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

Nonresidential Outdoor Sources – Results Report

Measure ID: 2022-NR-LIGHT3-F
Nonresidential Lighting

December 2022

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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

Copyright 2022 Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District. All rights reserved, except that this document may be used, copied, and distributed without modification.

Neither Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, Sacramento Municipal Utility District or any of its employees makes any warranty, express or implied; or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any data, information, method, product, policy or process disclosed in this document; or represents that its use will not infringe any privately-owned rights including, but not limited to, patents, trademarks or copyrights.

Pacific Gas and Electric Company
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
SDGE A Sempra Energy utility
LA DWP Los Angeles Department of Water & Power
SMUD

Document Information

Category:	**Codes and Standards**
Keywords:	Statewide Codes and Standards Enhancement (CASE) Initiative, Statewide Utility Codes and Standards Team, Codes and Standards Enhancements, 2022 Title 24, Part 6, efficiency, lighting zone reclassification; general hardscape; Lighting Power Allowance (LPA); multifamily.
Authors:	Annie Kuczkowski (Clanton & Associates); Dan Baldewicz, Rachel Levine, Christopher Uraine (Energy Solutions); Michael Mutmansky (TRC Companies, Inc.)
Prime Contractor	Energy Solutions
Project Management:	California Utilities Statewide Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District

Table of Contents

1. Introduction 1
2. Measure Description 1
2.1 Summary of Adopted Requirements 1
2.2 Summary of Proposed Requirements That Were Not Adopted 2
2.3 Summary of Proposed Requirements That Were Not Adopted 3
3. Statewide Energy Impacts of Adopted Requirements 4
4. Compliance and Enforcement 4
5. Interactions with Existing Regulations 5
6. Evolution of Code Requirements 6
7. Adopted Code Language 6
7.1 California Administrative Regulations, Title 24, Part 1 7
7.2 California Energy Code, Title 24, Part 6 7
8. Bibliography 15
Attachment 1: Public Comments Submitted by the Statewide CASE Team 16
Attachment 2: Final CASE Report 17

List of Tables

Table 1: Scope of Adopted Code Change 3
Table 2: First-Year[a] Statewide Energy and Impacts 4

1. Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (CEC) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities –Los Angeles Department of Water and Power, and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings to the CEC, the state agency that has authority to adopt revisions to Title 24, Part 6. The CEC evaluates proposals submitted by the Statewide CASE Team and other stakeholders and may revise or reject proposals.

In September 2020, the Statewide CASE Team submitted the CASE Report that is presented in Attachment 1 to recommend code changes related to nonresidential outdoor sources. This document explains the revisions that occurred to the proposed code changes between the submittal of the Final CASE Report to the CEC and the CEC's adoption of the 2022 Title 24, Part 6 Standards on August 11, 2021. The document begins with a concise description of the adopted code language, followed by the estimated energy savings of the adopted requirements, with the remainder of the document outlining the evolution of the code changes and the final adopted language.

2. Measure Description

2.1 Summary of Adopted Requirements

All submeasures in this report were adopted and are intended to be applied through the prescriptive approach to compliance and apply to new construction in California. The nonresidential submeasures also apply to alterations and additions in California. The determination of lighting zones is found in Section 10-114. Lighting zones determine which LPAs are applicable, so the Statewide CASE Team still considers this as affecting prescriptive requirements. Both the nonresidential lighting zone (LZ) reclassification and LPAs for general hardscape submeasures apply to nonresidential buildings only. The multifamily outdoor LPAs submeasure applies to multifamily properties, including those with mixed-use spaces contained within.

The Statewide CASE Team proposed a LZ reclassification that more closely aligns the statewide default location definitions with the Illuminating Engineering Society /

International Dark-Sky Association (IES/IDA) Model Lighting Ordinance land-use based LZ classifications. This adopted submeasure continues to use the 2010 U.S. Census population density mapping for the LZ determination with a revision that updates rural classifications as LZ 1 and added urban clusters as the default classification for LZ 2.

The adopted general hardscape LPAs were revised to align with the IES RP-8-18 Chapter 17 Addendum 1. The concrete and asphalt surface distinction was removed and LPAs were reduced to align with the lighting levels IES recommends for parking lots and general hardscape applications. A new allowance for security cameras was also developed by the Statewide CASE Team to address stakeholders' concerns for general hardscape areas with security needs and was added as Addendum O to the Final CASE Report.

The adopted multifamily outdoor LPA submeasure develops several new code sections that are placed in the new multifamily chapter of code. This measure addresses outdoor lighting needs of multifamily housing and creates limits for outdoor lighting that are more appropriate for residential conditions that are associated with multifamily housing.

The Statewide CASE Team proposed to update language in the mandatory section for outdoor lighting to revise outdated terminology. Specifically, Section 130.2(b) used "cutoff" which is now outdated, so the Statewide CASE Team proposed to update the language to "shielding." This proposal was adopted but has no affect stringency or associated savings.

Scope of Code Change Proposal

2.2 Summary of Proposed Requirements That Were Not Adopted

CEC adopted all of the Statewide CASE Team's major proposed requirements.

There was one minor difference between the Statewide CASE Team's proposed code language and the adopted language. The Statewide CASE Team recommended adding a definition in Section 100.1 for the IES Recommended Practice document titled "American National Standard Practice for Design and Maintenance of Roadway and Parking Facility Lighting", which is also known as IES RP-8 to the code. The lighting levels used to develop the adopted lighting allowances cam from IES RP-8. Since IES RP-8 was not referenced anywhere else in the code language, the CEC did not proceed with adding a definition of IES RP-8. The Statewide CASE Team agreed with this revision to the code language prior to the language being adopted as the change simplified code language and it did not affect the stringency of the adopted requirements.

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

Table 1: Scope of Adopted Code Change

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Would Compliance Software Be Modified?	Modified Compliance Document(s)
Nonresidential Lighting Zone Reclassification	Administrative	10-114	N/A	No	N/A
Nonresidential Lighting Power Allowances for General Hardscapes	Prescriptive	100.1 140.7	N/A	No	NRCC-LTO-E
Multifamily Outdoor Lighting Power Allowances	Mandatory and Prescriptive	130.2 140.7 (revised) 160.5 170.2(e)6 (new multifamily code sections)	N/A	No	NRCC-LTO-E (revised and renumbered to be unique for multifamily)

2.3 Summary of Proposed Requirements That Were Not Adopted

CEC adopted all of the Statewide CASE Team's major proposed requirements.

