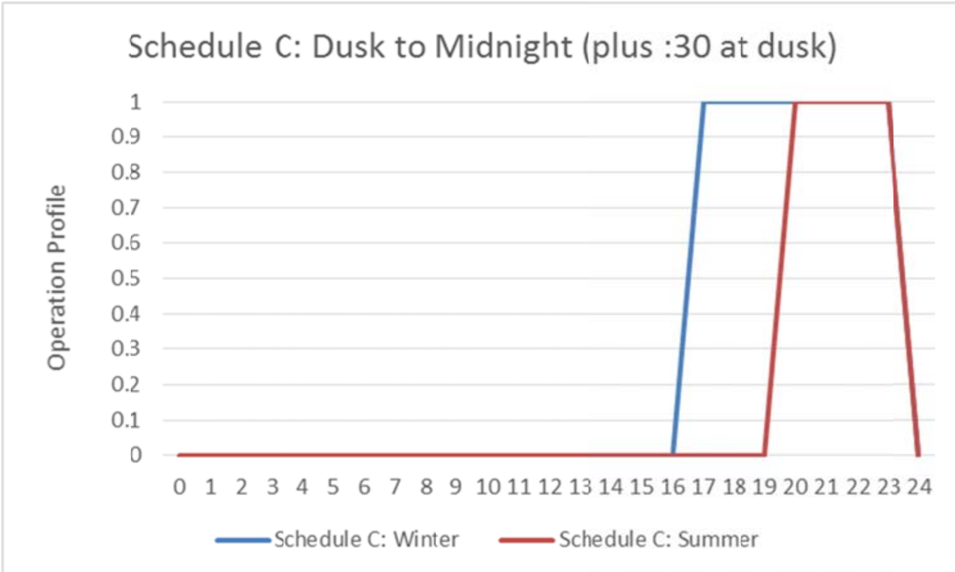


Figure 41 provides information on the various outdoor lighting applications that are designated in the LPA tables and which of the above schedules are applied to these for energy consumption and cost effectiveness calculations.

Figure 41: Lighting Application Schedule Use Matrix

Lighting Application	Use Schedule Applied
General Hardscape	Schedule A
Building Entrances	Schedule A
Primary Entrances	Schedule A
Drive Up Windows	Schedule C
Vehicle Service Uncovered Fuel Dispenser	Schedule A
ATM Machine	Schedule C
Outdoor Sales Frontage	Schedule C
Hardscape Ornamental Lighting	Schedule C
Building Facades	Schedule A
Outdoor Sales Lots	Schedule A
Vehicle Service Station Hardscape	Schedule A
Vehicle Service Station Canopies	Schedule A
Sales Canopies	Schedule A
Non-sales Canopies	Schedule A
Guard Stations	Schedule A
Student Pick-up/Drop-off Zone	Schedule B
Outdoor Dining	Schedule B
Special Security Lighting for Retail	Schedule A

APPENDIX F: COST EFFECTIVENESS CALCULATIONS

Provided below are tables that detail the cost calculations run for the general hardscape cost effectiveness calculations.

The information was collected by polling manufacturer representatives and producing a reasonable average for similarly-specified products, including Type III and Type IV luminaires and those with house-side shields (designated as (HS) in the Item labels.

The cost for the products is based on current pricing, and projects forward to 2017 through cost escalation. The LED products are projected forward in efficacy, with Columns 3 through 5 predicting the cost per lumen of the product based on the DOE cost projections. The result is Column 6, which shows the 2017 cost of the luminaires.

Column 7 adds the projected cost of installation based on Means cost estimations and cost escalation. The final column projects the cost of the product if the current LED technology were employed in 2017, with no cost per lumen savings due to the rapidly advancing LED technology.

Figure 42: Luminaire Costs for Construction, Based on Factory Representative Quotes and Adjusted Forward

Item	2014 Cost	lm	2014 $/kms	2017 $/klm**	2017 Cost***	2017 Cost with Installation*	2017 Cost without $/Klm Reduction
PSMH, Small (HS)	$ 887.5	--	--	--	$ 944.59	$ 1,086.28	$ 1,086.28
PSMH, Small	$ 846.0				$ 900.43	$ 1,035.49	$ 1,035.49
PSMH, Large (HS)	$ 1,161.5	--	--	--	$ 1,236.22	$ 1,421.66	$ 1,421.66
PSMH, Large	$ 1,079.0				$ 1,148.41	$ 1,320.68	$ 1,320.68
LED, Small (HS)	$ 1,068.0	4,319	$ 247.28	$ 173.10	$ 859.74	$ 988.70	$ 1,307.21
LED, Small	$ 1,056.0	5,129	$ 205.89	$ 144.12	$ 850.08	$ 977.59	$ 1,292.53
LED, Medium (HS)	$ 1,675.0	9,487	$ 176.56	$ 123.59	$ 1,348.38	$ 1,550.63	$ 2,050.17
LED, Medium	$ 1,663.0	10,705	$ 155.35	$ 108.74	$ 1,338.72	$ 1,539.52	$ 2,035.48
LED, Large OPT1 (HS)	$ 1,675.0	15,790	$ 106.08	$ 74.26	$ 1,348.38	$ 1,550.63	$ 2,050.17
LED, Large OPT1	$ 1,663.0	17,928	$ 92.76	$ 64.93	$ 1,338.72	$ 1,539.52	$ 2,035.48
25ft Pole	$ 829.0	--	--	--	$ 882.33	$ 1,014.68	$ 1,014.68
30ft Pole	$ 1,045.0	--	--	--	$ 1,112.23	$ 1,279.06	$ 1,279.06
35ft Pole OPT1	$ 1,304.0	--	--	--	$ 1,387.89	$ 1,596.07	$ 1,596.07
PSMH, Wall Pack	$ 322.0	--	--	--	$ 342.71	$ 394.12	$ 394.12
LED, Large OPT2	$ 1,366.0	11,294	$ 120.95	$ 84.66	$ 1,099.63	$ 1,264.57	$ 1,671.96
35ft Pole OPT2	$ 1,516.0	--	--	--	$ 1,613.53	$ 1,855.56	$ 1,855.56
39ft Pole OPT2	$ 1,874.0	--	--	--	$ 1,994.56	$ 2,293.74	$ 2,293.74

Notes:

*Installation Mark-Up	0.15
**2017 LED Cost	0.3
**2017 LED Source	Report_SSL Trend Analysis 2013.pdf, Executive Summary
***Retail Rate Escalation	0.021
***Retail Rate Source	Title24_2013_TDV_Methodology_Report_23Feb2011.pdf, Retail Rate Escalation

Figure 43: Itemized Costs for Construction, Based on RS Means and Adjusted Forward

ITEM	2012 Means: Conduit or Mat.	2012 Means: Fittings	2012 Means: Boxes	San Fancisco Adder: Trenching	San Fancisco Adder: %	San Fancisco Adder: 2012 Sub-Total	2012 Cost	2014 Cost	2017 Cost
1/2" EMT w/fittings and boxes	3.13	0.757	0.305		1.312	$ 4.19	$ 5.50	$ 5.73	$ 6.10
3/4" Sched 80 PVC w/box 300'	4.11	1.048	1.000	8.95	1.312	$ 15.11	$ 19.82	$ 20.66	$ 21.99
1" Sched 80 PVC w/box 300'	5.43	1.175	1.000	8.95	1.312	$ 16.56	$ 21.72	$ 22.64	$ 24.10
1 1/4" Sched 80 PVC w/box 300'	6.95	1.301	1.333	8.95	1.312	$ 18.53	$ 24.32	$ 25.35	$ 26.98
1 1/2" Sched 80 PVC w/box 300'	7.75	1.447	1.667	8.95	1.312	$ 19.81	$ 26.00	$ 27.10	$ 28.84
2" Sched 80 PVC w/box 300'	10.07	1.724	2.000	8.95	1.312	$ 22.74	$ 29.84	$ 31.11	$ 33.11
THWN #12 AWG CU	0.5185				1.312	$ 0.52	$ 0.68	$ 0.71	$ 0.75
THWN #10 AWG CU	0.63				1.312	$ 0.63	$ 0.83	$ 0.86	$ 0.92
THWN #8 AWG CU	0.85				1.312	$ 0.85	$ 1.12	$ 1.16	$ 1.24
THWN #6 AWG CU	1.21				1.312	$ 1.21	$ 1.59	$ 1.65	$ 1.76
THWN #4 AWG CU	1.68				1.312	$ 1.68	$ 2.20	$ 2.30	$ 2.45
THWN #3 AWG CU	1.965				1.312	$ 1.97	$ 2.58	$ 2.69	$ 2.86
THWN #2 AWG CU	2.345				1.312	$ 2.35	$ 3.08	$ 3.21	$ 3.41
FOUNDATIONS (Mat. & Labor)									
Foundation 25' pole CDOT	575	75		420.15	1.242	$ 1,070.15	$ 1,329.13	$ 1,385.54	$ 1,474.67
Foundation 30' pole CDOT	637	75		495	1.242	$ 1,207.00	$ 1,499.09	$ 1,562.72	$ 1,663.25
Foundation 35' pole CDOT	762	75		619	1.242	$ 1,456.00	$ 1,808.35	$ 1,885.10	$ 2,006.37
Foundation 39' pole CDOT	762	75		619	1.242	$ 1,456.00	$ 1,808.35	$ 1,885.10	$ 2,006.37
LIGHT STANDARD POLES (Labor Only)									
Light Standard 25' pole				451	1.312	$ 451.00	$ 591.71	$ 616.82	$ 656.51
Light Standard 30' pole				502.6	1.312	$ 502.60	$ 659.41	$ 687.40	$ 731.62
Light Standard 35' pole				525	1.312	$ 525.00	$ 688.80	$ 718.03	$ 764.23
Light Standard 39' pole				678	1.312	$ 678.00	$ 889.54	$ 927.29	$ 986.94
LUMINAIRES (Labor Only)									
70W PSMH, Small				33	1.312	$ 33.00	$ 43.30	$ 45.13	$ 48.04
PSMH Wallpack				33	1.312	$ 33.00	$ 43.30	$ 45.13	$ 48.04
100W PSMH, Small				39.5	1.312	$ 39.50	$ 51.82	$ 54.02	$ 57.50
150W PSMH, Small				103	1.312	$ 103.00	$ 135.14	$ 140.87	$ 149.93
400W PSMH, Large				103	1.312	$ 103.00	$ 135.14	$ 140.87	$ 149.93
LED, Small				33	1.312	$ 33.00	$ 43.30	$ 45.13	$ 48.04
LED, Medium				103	1.312	$ 103.00	$ 135.14	$ 140.87	$ 149.93
LED, Large OPT1				103	1.312	$ 103.00	$ 135.14	$ 140.87	$ 149.93
PULL BOXES (Polymer Concrete Tier22)									
11"x18"x12"Dp. Bottomless	475	375			1.312	$ 850.00	$ 1,115.20	$ 1,162.53	$ 1,237.32
PANEL BOARD ADDER									
100A-120/240V-1PH, 30-POLE	1975	500			1.312	$ 2,475.00	$ 3,247.20	$ 3,385.01	$ 3,602.78