There was one minor difference between the Statewide CASE Team's proposed code language and the adopted language. The Statewide CASE Team recommended adding a definition in Section 100.1 for the IES Recommended Practice document titled "American National Standard Practice for Design and Maintenance of Roadway and Parking Facility Lighting", which is also known as IES RP-8 to the code. The lighting levels used to develop the adopted lighting allowances cam from IES RP-8. Since IES RP-8 was not referenced anywhere else in the code language, the CEC did not proceed with adding a definition of IES RP-8. The Statewide CASE Team agreed with this revision to the code language prior to the language being adopted as the change simplified code language and it did not affect the stringency of the adopted requirements.

3. Statewide Energy Impacts of Adopted Requirements

Error! Reference source not found. presents the estimated energy and demand impacts of the proposed code change that would be realized statewide during the first 12 months that the 2022 Title 24, Part 6 requirements are in effect. First-year statewide energy impacts are represented by the following metrics: electricity savings in gigawatt-hours per year (GWh/yr), peak electrical demand reduction in megawatts (MW), natural gas savings in million therms per year (MMTherms/yr), and time dependent valuation (TDV) energy savings in kilo British thermal units per year (TDV kBtu/yr). See Final CASE Report, Section B for more details on the first-year statewide impacts calculated by the Statewide CASE Team. The Final CASE Report, Section **Error! Reference source not found.** contains details on the per-unit energy savings calculated by the Statewide CASE Team.

Table 2: First-Year[a] Statewide Energy and Impacts

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (MMTherms/yr)
LZ Reclassification (Total)	**2.82**	**0.45**	**N/A**
New Construction and Additions	0.69	0.11	N/A
Alterations	2.13	0.34	N/A
General Hardscape LPAs (Total)	**24.30**	**3.11**	**N/A**
New Construction and Additions	5.91	0.76	N/A
Alterations	18.40	2.35	N/A
Multifamily (Total)	**11.75**	**2.29**	**N/A**
New Construction and Additions	2.28	0.45	N/A
Alterations	9.47	1.85	N/A

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

4. Compliance and Enforcement

- There were no changes to the compliance or enforcement recommendations between the time the Statewide CASE Team submitted the Final CASE Report and the CEC adopted requirements. Compliance and enforcement is discussed in Section 2.5 and Appendix E of the Final CASE Report, which is provided in Statewide CASE Team, Docket #21-BSTD-01 TN#238404 “Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 1”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238404&DocumentContentId

=71705

- Statewide CASE Team, Docket #21-BSTD-01 TN#238406, “Statewide Utility Codes and Standards Enhancement Team Comments -Comments on 45-Day Express Terms_Part 2”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238406&DocumentContentId=71707
- Statewide CASE Team, Docket #21-BSTD-01 TN#238409 “Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 3”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238409&DocumentContentId=71710
- Statewide CASE Team, Docket #21-BSTD-01 TN#239075 “Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 1”, 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239075&DocumentContentId=72509
- Statewide CASE Team, Docket #21-BSTD-01 TN#239074 “Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 2”, 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239074&DocumentContentId=72510

Attachment 2: Final CASE Report.

5. Interactions with Existing Regulations

- Section 2.4 of the Final CASE Report describes how the proposed code changes interact with existing regulations. Since CEC adopted the requirements as proposed with only minor revisions, the information in the Final CASE Report remains an accurate description of how the adopted requirements interact with existing regulations. See the Final CASE Report in Statewide CASE Team, Docket #21-BSTD-01 TN#238404 “Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 1”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238404&DocumentContentId=71705
- Statewide CASE Team, Docket #21-BSTD-01 TN#238406, “Statewide Utility Codes and Standards Enhancement Team Comments -Comments on 45-Day Express Terms_Part 2”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238406&DocumentContentId

=71707

- Statewide CASE Team, Docket #21-BSTD-01 TN#238409 “Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 3”, 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238409&DocumentContentId=71710
- Statewide CASE Team, Docket #21-BSTD-01 TN#239075 “Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 1”, 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239075&DocumentContentId=72509
- Statewide CASE Team, Docket #21-BSTD-01 TN#239074 “Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 2”, 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239074&DocumentContentId=72510

Attachment 2: Final CASE Report.

6. Evolution of Code Requirements

The Statewide CASE Team submitted the Final CASE Report to the CEC in September 2020. The Final CASE Report addresses input that was received during utility-sponsored stakeholder meetings held on September 5, 2019 and March 3, 2020 as well as during the CEC’s pre-rulemaking workshops that were held on October 7, 2020 and September 22, 2020. This section is intended to describe how the code change proposal evolved between the time Final CASE Report was submitted to the CEC and the time the standards were adopted.

As noted in Section 2.1, the CEC adopted all major proposed changes that the Statewide CASE Team recommended in the Final CASE Report. The proposals did not evolve in a substantive way between the time Final CASE Report was submitted to the CEC and the time the standards were adopted.

7. Adopted Code Language

The adopted code language for the standards and Reference Appendices are presented in the following sections. Additions to the 2019 Title 24, Part 6 code language are <u>underlined</u> and deletions are ~~struck~~.

7.1 California Administrative Regulations, Title 24, Part 1

SECTION 10-114 – DETERMINATION OF OUTDOOR LIGHTING ZONES AND ADMINISTRATIVE RULES FOR USE

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

Zone	Ambient Illumination	Statewide 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 areas of government designated parks, recreation areas, and wildlife preserves can be designated as LZ1 or LZ2 if they are contained within such a zone.	Not applicable
LZ1	Low	Rural areas, as defined by the 2010 U.S. Census. These areas include: single or dual family residential areas, parks, and agricultural zone districts, ~~Developed~~ developed portion 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 portion of a government designated park, recreation area, or wildlife preserve, can be designated as LZ2 or LZ3 if they are contained within such a zone. Retail stores, located in a residential neighborhood, and rural town centers, as defined by the 2010 U.S. Census, can be designated as LZ2 if the business operates during hours of darkness.	Not applicable.
LZ2	Moderate	~~Rural areas~~ Urban clusters, as defined by the 2010 U.S. Census. The following building types may occur here: multifamily housing, mixed use residential neighborhoods, religious facilities, schools, and light commercial business districts or industrial zoning districts.	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~~ mixed-use residential area or city center.	Special districts ~~and government designated parks within a default LZ2 zone~~ may be designated as LZ1 by the local jurisdiction, ~~for lower illumination standards,~~ without any size limits.
LZ3	Moderately High	Urban areas, as defined by the 2010 U.S. Census. The following building types may occur here: high intensity commercial corridors, entertainment centers, and heavy industrial or manufacturing zone districts.	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.