The cost estimating process involves producing a design on each lot, to develop the quantities of equipment needed to meet the IES design criteria for each scenario.

These lighting designs are also put through an electrical design step to predict the cost implications of the electrical supply system, since this is a substantial portion of the total cost of a parking lot lighting design. The quantity take-offs of the lighting and electrical systems are built upon the information visible in Figure 43 above and are shown in summary form in the following Tables.

Figure 44: Costing Calculations for LZ1 of Real Site Design

Small Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	7	$ 888	$ 1,086	$ 7,604
Labor, Luminaire	7	$ 45	$ 48	$ 336
25ft Pole	7	$ 829	$ 1,015	$ 7,103
Labor, Pole	7	$ 617	$ 657	$ 4,596
Foundation	7	$ 1,386	$ 1,475	$ 10,323
Conduit 3/4"PVC	605	$ 21	$ 22	$ 13,305
Wiring #10AWG CU	1685	$ 1	$ 1	$ 1,545
			Total	$ 44,812

Small Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small (HS)	4	$ 1,068	$ 989	$ 3,955	$ 5,229
Labor, Luminaire	4	$ 45	$ 48	$ 192	$ 192
25ft Pole	4	$ 829	$ 1,015	$ 4,059	$ 4,059
Labor, Pole	4	$ 617	$ 657	$ 2,626	$ 2,626
Foundation	4	$ 1,386	$ 1,475	$ 5,899	$ 5,899
Conduit 3/4"PVC	425	$ 21	$ 22	$ 9,347	$ 9,347
Wiring #12AWG CU	1975	$ 1	$ 1	$ 1,491	$ 1,491
			Total	$ 27,568	$ 28,842

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	6	$ 888	$ 1,086	$ 6,518
PSMH, Small	12	$ 846	$ 1,035	$ 12,426
Labor, Luminaire	18	$ 45	$ 48	$ 865
PSMH, Wall Pack	3	$ 322	$ 394	$ 1,182
Labor, Luminaire	3	$ 45	$ 48	$ 144
25ft Pole	12	$ 829	$ 1,015	$ 12,176
Labor, Pole	12	$ 617	$ 657	$ 7,878
Foundation	12	$ 1,386	$ 1,475	$ 17,696
Conduit 1 1/2"PVC	910	$ 27	$ 29	$ 26,246
Conduit 1/2"EMT	150	$ 6	$ 6	$ 915
Wiring #4 AWG CU	3590	$ 2	$ 2	$ 8,779
Wiring #12AWG CU	620	$ 1	$ 1	$ 468
			Total	$ 95,294

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small (HS)	3	$ 1,068	$ 989	$ 2,966	$ 3,922
LED, Small	8	$ 1,056	$ 978	$ 7,821	$ 10,340
Labor, Luminaire	11	$ 45	$ 48	$ 528	$ 528
25ft Pole	7	$ 829	$ 1,015	$ 7,103	$ 7,103
Labor, Pole	7	$ 617	$ 657	$ 4,596	$ 4,596
Foundation	7	$ 1,386	$ 1,475	$ 10,323	$ 10,323
Conduit 1"PVC	620	$ 23	$ 24	$ 14,941	$ 14,941
Wiring #8 AWG CU	3050	$ 1	$ 1	$ 3,774	$ 3,774
			Total	$ 33,336	$ 55,526

Large Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	24	$ 888	$ 1,086	$ 26,071
PSMH, Small	42	$ 846	$ 1,035	$ 43,491
Labor, Luminaire	66	$ 45	$ 48	$ 3,170
30ft Pole	45	$ 1,045	$ 1,279	$ 57,558
Labor, Pole	45	$ 687	$ 732	$ 32,923
Foundation	45	$ 1,563	$ 1,663	$ 74,846
Conduit 2"PVC	3090	$ 31	$ 33	$ 102,303
Wiring #4 AWG CU	15887	$ 2	$ 2	$ 38,852
			Total	$ 379,214

Large Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small	56	$ 1,056	$ 978	$ 54,745	$ 72,381
Labor, Luminaire	56	$ 45	$ 48	$ 2,690	$ 2,690
25ft Pole	35	$ 829	$ 1,015	$ 35,514	$ 35,514
Labor, Pole	35	$ 617	$ 657	$ 22,978	$ 22,978
Foundation	35	$ 1,386	$ 1,475	$ 51,613	$ 51,613
Conduit 2"PVC	2580	$ 31	$ 33	$ 85,418	$ 85,418
Wiring #6 AWG CU	13580	$ 2	$ 2	$ 23,919	$ 23,919
			Total	$ 276,877	$ 294,514

Figure 45: Costing Calculations for LZ2 of Real Site Design

Small Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	7	$ 888	$ 945	$ 6,612
Labor, Luminaire	7	$ 45	$ 48	$ 336
25ft Pole	7	$ 829	$ 1,015	$ 7,103
Labor, Pole	7	$ 617	$ 657	$ 4,596
Foundation	7	$ 1,386	$ 1,475	$ 10,323
Conduit 3/4"PVC	605	$ 21	$ 22	$ 13,305
Wiring #10AWG CU	1685	$ 1	$ 1	$ 1,545
			Total	$ 43,820

Small Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small (HS)	4	$ 1,068	$ 989	$ 3,955	$ 5,229
Labor, Luminaire	4	$ 45	$ 48	$ 192	$ 192
25ft Pole	4	$ 829	$ 1,015	$ 4,059	$ 4,059
Labor, Pole	4	$ 617	$ 657	$ 2,626	$ 2,626
Foundation	4	$ 1,386	$ 1,475	$ 5,899	$ 5,899
Conduit 3/4"PVC	425	$ 21	$ 22	$ 9,347	$ 9,347
Wiring #12AWG CU	1975	$ 1	$ 1	$ 1,491	$ 1,491
			Total	$ 27,568	$ 28,842

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	6	$ 888	$ 1,086	$ 6,518
PSMH, Small	12	$ 846	$ 1,035	$ 12,426
Labor, Luminaire	18	$ 45	$ 48	$ 865
PSMH, Wall Pack	2	$ 322	$ 394	$ 788
Labor, Luminaire	2	$ 45	$ 48	$ 96
25ft Pole	12	$ 829	$ 1,015	$ 12,176
Labor, Pole	12	$ 617	$ 657	$ 7,878
Foundation	12	$ 1,386	$ 1,475	$ 17,696
Conduit 1 1/2"PVC	910	$ 27	$ 29	$ 26,246
Conduit 1/2"EMT	150	$ 6	$ 6	$ 915
Wiring #4 AWG CU	3590	$ 2	$ 2	$ 8,779
Wiring #12AWG CU	620	$ 1	$ 1	$ 468
			Total	$ 94,852

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small (HS)	3	$ 1,068	$ 989	$ 2,966	$ 3,922
LED, Small	8	$ 1,056	$ 978	$ 7,821	$ 10,340
Labor, Luminaire	11	$ 45	$ 48	$ 528	$ 528
25ft Pole	7	$ 829	$ 1,015	$ 7,103	$ 7,103
Labor, Pole	7	$ 617	$ 657	$ 4,596	$ 4,596
Foundation	7	$ 1,386	$ 1,475	$ 10,323	$ 10,323
Conduit 1"PVC	620	$ 23	$ 24	$ 14,941	$ 14,941
Wiring #8 AWG CU	3050	$ 1	$ 1	$ 3,774	$ 3,774
			Total	$ 33,336	$ 55,526

Large Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	16	$ 888	$ 945	$ 15,114
PSMH, Small	42	$ 846	$ 1,035	$ 43,491
Labor, Luminaire	58	$ 54	$ 57	$ 3,335
25ft Pole	37	$ 829	$ 1,015	$ 37,543
Labor, Pole	37	$ 617	$ 657	$ 24,291
Foundation	37	$ 1,386	$ 1,475	$ 54,563
Conduit 2"PVC	2875	$ 31	$ 33	$ 95,185
Wiring #4 AWG CU	13935	$ 2	$ 2	$ 34,078
			Total	$ 307,599