NOTE: Authority: Sections 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

7.2 California Energy Code, Title 24, Part 6

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

IES LM-79-19~~08~~ is ~~the~~an American National Standards authored by the Illuminating Engineering Society ~~document~~and titled, "Approved Method: Optical and Electrical Measurements of Solid State Lighting

Products~~IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products~~" (20~~0~~19~~8~~) (ANSI/IES LM-79-19).

IES TM-15-20-~~11~~ is an American National Standards authored by the Illuminating Engineering Society ~~document~~ and titled, "Technical Memorandum: Luminaire Classification System~~l w~~ for Outdoor Luminaires" (~~2011~~2020) (ANSI/IES TM-15-20).

Ornamental (Lighting/Luminaires) is lighting or luminaires installed outdoor which are rated for 50 watts or less ~~whichare rated for 30 watts or less thth~~that ~~at~~ are post-top luminaires, lanterns, pendant luminaires, chandeliers, and marqueelighting, not providing general lighting or task lighting.

Security Cameras are any operational camera used to enhance the safety and security within a general hardscape area.

SECTION 130.2 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(b) Luminaire ~~Cutoff~~ Shielding Requirements. All outdoor luminaires of 6,200 initial luminaire lumens or greater, shall comply with Backlight, Uplight, and Glare (BUG) (~~collectively referred to as "BUG"~~ in accordance with ANSI/IES TM-15-~~11~~20, ~~Addendum~~ Annex A) requirements~~ as follows~~

SECTION 140.7 – PRESCRIPTIVE REQUIREMENTS FOR OUTDOOR LIGHTING

TABLE 140.7-A GENERAL HARDSCAPE LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0[3]	Lighting Zone 1[3]	Lighting Zone 2[3]		Lighting Zone 3[3]		Lighting Zone 4[3]
	~~Asphalt/ Concrete~~	~~Asphalt/ Concrete~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt/ Concrete~~
Area Wattage Allowance (AWA)	No allowance[1]	~~0.018~~ 0.016 W/ft²	~~0.023~~ 0.019 W/ft²	~~0.025 W/ft²~~	~~0.025~~ 0.021 W/ft²	~~0.03 W/ft²~~	~~0.03~~ 0.024 W/ft²
Linear Wattage Allowance (LWA)	No allowance[1]	~~0.15~~ 0.13 W/lf	~~0.17~~ 0.15 W/lf	~~0.4 W/lf~~	~~0.25~~ 0.20 W/lf	~~0.4 W/lf~~	~~0.35~~ 0.29 W/lf
Initial Wattage Allowance (IWA)	No allowance[1]	~~180~~ 150 W	~~250~~ 200 W	~~250 W~~	~~350~~ 250 W	~~350 W~~	~~400~~ 320 W

[1] Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an 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 installed shall meet the maximum zonal lumen limits as specified in Section 130.2(b).

[2] ~~Where greater than 50% of the paved surface of a parking lot is finished with concrete. This does not extend beyond the parking lot, and does not include any other General Hardscape areas~~ RESERVED.

[3] Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna – shall be allowed a 2.0 lighting power allowance multiplier.

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.	Not applicable	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care Facilities, Police Stations, Healthcare Facilities, 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.	Not applicable	20 watts	40 watts	57 watts	60 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.	Not applicable	16 watts	30 watts	50 watts	75 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.	Not applicable	55 watts	77 watts	81 watts	135 watts
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	Not applicable	for first ATM machine, 35 watts for eachadditional 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.	Not applicable	No Allowance	11 W/linear ft	19 W/linear ft	25 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~~ 50 watts or less as determined in accordance with Section 130.0(~~d~~c), and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicable	No Allowance	0.007 W/ft²	0.013 W/ft²	0.019 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.	Not applicable	No Allowance	0.100 W/ft²	0.170 W/ft²	0.225 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.	Not applicable	0.060 W/ft²	0.210 W/ft²	0.280 W/ft²	0.485 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.	Not applicable	0.006 W/ft²	0.068 W/ft²	0.138 W/ft²	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.	Not applicable	0.220 W/ft²	0.430 W/ft²	0.580 W/ft²	1.010 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.	Not applicable	No Allowance	0.470 W/ft²	0.622 W/ft²	0.740 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.	Not applicable	0.057 W/ft²	0.137 W/ft²	0.270 W/ft²	0.370 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.	Not applicable	0.081 W/ft²	0.176 W/ft²	0.325 W/ft²	0.425 W/ft²
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.	Not applicable	No Allowance	0.056 W/ft²	0.200 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 shallbe within 2 mounting heights of the hardscape area of outdoor dining.	Not applicable	0.004 W/ft²	0.030 W/ft²	0.050 W/ft²	0.075 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.	Not applicable	0.004 W/ft²	0.005 W/ft²	0.010 W/ft²	No Allowance
Security Cameras. This additional allowance is for illuminated general hardscape area. This allowance shall apply when a security camera is installed within 2 mounting heights of the general hardscape area and mounted more than 10 feet away from a building.	Not applicable	No Allowance	0.018 W/ft²	0.018 W/ft²	0.018 W/ft²

SECTION 160.5 – MANDATORY LIGHTING REQUIREMENTS FOR INDOOR AND OUTDOOR SPACES

(c) Outdoor Lighting and Controls Equipment. Multifamily buildings shall comply with the applicable requirements of Sections 160.5(c)1 through 160.5(c)2.

1. Luminaire Shielding Requirements. All outdoor luminaires of 6,200 initial luminaire lumens or greater, shall comply with Backlight, Uplight, and Glare (BUG) (in accordance with ANSI/IES TM-15-20, Annex A) requirements in accordance with Title 24, Part 11, Section 5.106.8.

EXCEPTION 1 to Section 160.5(c)1: Signs.

EXCEPTION 2 to Section 160.5(c)1: Lighting for building facades, public monuments, public art, statues, and vertical surfaces of bridges.