Large Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Small	56	$ 1,056	$ 978	$ 54,745	$ 72,381
Labor, Luminaire	56	$ 45	$ 48	$ 2,690	$ 2,690
25ft Pole	35	$ 829	$ 1,015	$ 35,514	$ 35,514
Labor, Pole	35	$ 617	$ 657	$ 22,978	$ 22,978
Foundation	35	$ 1,386	$ 1,475	$ 51,613	$ 51,613
Conduit 2"PVC	2580	$ 31	$ 33	$ 85,418	$ 85,418
Wiring #6 AWG CU	13580	$ 2	$ 2	$ 23,919	$ 23,919
			Total	$ 276,877	$ 294,514

Figure 46: Costing Calculations for LZ3 of Real Site Design

Small Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	7	$ 888	$ 1,086	$ 7,604
Labor, Luminaire	7	$ 141	$ 150	$ 1,050
30ft Pole	7	$ 1,045	$ 1,279	$ 8,953
Labor, Pole	7	$ 687	$ 732	$ 5,121
Foundation	7	$ 1,563	$ 1,663	$ 11,643
Conduit 1"PVC	605	$ 23	$ 24	$ 14,580
Wiring #8AWG CU	1685	$ 1	$ 1	$ 2,085
			Total	**$ 51,036**

Small Parking LED

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost, $/Klm Cost Reduction	2017 Total Cost, **without** $/Klm Reduction
LED, Medium (HS)	4	$ 1,675	$ 1,551	$ 6,203	$ 8,201
Labor, Luminaire	4	$ 54	$ 57	$ 230	$ 230
30ft Pole	4	$ 1,045	$ 1,279	$ 5,116	$ 5,116
Labor, Pole	4	$ 687	$ 732	$ 2,926	$ 2,926
Foundation	4	$ 1,563	$ 1,663	$ 6,653	$ 6,653
Conduit 3/4"PVC	360	$ 21	$ 22	$ 7,917	$ 7,917
Wiring #12AWG CU	1350	$ 1	$ 1	$ 1,019	$ 1,019
			Total	**$ 30,064**	**$ 32,063**

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	5	$ 888	$ 1,086	$ 5,431
PSMH, Small	8	$ 846	$ 1,035	$ 8,284
Labor, Luminaire	13	$ 141	$ 150	$ 1,949
PSMH, Wall Pack	1	$ 322	$ 394	$ 394
Labor, Luminaire	1	$ 45	$ 48	$ 48
35ft Pole OPT1	9	$ 1,304	$ 1,596	$ 14,365
Labor, Pole	9	$ 718	$ 764	$ 6,878
Foundation	9	$ 1,885	$ 2,006	$ 18,057
Conduit 2"PVC	760	$ 31.11	$ 33.11	$ 25,162
Conduit 1/2"EMT	100	$ 6	$ 6	$ 610
Wiring #2 AWG CU	2990	$ 3	$ 3	$ 10,206
Wiring #12AWG CU	305	$ 1	$ 1	$ 230
			Total	**$ 91,615**

Medium Parking LED

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost, $/Klm Cost Reduction	2017 Total Cost, **without** $/Klm Reduction
LED, Medium (HS)	4	$ 1,675	$ 1,551	$ 6,203	$ 8,201
LED, Medium	8	$ 1,663	$ 1,540	$ 12,316	$ 16,284
Labor, Luminaire	12	$ 54	$ 57	$ 690	$ 690
30ft Pole	8	$ 1,045	$ 1,279	$ 10,232	$ 10,232
Labor, Pole	8	$ 687	$ 732	$ 5,853	$ 5,853
Foundation	8	$ 1,563	$ 1,663	$ 13,306	$ 13,306
Conduit 1 1/4"PVC	635	$ 25.35	$ 26.98	$ 17,132	$ 17,132
Wiring #6 AWG CU	3250	$ 2	$ 2	$ 5,724	$ 5,724
			Total	**$ 48,600**	**$ 77,423**

Large Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Small (HS)	16	$ 888	$ 945	$ 15,114
PSMH, Small	42	$ 846	$ 1,035	$ 43,491
Labor, Luminaire	58	$ 141	$ 150	$ 8,696
35ft Pole OPT1	28	$ 1,304	$ 1,596	$ 44,690
Labor, Pole	28	$ 718	$ 764	$ 21,398
Foundation	28	$ 1,885	$ 2,006	$ 56,178
Conduit 2"PVC	3055	$ 31.11	$ 33.11	$ 101,144
Wiring #4 AWG CU	19220	$ 2	$ 2	$ 47,003
Panel & feeder Ad	1	$ 3,247	$ 3,603	$ 3,603
			Total	**$ 337,714**

Large Parking LED

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost, $/Klm Cost Reduction	2017 Total Cost, **without** $/Klm Reduction
LED, Large OPT1	34	$ 1,663	$ 1,540	$ 52,344	$ 69,206
Labor, Luminaire	34	$ 141	$ 150	$ 5,098	$ 5,098
35ft Pole OPT1	22	$ 1,304	$ 1,596	$ 35,114	$ 35,114
Labor, Pole	22	$ 718	$ 764	$ 16,813	$ 16,813
Foundation	22	$ 1,885	$ 2,006	$ 44,140	$ 44,140
Conduit 2"PVC	3065	$ 31	$ 33	$ 101,475	$ 101,475
Wiring #4 AWG CU	17395	$ 2	$ 2	$ 42,540	$ 42,540
			Total	**$ 297,523**	**$ 314,386**

Figure 47: Costing Calculations for LZ4 of Real Site Design

Small Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Large (HS)	6	$ 1,162	$ 1,422	$ 8,530
Labor, Luminaire	6	$ 141	$ 150	$ 900
35ft Pole OPT1	6	$ 1,304	$ 1,596	$ 9,576
Labor, Pole	6	$ 718	$ 764	$ 4,585
Foundation	6	$ 1,885	$ 2,006	$ 12,038
Conduit 1"PVC	420	$ 23	$ 24	$ 10,121
Wiring #6AWG CU	1520	$ 2	$ 2	$ 2,677
			Total	$ 48,428

Small Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Large OPT1 (H	6	$ 1,675	$ 1,551	$ 9,304	$ 12,301
Labor, Luminaire	6	$ 141	$ 150	$ 900	$ 900
30ft Pole	6	$ 1,045	$ 1,279	$ 7,674	$ 7,674
Labor, Pole	6	$ 687	$ 732	$ 4,390	$ 4,390
Foundation	6	$ 1,563	$ 1,663	$ 9,980	$ 9,980
Conduit 3/4"PVC	435	$ 21	$ 22	$ 9,567	$ 9,567
Wiring #8AWG CU	1845	$ 1	$ 1	$ 2,283	$ 2,283
			Total	$ 44,096	$ 47,094

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Large (HS)	4	$ 1,162	$ 1,422	$ 5,687
PSMH, Large	8	$ 1,079	$ 1,321	$ 10,565
Labor, Luminaire	12	$ 141	$ 150	$ 1,799
30ft Pole	8	$ 1,045	$ 1,279	$ 10,232
Labor, Pole	8	$ 687	$ 732	$ 5,853
Foundation	8	$ 1,563	$ 1,663	$ 13,306
Ingrade pull box by	8	$ 1,163	$ 1,237	$ 9,899
Conduit 1 1/2"PVC	1080	$ 31	$ 33	$ 35,756
Wiring #3AWG CU	4320	$ 3	$ 3	$ 14,747
			Total	$ 93,098

Medium Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Large OPT2	12	$ 1,366	$ 1,265	$ 15,175	$ 20,064
Labor, Luminaire	12	$ 141	$ 150	$ 1,799	$ 1,799
35ft Pole OPT2	8	$ 1,516	$ 1,856	$ 14,844	$ 14,844
Labor, Pole	8	$ 718	$ 764	$ 6,114	$ 6,114
Foundation	8	$ 1,885	$ 2,006	$ 16,051	$ 16,051
Conduit 1 1/2"PVC	700	$ 27	$ 29	$ 20,189	$ 20,189
Wiring #4AWG CU	3380	$ 2	$ 2	$ 8,266	$ 8,266
			Total	$ 82,439	$ 87,327

Large Parking

Item	Quantity	2014 Cost	2017 Cost	2017 Total Cost
PSMH, Large (HS)	24	$ 1,162	$ 1,422	$ 34,120
PSMH, Large	24	$ 1,079	$ 1,321	$ 31,696
Labor, Luminaire	48	$ 141	$ 150	$ 7,197
35ft Pole OPT1	36	$ 1,304	$ 1,596	$ 57,459
Labor, Pole	36	$ 718	$ 764	$ 27,512
Foundation	36	$ 1,885	$ 2,006	$ 72,229
Ingrade pull box by	36	$ 1,163	$ 1,237	$ 44,543
Conduit 2"PVC	5270	$ 31	$ 33	$ 174,478
Wiring #2 AWG CU	28690	$ 3	$ 3	$ 97,935
Panel&feeder add	1	$ 3,385	$ 3,603	$ 3,603
			Total	$ 449,234

Large Parking

Item	Quantity	2014 Cost	2017 Cost	Cost, $/Klm Cost	Cost, **without**
LED, Large OPT2	64	$ 1,366	$ 1,265	$ 80,933	$ 107,005
Labor, Luminaire	64	$ 141	$ 150	$ 9,596	$ 9,596
39ft Pole OPT2	28	$ 1,874	$ 2,294	$ 64,225	$ 64,225
Labor, Pole	28	$ 927	$ 987	$ 27,634	$ 27,634
Foundation	28	$ 1,885	$ 2,006	$ 56,178	$ 56,178
Conduit 2"PVC	3400	$ 31	$ 33	$ 112,566	$ 112,566
Wiring #4 AWG CU	21275	$ 2	$ 2	$ 52,029	$ 52,029
			Total	$ 403,161	$ 429,234

Figure 48 below, provides a summary of the results of these individual calculations for the respective sites.