EXCEPTION 3 to Section 160.5(c)1: Lighting not permitted by a health or life safety statute, ordinance, or regulation to be a cutoff luminaire.

EXCEPTION 4 to Section 160.5(c)1: Temporary outdoor lighting.

EXCEPTION 5 to Section 160.5(c)1: Replacement of existing pole mounted luminaires in hardscape areas meeting all of the following conditions:

A. Where the existing luminaire does not meet the luminaire BUG requirements in Section

160.5(c)1; and

B. Spacing between existing poles is greater than six times the mounting height of the existing luminaires; and

C. Where no additional poles are being added to the site; and

D. Where new wiring to the luminaires is not being installed; and

E. Provided that the connected lighting power wattage is not increased.

EXCEPTION 6 to Section 160.5(c)1: Luminaires that illuminate the public right of way including publicly-maintained or utility-maintained roadways, sidewalks, and bikeways.

EXCEPTION 7 to Section 160.5(c)1: Outdoor lighting attached to a multifamily building and separately controlled from the inside of a dwelling unit.

2. Controls for Outdoor Lighting. Outdoor lighting shall be independently controlled from other electrical loads, and the controls for outdoor lighting shall meet the following functional requirements:

EXCEPTION 1 to Section 160.5(c)2: Outdoor lighting not permitted by a health or life safety statute, ordinance, or regulation to be turned OFF or reduced.

EXCEPTION 2 to Section 160.5(c)2: Lighting in tunnels required to be illuminated 24 hours per day and 365 days per year.

A. Daylight Availability. All installed outdoor lighting shall be controlled by a photo control, astronomical time- switch control, or other control capable of automatically shutting OFF the outdoor lighting when daylight is available.

B. Automatic Scheduling Controls.

i. Automatic scheduling controls shall be installed for all outdoor lighting. Automatic scheduling controls may be installed in combination with motion sensing controls or other outdoor lighting controls.

ii. Automatic scheduling controls shall be capable of reducing the outdoor lighting power by at least 60 50 percent and no more than 90 percent, and separately capable of turning the lighting OFF, during scheduled unoccupied periods.

iii. Automatic scheduling controls shall allow scheduling of a minimum of two nighttime periods with independent lighting levels, and may include an override function that turns lighting ON during its scheduled dim or OFF state for no more than two hours when an override is initiated.

C. Motion Sensing Controls.

i. Motion sensing controls shall be installed for the following luminaires. Motion sensing controls may be installed for other outdoor lighting and in combination with other outdoor lighting controls:

a. Outdoor luminaires other than those providing Building Façade, Ornamental Hardscape, or Outdoor Dining, where the bottom of luminaire is mounted 24 feet above grade or lower; and,

b. Outdoor wall mounted luminaires installed for General Hardscape parking lot lighting, located within 1 mounting height of a parking space, mounted 24 feet above grade or lower.

ii. Motion sensing controls shall be capable of reducing the outdoor lighting power of each controlled luminaire by at least 50 percent and no more than 90 percent, and separately capable of turning the luminaire OFF, during unoccupied periods.

iii. Motion sensing controls shall be capable of reducing the lighting to its dim or OFF state no longer than 15 minutes after the area has been vacated, and of returning the lighting to its

ON state when the area becomes occupied.

iv. No more than 1,500 watts of lighting power shall be controlled by a single sensor or as a single zone.

EXCEPTION 1 to Section 160.5(c)2C: Luminaires with a maximum rated wattage of 40 watts each are not required to have motion sensing controls.

EXCEPTION 2 to Section 160.5(c)2C: Applications listed as Exceptions to Section 170.2(e)2A are not required to have motion sensing controls.

EXCEPTION 3 to Section 160.5(c)2C: Lighting subject to a health or life safety statute, ordinance, or regulation may have a minimum time-out period longer than 15 minutes or a minimum dimming level above 50 percent when necessary to comply with the applicable law.

~~(Draft1) Exception 4 to 160.5(c)2C: Parking lot luminaires installed to provide a light distribution of 4 mounting height (MH) or greater.~~

~~(or Draft2) Exception 4 to 160.5(c)2C: Parking lot luminaires installed at a mounting height greater than 15 feet and less than 24 feet above grade.~~

~~EXCEPTION 4 to Section 160.5(c)2C: For parking lots, luminaires with a maximum rated wattage of 78 watts each are not required to have motion sensing controls.~~

SECTION 170.2 – PRESCRIPTIVE APPROACH

6. Outdoor Lighting.

A. A multifamily or mixed occupancy outdoor lighting installation complies with this section if it meets the requirements in Subsections 170.2(e)6B and C, and the actual outdoor lighting power installed is no greater than the allowed outdoor lighting power calculated under Subsection 170.2(e)6D. The allowed outdoor lighting shall be calculated according to Outdoor Lighting Zone in Title 24, Part 1, Section 10-114.

EXCEPTIONS to Section 170.2(e)6A: 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 170.2(e)6:

i. Temporary outdoor lighting.

ii. Lighting required and regulated by the Federal Aviation Administration, and the Coast Guard.

iii. Lighting for public streets, roadways, highways, and traffic signage lighting, including lighting for driveway entrances occurring in the public right-of-way owned or maintained by local municipality or utility.

iv. Lighting for sports and athletic fields, and children's playgrounds.

v. RESERVED.

vi. Lighting of public monuments.

vii. Lighting of signs complying with the requirements of Sections 160.5(d) and 170.2(e)7.

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

ix. Landscape lighting.

x. RESERVED.

xi. 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.

xii. 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 170.2(e)6.

B. Outdoor Lighting Power Trade-offs. Outdoor lighting power trade-offs shall be determined as follows:

i. Allowed lighting power determined according to Section 170.2(e)6Di for general hardscape lighting allowance may be traded to specific applications in Section 170.2(e)6Dii, provided the hardscape area from which the lighting power is traded continues to be illuminated in accordance with Section 170.2(e)6Dia.

ii. Allowed lighting power determined according to Section 170.2(e)2Dii for additional lighting power allowances for specific applications shall not be traded between specific applications, or to hardscape lighting in Section 170.2(e)6Di.

iii. Trading off lighting power allowances between outdoor and indoor areas shall not be permitted.

C. Calculation of Actual Lighting Power. The wattage of outdoor luminaires shall be determined in accordance with Section 160.5(b)1.