The second column shows the projected cost of the PSMH system required to meet the design criteria. The third column shows the projected cost of the LED system necessary to meet the same design criteria. In all cases, the overall higher performance of the lighting equipment resulted in reductions in the amount of equipment, and as a result, the installed cost with an LED system produces a lower first cost approach to meet the design requirements.

The final column shows the projected cost of the system without the reduction in the cost of the LED technology that is anticipated. This still has the efficacy improvements factored in, but the calculations presume that there are no savings in the LED cost per lumen compared to today. This represents a very conservative position, as history has proven that the cost will decline as the technology improves. Even so, the LED lighting systems project to have lower first-cost in 2017.

As a result, the general hardscape cost effectiveness presumes that the LED baseline measure will not add additional cost to the lighting system compared to the incumbent PSMH technology.

Figure 48: Costing Calculations for Real Site Designs of Three Sites in Four Lighting Zones

LZ1 - 2017 Cost			
	2017 PSMH	2017 LED, $/klm Reduction	2017 LED, **without** $/klm Reduction
Small Parking	$ 44,812	$ 27,568	$ 28,842
Medium Parking	$ 95,294	$ 33,336	$ 55,526
Large Parking	$ 379,214	$ 276,877	$ 294,514

LZ2 - 2017 Cost			
	2017 PSMH	2017 LED, $/klm Reduction	2017 LED, **without** $/klm Reduction
Small Parking	$ 43,820	$ 27,568	$ 28,842
Medium Parking	$ 94,852	$ 33,336	$ 55,526
Large Parking	$ 307,599	$ 276,877	$ 294,514

LZ3 - 2017 Cost			
	2017 PSMH	2017 LED, $/klm Reduction	2017 LED, **without** $/klm Reduction
Small Parking	$ 51,036	$ 30,064	$ 32,063
Medium Parking	$ 91,615	$ 48,600	$ 77,423
Large Parking	$ 337,714	$ 297,523	$ 314,386

LZ4 - 2017 Cost			
	2017 PSMH	2017 LED, $/klm Reduction	2017 LED, **without** $/klm Reduction
Small Parking	$ 48,428	$ 44,096	$ 47,094
Medium Parking	$ 93,098	$ 82,439	$ 87,327
Large Parking	$ 449,234	$ 403,161	$ 429,234

Appendix G: Statewide General Hardscape Area Estimates Information

Since the outdoor hardscape is not estimated as part of the construction forecasts, statewide impacts must be completed by making proxies with reasonable estimates of the relationship of the line item to the potential gross square footage of indoor spaces associated with the measure.

In effect, the estimates relate the unit of the measure (square foot of hardscape), with an equivalent unit of gross interior space, which can then be projected using the construction forecasts. Most measure line items only apply to certain building types (retail or small office, for example), and this is taken into account as well.

The process to develop the relationship of General Hardscape square footage to building gross square footage for statewide construction estimates is as follows:

1. Establish the square footage of a parking space (which will be the basic unit of comparison because of the code use of minimum spaces per square foot).
2. Determine any modifications to the basic unit required for specific building types to accommodate specific design requirements. This is primarily to adjust for warehouse buildings.
3. Determine the basic parking requirements for the listed building types in the construction forecasts.
4. Create a table of adjustment factors to apply to the respective building types, normalizing the value back to a single square footage unit to make the calculations work in a direct manner.

Step #1: Establish 'per space' Square Footage

The Statewide CASE Team first established the approximate square footage of hardscape associated with a single parking space, using the following assumptions that are based on general design documents and traditional design standards:

- Each parking space is approximately 144 square feet (8 feet by 18 feet).
- There is a drive lane to gain access to the space, and the minimum amount is one-half of the drive lane directly in front of the parking space. This adds 80 square feet (8 feet by 10 feet).
- The parking is only 'funded' to 75% on-site. This reduces the vehicle hardscape from 224 square feet to 168 square feet. There are many reasons this may occur, including trade-offs with mass transit, on-street parking, garage space parking, etc. Many municipalities permit trades of this kind. The actual amount is unclear, so this adjustment is an estimate based on reasonable expectations.
- There is vehicular hardscape that is not specifically associated with the parking lot. This adds 40 square feet per space. This constitutes all of the hardscape on a site that is oriented to vehicles, but not specifically included in the parking space requirements that

the municipalities are establishing, including loading docks, access drives, pick-up and drop-off zones, etc. However, warehouse buildings have a large requirement for loading dock and access hardscape that is underrepresented in this without increasing this value to 1,800 square feet.

- There is hardscape that is not vehicle oriented that must be included. This constitutes all the rest of the hardscape on a site, and includes sidewalks required to gain access to the building. The non-vehicular hardscape adds 40 square feet to the hardscape per space.