D. Calculation of Allowed Lighting Power. The allowed lighting power shall be the combined total of the sum of the general hardscape lighting allowance determined in accordance with Section 170.2(e)2Di, and the sum of the additional lighting power allowance for specific applications determined in accordance with Section 170.2(e)6Dii.

i. 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), bridge(s), tunnel(s), and other improved area(s) that are illuminated. Public roadway(s) that are illuminated by a lighting system owned or maintained by the local municipality or utility shall not be included in the area calculations. 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 170.2-R for the appropriate Lighting Zone.

b. Determine the Initial Wattage Allowance (IWA) for general hardscape lighting from TABLE 170.2-R for the appropriate lighting zone. The hardscape area shall be permitted one IWA per site.

c. The general hardscape lighting allowance shall be the sum of the allowed watts determined from a and b above.

ii. Additional Lighting Power Allowance for Specific Applications. Additional lighting power for specific applications shall be the smaller of the additional lighting allowances for specific applications determined in accordance with TABLE170.2-S for the appropriate lighting zone, or the actual installed lighting power meeting the requirements for the allowance.

TABLE 170.2-R GENERAL HARDSCAPE MULTIFAMILY LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0[2]	Lighting Zone 1[2]	Lighting Zone 2[2]	Lighting Zone 3[2]	Lighting Zone 4[2]
Area Wattage Allowance (AWA)	No allowance[1]	0.026 W/ft²	0.030 W/ft²	0.038 W/ft²	0.055 W/ft²
Initial Wattage Allowance (IWA)	No allowance[1]	300 W	350 W	400 W	450 W

1 Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an 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 installed shall meet the maximum zonal lumen limits as specified in Section 160.5(c)1.

2 Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna – shall be allowed a 2.0 lighting powerallowance multiplier.

TABLE 170.2-S ADDITIONAL MULTIFAMILY 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.	Not applicable	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care 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.	Not applicable	20 watts	40 watts	57 watts	60 watts
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	Not applicable	100 watts for first ATM machine, 35 watts for each additional ATM machine.			
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 50 watts or less as determined in accordance with Section 160.5(b)1 and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicable	No Allowance	0.007 W/ft²	0.013 W/ft²	0.019 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. This allowance calculation shall not include portions of the building facades within 20 feet of residence bedroom windows.	Not applicable	No Allowance	0.100 W/ft²	0.170 W/ft²	0.225 W/ft²
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.	Not applicable	0.057 W/ft²	0.137 W/ft²	0.270 W/ft²	0.370 W/ft²

	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.	Not applicable	No Allowance	0.056 W/ft²	0.200 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.	Not applicable	0.004 W/ft²	0.030 W/ft²	0.050 W/ft²	0.075 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.	Not applicable	0.004 W/ft²	0.005 W/ft²	0.010 W/ft²	No Allowance
	Security Camera. This additional allowance is for the illuminated general hardscape area. This allowance shall apply when a security camera is installed within 2 mounting heights of the general hardscape area and mounted more than 10 feet away from a building.	Not applicable	No Allowance	0.018 W/ft²	0.018 W/ft²	0.018 W/ft²

8. Bibliography

Statewide CASE Team. 2020. "Nonresidential Outdoor Sources – Final CASE Report." https://title24stakeholders.com/wp-content/uploads/2020/09/NR-Outdoor-Light-Sources_Final-CASE-Report_Statewide-CASE-Team.pdf

Attachment 1: Public Comments Submitted by the Statewide CASE Team

Attachment 1 presents comments that the Statewide CASE Team submitted to the Energy Commission's docket that are relevant to this measure.

- Statewide CASE Team, Docket #21-BSTD-01 TN#238087 "Statewide Utility Codes and Standards Enhancement Team Comments on Outdoor Lighting Controls for 45-Day Language", 6/1/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238087&DocumentContentId=71361
- Statewide CASE Team, Docket #21-BSTD-01 TN#238404 "Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 1", 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238404&DocumentContentId=71705
- Statewide CASE Team, Docket #21-BSTD-01 TN#238406, "Statewide Utility Codes and Standards Enhancement Team Comments -Comments on 45-Day Express Terms_Part 2", 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238406&DocumentContentId=71707
- Statewide CASE Team, Docket #21-BSTD-01 TN#238409 "Statewide Utility Codes and Standards Enhancement Team Comments on 45-Day Express Terms_Part 3", 6/21/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238409&DocumentContentId=71710
- Statewide CASE Team, Docket #21-BSTD-01 TN#239075 "Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 1", 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239075&DocumentContentId=72509
- Statewide CASE Team, Docket #21-BSTD-01 TN#239074 "Statewide Utility Codes and Standards Enhancement Team Comments - Statewide CASE Team Support for Adoption of 15-Day Express Terms Part 2", 7/29/2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=239074&DocumentContentId=72510

Attachment 2: Final CASE Report

The final version of the CASE Report is provided in full in Attachment 2 to this report.

Nonresidential Outdoor Sources

2022-NR-LIGHT3-F | Nonresidential Lighting | September 2020 FINAL CASE REPORT

Prepared by Clanton & Associates, Energy Solutions,
and TRC Companies, Inc.

Please submit comments to info@title24stakeholders.com.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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

Copyright 2020 Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District. All rights reserved, except that this document may be used, copied, and distributed without modification.

Neither Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, Sacramento Municipal Utility District or any of its employees makes any warranty, express or implied; or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any data, information, method, product, policy or process disclosed in this document; or represents that its use will not infringe any privately-owned rights including, but not limited to, patents, trademarks or copyrights.

Pacific Gas and Electric Company
Southern California Edison — Energy for What's Ahead
SDGE — A Sempra Energy utility
LA DWP Los Angeles Department of Water & Power
SMUD

Document Information

Category:	**Codes and Standards**
Keywords:	Statewide Codes and Standards Enhancement (CASE) Initiative; California Statewide Utility Codes and Standards Team; Codes and Standards Enhancements; 2022 California Energy Code; 2022 Title 24, Part 6; efficiency; lighting zone reclassification; general hardscape; LPA; multifamily.
Authors:	Annie Kuczkowski (Clanton & Associates); Dan Baldewicz, Rachel Levine, Christopher Uraine (Energy Solutions); Michael Mutmansky (TRC Companies, Inc.)
Prime Contractor:	Energy Solutions
Project Management:	California Statewide Utility Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Sacramento Municipal Utility District, Los Angeles Department of Water and Power.

Table of Contents

1. Introduction ____ 17

2. Measure Description ____ 20

2.1 Measure Overview ... 20
2.2 Measure History ... 24
2.3 Summary of Proposed Changes to Code Documents ... 28
2.4 Regulatory Context ... 32
2.5 Compliance and Enforcement ... 34

3. Market Analysis ____ 37

3.1 Market Structure ... 37
3.2 Technical Feasibility, Market Availability, and Current Practices ... 37
3.3 Market Impacts and Economic Assessments ... 39
3.4 Economic Impacts ... 48

4. Energy Savings ____ 52

4.1 Key Assumptions for Energy Savings Analysis ... 52
4.2 Energy Savings Methodology ... 59
4.3 Per-Unit Energy Impacts Results ... 64

5. Cost and Cost Effectiveness ____ 67

5.1 Energy Cost Savings Methodology ... 67
5.2 Energy Cost Savings Results ... 67
5.3 Incremental First Cost ... 70
5.4 Incremental Maintenance and Replacement Costs ... 71
5.5 Cost Effectiveness ... 71

6. First-Year Statewide Impacts ____ 75

6.1 Statewide Energy and Energy Cost Savings ... 75
6.2 Statewide Greenhouse Gas (GHG) Emissions Reductions ... 80
6.3 Statewide Water Use Impacts ... 81
6.4 Statewide Material Impacts ... 81
6.5 Other Non-Energy Impacts ... 87

7. Proposed Revisions to Code Language ____ 90

7.1 Guide to Markup Language ... 90
7.2 Standards ... 90
7.3 Reference Appendices ... 107
7.4 ACM Reference Manual ... 107
7.5 Compliance Manuals ... 107
7.6 Compliance Documents ... 109

8. Bibliography 110
Appendix A : Statewide Savings Methodology 115
Appendix B : Embedded Electricity in Water Methodology 124
Appendix C : Environmental Impacts Methodology 125
Appendix D : California Building Energy Code Compliance (CBECC) Software Specification 127
Appendix E : Impacts of Compliance Process on Market Actors 128
Appendix F : Summary of Stakeholder Engagement 136
Appendix G : Multifamily Light and Health Topics 154
Appendix H : Multifamily Prototype Characterization 160
Appendix I : Multifamily Calculation Approach 168
Appendix J : Lighting Zone Calculations 188
Appendix K : General Hardscape Lighting Power Allowance Calculations 217
Appendix L : Mapping of IES Criteria 222
Appendix M : Nonresidential Use Schedules 230
Appendix N : Nominal Cost Savings Tables 236
Appendix O : Security Camera Technology 238
Appendix P : Ornamental Hardscape LED Conversion 240

List of Tables

Table 1: Scope of Code Change Proposal 13
Table 2: First-Year Statewide Energy and Impacts 15
Table 3: First-Year Statewide GHG Emissions Impacts 16
Table 4: California Construction Industry, Establishments, Employment, and Payroll 40
Table 5: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard 40
Table 6: California Building Designer and Energy Consultant Sectors 42
Table 7: California Housing Characteristics 44
Table 8: Distribution of California Housing by Vintage 45
Table 9: Owner- and Renter-Occupied Housing Units in California by Income 45
Table 10: Employment in California State and Government Agencies with Building Inspectors 47

Table 11: Estimated Impact that the Adoption of the Proposed Measures Would Have On The California Commercial Construction Sector 49

Table 12: Estimated Impact that Adoption of the Proposed Measure Would Have On The California Building Designers and Energy Consultants Sectors 49

Table 13: Estimated Impact that Adoption of the Proposed Measure Would Have On California Building Inspectors 50

Table 14: Nonresidential Outdoor Lighting Hours of Operation per Application 54

Table 15: Description of General Hardscape Layouts Used for Energy, Demand, Cost, and Environmental Impacts Analysis for General Hardscape 57

Table 16: Update to Percent of Construction Activity Per Lighting Zone 60

Table 17: Percent of Construction Activity Per Lighting Zone for General Hardscape Lighting Power Allowance 62

Table 18: Evaluated Site Characteristics by Prototype 63

Table 19: Multifamily Building Associated Prototype Weighting 63

Table 20: First-Year Energy Impacts Per Unit – Lighting Zone Reclassification 64

Table 21: First-Year Energy Impacts Per Unit – General Hardscape Lighting Power Allowance 65

Table 22: Weighted Average First-Year Energy Impacts Per Dwelling Unit – Multifamily Outdoor Lighting Power Allowance 66

Table 23: Update to Percent of Construction Activity Per Lighting Zone 67

Table 24: Lighting Zone Reclassification: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Unit – New Construction and Alterations 68

Table 25: Percent of Construction Activity Per Lighting Zone 69

Table 26: General Hardscape Lighting Power Allowance: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot 69

Table 27: Percent of Construction Activity Per Lighting Zone 69

Table 28: Multifamily Outdoor Lighting Power Allowance 2023 Present Value TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Dwelling Unit – New Construction and Alterations 70

Table 29: 15-Year Cost-Effectiveness Summary Per Unit – New Construction 73

Table 30: 15-Year Cost-Effectiveness Summary Per Unit – Alterations 74

Table 31: Statewide Energy and Energy Cost Impacts – Lighting Zone Reclassification – New Construction (NC), Alterations and Additions (A) 76