This results in a net of 250 square feet of hardscape per parking space for the basic Parking Space unit.

Step #2: Modifications for Specific Building Types

The majority of building types in the construction forecasts can use the 250 square feet per space estimate. However, warehouses are an exception to this and need adjustment to these values.

- Parking space - 144 square feet.
- Drive lane - 80 square feet.
- The parking is only 'funded' to 75% on-site - 168 square feet.
- Other vehicular hardscape - Warehouse buildings have a large requirement for loading dock and access hardscape that is underrepresented without using a much higher hardscape value because the number of people in the buildings is low relative to the size of the building and the large vehicles on the site. Based on reasonable estimates, this addition should be 390 square feet.
- Non-vehicular hardscape - 40 square feet.

This results in a net of 600 square feet of hardscape per parking space for warehouses. This will be applied as an adjustment multiplier in step #4.

Step #3: Determine General Parking Requirements

The general hardscape square footage values are based on the requirements for parking spaces in various building development codes. These vary depending on the building density and location; how urban or suburban the region is. The parking space requirements also vary depending on the use of the building, and other variables. Figure 49 provides information from three metropolitan areas that show the range of minimum parking space accommodation requirements in the local building standards (NRC2013), (MTC2012), (LADBS2013).

Figure 49: Parking Space Requirements for Various Metropolitan Regions

Metro Region	Office	Retail	Restaurant	Mixed Use	Warehouse	Hotel	Industrial	School	College
	Parking Space Minimums (One space Per...)								
Los Angeles Area[1.]	500sf	250sf	100sf	-	500sf up to 10,000sf, 5,000sf after		500sf	Classroom (elementary)	5 seats (classroom)
San Diego Area[2.]	250sf to 330sf	200sf to 1,000sf	70sf to 1,000sf	-	1,000sf	Each hotel room, and Per 100sf convention space	400sf to 650sf	.5 Classroom (elementary), 5 students (high school)	-
Bay Area Metro Region[3.]	200sf to 400sf	200sf to 500sf	-	500sf to 1,000sf	1,000sf	-	-	-	-

1. *Los Angeles City Department of Bulding and Safety, 2013. P/ZC 2002-011.*
2. *Dan Diego Municipal Code, 2009. Chapter 4: General Regulations.*
3. *Survey of Bay Area Cities' Parking Requirements: Summary Report. Includes cities in Alameda, Contra Costa, Napa, San Mateo, Santa Clara, Solano, and Sonoma counties.*

Using reasonable estimates from the wide range of parking space requirements, the minimums were translated into reasonable single values for individual building types that match the construction estimate forecasts. These values are shown in Figure 50.

Figure 50: Representative Code Parking Space Requirements Employed

	Office, LG & SM	Retail	Restaurant	Food (Grocery)	Warehouse, Ref & NR	Hotel	School	College	Other
	Representative Code-Collected Parking Minimums (One space per)								
Value Employed	250sf	360sf	250sf	250sf	2,000sf	360sf	360sf	250sf	360sf

These values were grouped into three basic groups; 250sf, 360sf, and 2,000sf. These will also be applied as adjustment multiplier in step #4.

Step #4: Create a Table of Adjustment Factors

The best method to apply general hardscape to each building type is to determine a single unit of adjustment and apply that unit to the construction square footage uniformly if possible.

In this case, the unit selected is a single Parking Space, which represents 250 square feet of hardscape, as was determined in Step #1.

However, since some building types require more square footage per space, and the various buildings have different densities for the spaces, a table must be developed to adjust this unit for the specifics of the individual building types.

Figure 51 below provides this table and represents the process for making the adjustments to the influence factors that are applied in the statewide impacts calculations.

Figure 51: Parking Space Area Multipliers Applied in Statewide Calculations

	Area Multipliers to Apply to Building Types (Using 250sf as Basic Unit)						
	Basic Parking Unit	Adjustment for Site Differences		Adjustment for Code Requirement Differences		Final Value	**Converted Into "Basic (250sf) Parking Units"**
		S. F. Per Space Required	Adjustment	Per Space Min. Required	Adjustment		
Parking Space for Office, Grocery, Restaurant, College Building Types	250sf	---	---	250sf	1	250sf	**1**
Parking Space for Retail, Hotel, School, Other Building Types	250sf	---	----	360sf	0.7	360sf	**0.7**
Parking Space for Warehouse, REF & NR	250sf	600sf	2.4	2,000sf	0.125	830sf	**0.3**

As a result, the energy savings in the first row of building types are applied at the rate of 250 square feet of hardscape for each 250 square feet of gross building area. The second row of building types savings are applied at the rate of 250 square feet of hardscape to 360 square feet of gross building area. Warehouse savings are applied at the rate of 250 square feet for every 830 square feet of warehouse gross area, which is equivalent to 600 square feet of hardscape in 2,000 square feet for warehouse.