Table 32: Statewide Energy and Energy Cost Impacts – General Hardscape – New Construction, Alterations, and Additions 78
Table 33: Statewide Energy and Energy Cost Impacts Multifamily Outdoor Lighting Power Allowance – New Construction 79
Table 34: Statewide Energy and Energy Cost Impacts Multifamily Outdoor Lighting Power Allowance – Alterations 79
Table 35: First-Year Statewide GHG Emissions Impacts .**Error! Bookmark not defined.**
Table 36: GHG First-Year Reductions from Materials Impacts 81
Table 37: Mapping Building Types to Associated Parking Lot Size 83
Table 38: Estimated Reduction in Luminaires and Light Poles per Different Sized Parking Lots, General Hardscape 84
Table 39: Estimated Reduction in Luminaires and Light Poles per Different Sized Parking Lots, Multifamily 84
Table 40: First-Year Statewide Impacts on Material Use for General Hardscape Lighting Power Allowance 85
Table 41: First-Year Statewide Impacts on Material Use for Multifamily Hardscape Lighting Power Allowance 86
Table 42: First-Year Statewide Impacts on Material Use for All Measures 87
Table 43: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2023, by General Hardscape and Specific Application and Building Type (Million Square Feet) 117
Table 44: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2023 (Alterations), by General Hardscape and Application and Building Type (Million Square Feet) 119
Table 45: Example of Redistribution of Miscellaneous Category - 2023 New Construction in Climate Zone 1 121
Table 46: Estimated Security Camera Prevalence in General Hardscape, by Building Type. 122
Table 47: Percent of Floorspace Impacted by Proposed Measure, by Climate Zone .. 123
Table 48: Roles of Market Actors in the Proposed Compliance Process 130
Table 49. Room and Window Modeling Properties 156
Table 50: Light and Health Survey Responses 156
Table 51: 2019 Nonresidential Lighting Power Allowance by Lighting Zone 161

Table 52: 2019 Calculated Lighting Power Allowance Wattage by Site Using 2019 NR Allowance Table 161
Table 53: 2019 Equivalent Lighting Power Allowance without Linear Wattage Allowance 162
Table 54: 2019 Lighting Power Allowance Wattage by Site Using Alternate LPA Table Excluding Linear Wattage Allowance 162
Table 55: Area to Perimeter Ratio by Site 163
Table 56: Percent Change in Total Lighting Power Allowance by Site 164
Table 57: 2022 Proposed Nonresidential Lighting Power Allowance Values 165
Table 58: Percent Change in Lighting Power Allowance between 2019 and 2022 Nonresidential Lighting Power Allowance Values 165
Table 59: 2022 Proposed Multifamily Allowance Values 165
Table 60: Site Characteristics by Prototype 166
Table 61: Evaluated Site Characteristics 167
Table 62: Parking Lot Geometry Assumptions 169
Table 63: Parking Lot Calculation Grid Values 170
Table 64: Parking Lot Building Calculation Grid Values 170
Table 65: Parking Lot Calculation Design Criteria 170
Table 66: Pedestrian Space Calculation Geometry Assumptions 171
Table 67: Pedestrian Space Calculation Grid Values 173
Table 68: Pedestrian Space Building Calculation Grid Values 173
Table 69: Calculation Results – Parking Lot, Pt. 1 178
Table 70: Calculation Results – Parking Lot, Pt. 2 179
Table 71: Calculation Results – Parking Lot, Pt. 3 180
Table 72: Calculation Results – Parking Lot, Pt. 4 181
Table 73: Calculation Results – Parking Lot, Pt. 5 182
Table 74: Calculation Results – Parking Lot, Pt. 6 183
Table 75: Calculation Results – Plaza, Pt. 1 184
Table 76: Calculation Results – Plaza, Pt. 2 185
Table 77: Calculation Results – Plaza, Pt. 3 186
Table 78: Calculation Results – Plaza, Pt. 4 187

Table 79: Building Entrances and Exits Cost per Watt 189
Table 80: Building Entrances and Exits Cost per Watt, continued 190
Table 81: Building Entrances and Exits Cost per Watt, continued 191
Table 82: Primary Entrances Cost per Watt 192
Table 83: Primary Entrances Cost per Watt, continued 193
Table 84: Primary Entrances Cost per Watt, continued 194
Table 85: Drive-Up Window Cost per Watt 195
Table 86: Drive-Up Window Cost per Watt, continued 196
Table 87: Drive-Up Window Cost per Watt, continued 197
Table 88: Uncovered Fuel Dispenser Cost per Watt 198
Table 89: ATM Machine Lighting Cost per Watt 199
Table 90: ATM Machine Lighting Cost per Watt, continued 200
Table 91: Outdoor Sales Frontage Cost per Watt 201
Table 92: Hardscape Ornamental Lighting Cost per Watt 201
Table 93: Building Facades Cost per Watt 202
Table 94: Outdoor Sales Lots Cost per Watt 203
Table 95: Vehicle Service Station Hardscape Cost per Watt 204
Table 96: Vehicle Service Station Canopies Cost per Watt 205
Table 97: Sales Canopies Cost per Watt 206
Table 98: Sales Canopies Cost per Watt, continued 207
Table 99: Non-sales Canopies and Tunnels Cost per Watt 208
Table 100: Non-sales Canopies and Tunnels Cost per Watt, continued 209
Table 101: Guard Stations Cost per Watt 210
Table 102: Student Pick-up / Drop-off Zone Cost per Watt 211
Table 103: Student Pick-up / Drop-off Zone, continued 212
Table 104: Student Pick-up / Drop-off Zone, continued 213
Table 105: Outdoor Dining Cost per Watt 214
Table 106: Outdoor Dining Cost per Watt, continued 215
Table 107: Special Security Lighting for Retail Parking and Pedestrian Hardscape Cost per Watt 216

Table 108: General Hardscape Luminaire Characteristics and Cost 218
Table 109: General Hardscape Weighting 219
Table 110: 2019 Title 24 Lighting Zone Weighting 220
Table 111: 2022 Title 24 Lighting Zone Weighting 220
Table 112: General Hardscape Weighted Cost Comparison 221
Table 113: Lighting Criteria Mapping 222
Table 114: Lighting Zone Reclassification: Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Unit – New Construction and Alterations 236
Table 115: General Hardscape Lighting Power Allowance: Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot 237
Table 116: Multifamily Outdoor Lighting Power Allowance Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Dwelling Unit – New Construction and Alterations 237
Table 117: LED Equivalent Ornamental Hardscape Products 241

List of Figures

Figure 1: Representation of general hardscape layouts used to determine new lighting power allowances. 57
Figure 2: Real parking lot designs used to confirm recommended light levels could be achieved with the proposed lighting power allowances. 58
Figure 3: Top five respondent roles (n=54). 139
Figure 4: Percent of respondents with experience with various lighting types (n=62). 139
Figure 5: Impact on designed lighting levels if IES decreased lighting level recommendations (n=42). 140
Figure 6: Likelihood of security issues from applying IES recommendations for projects in non-secure environments (n=42). 140
Figure 7: How often respondents think IES-recommended lighting levels would negatively affect their lighting projects (n=51). 141
Figure 8: Familiarity with Dark-Sky Association (IDA) and the Illuminating Engineering Society Model Lighting Ordinance (MLO) (n=50). 141
Figure 9: Overall importance of considering light pollution or light trespass for outdoor lighting design (n=50). 142

Figure 10: Likelihood of installing luminaires with appropriate lumen outputs, distribution, and shielding instead of installing additional equipment (n=48). 143
Figure 11: Desired assistance in determining lighting zones. 144
Figure 12: Typical mounting height for parking poles (n=33). 144
Figure 13: Typical mounting height for building entrances (n=32). 145
Figure 14: Typical mounting height for building mounted area lights (n=33). 145
Figure 15: Typical pole-to-pole spacing for parking poles (n=28). 146
Figure 16: Typical pole to pole spacing for pedestrian poles (n=30). 146
Figure 17: Typical lighting output for parking poles for projects completed in past six months (n=27). 147
Figure 18: Typical lighting output for building entrances for projects completed in past six months (n=29). 147
Figure 19: Typical lighting output for pedestrian poles for projects completed in past six months (n=24). 148
Figure 20: Typical light distribution for pedestrian and parking poles for projects completed in past six months. 148
Figure 21: Frequency of consideration of light trespass in different scenarios. 149
Figure 22: Frequency of generation of site photometric calculation to analyze potential light trespass into residential units (n=23). 149
Figure 23: Use of internal and external shielding to ensure no light shines above 90 degrees from horizontal (n=29). 150
Figure 24: Familiarity with IES Backlight, Uplight, and Glare (BUG) rating system (n=32). 150
Figure 25: Frequency of specification or implementation of lighting products with specific cutoff attributes on multifamily lighting design projects to address light trespass concerns for residents (n=27). 151
Figure 26: How often respondents specify or implement lighting with specific BUG attributes to address light trespass concerns (n=27). 151
Figure 27: Color temperature preferences for outdoor lighting projects (n=28). 152
Figure 28: Color temperature preferences for nonresidential outdoor lighting projects (n=15). 152
Figure 29: Reduction of lighting system from late-night setback for site lighting (n=29). 153

Figure 30: Parking space calculation model. 169
Figure 31: Pedestrian space calculation model. 172
Figure 32: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios. 174
Figure 33: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios with lighting zone differentiation. 175
Figure 34: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios with mounting height differentiation 176
Figure 35: General Hardscape with Motion Sensor 230
Figure 36: General Hardscape 230
Figure 37: Schedule A 231
Figure 38: Schedule B 231
Figure 39: Schedule C 232
Figure 40: Schedule D 232
Figure 41: Schedule Retail 233
Figure 42: Schedule Service Station Hardscape 233
Figure 43: Schedule Service Station Canopies 234
Figure 44: Schedule ATM 234
Figure 45: Schedule Outdoor Dining 235
Figure 46: Schedule Outdoor Sales Lots 235

Executive Summary

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

Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2022 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency.

The overall goal of this CASE Report is to present a code change proposal for nonresidential and multifamily outdoor lighting sources. The report contains pertinent information supporting the code change.

Measure Description

Proposed Submeasure History

The nonresidential lighting zone reclassification proposed submeasure is based on a joint recommendation by the International Dark-Sky Association (IDA) and the Illuminating Engineering Society (IES) to lower outdoor lighting use levels and aims to protect the environment and reduce unnecessary outdoor lighting energy use. Five

lighting zones (LZ0-LZ4) are currently defined in Title 24, Part 6 by using the definitions of rural and urban areas in United States (U.S.) Census. This method has resulted in the misclassification and subsequent over lighting of much of the state. Several cities nationwide have already adopted lighting zone classifications lower than what current code requires, including: Malibu, California; Los Angeles County, California; San Jose, California; and Plymouth, Minnesota.

A recent addendum to IES RP-8-18 (previously published as IES RP-20-14), based in part on research by the Virginia Tech Transportation Institute (VTTI), indicates that visibility improvements in parking lots plateau at lower light levels than those recommended in IES RP-8-18 (Bhagavathula and Gibbons 2019). The proposed changes to the lighting power allowances (LPAs) for general hardscape applications would realign the code language with IES RP-8-18 Chapter 17 Addendum 1.

The multifamily outdoor LPAs submeasure develops several new code sections that would be placed in the multifamily chapter of code being proposed for the Multifamily Chapter Restructuring Final CASE Report.[1] This new chapter is intended only for the multifamily building type and carves this section of coverage away from the current nonresidential chapters of Title 24, Part 6. This measure addresses outdoor lighting needs of multifamily housing and creates limits for outdoor lighting that are more appropriate for residential conditions that are associated with multifamily housing.

Proposed Code Change

All submeasures proposed in this report are intended to be applied through the prescriptive approach to compliance and apply to new construction in California. The nonresidential submeasures also apply to alterations, and additions in California. It should be noted that the determination of lighting zones is found in Section 10-114. However, lighting zones determine which LPAs are applicable, so the Statewide CASE Team still considers this as affecting prescriptive requirements. Both the nonresidential lighting zone reclassification and LPAs for general hardscape submeasures apply to nonresidential buildings only. The multifamily outdoor LPAs submeasure applies to multifamily properties, including those with mixed-use spaces contained within.

The Statewide CASE Team is proposing a lighting zone reclassification that aligns the Statewide default location definitions with the IES/IDA Model Lighting Ordinance land-use based lighting zone classifications. This submeasure continues to use the 2010 U.S. Census population density mapping for the lighting zone determination with a

[1] More information on the Multifamily Chapter Restructuring Final CASE Report can be found here: https://title24stakeholders.com/measures/cycle-2022/multifamily-chapter-restructuring/

revision that would update rural classifications as lighting zone 1 and add urban clusters as the default classification for lighting zone 2.

The general hardscape LPAs are proposed to be revised to align with the IES RP-8-18 Chapter 17 addendum 1. The concrete and asphalt surface distinction would be removed and these LPAs would be reduced to align with the lighting levels IES now recommends for parking lots and general hardscape applications. A new allowance for security cameras is proposed to address stakeholders' concerns for general hardscape areas with security needs.

The multifamily outdoor LPA submeasure develops several new code sections that would be placed in the proposed multifamily chapter of code. This measure addresses outdoor lighting needs of multifamily housing and creates limits for outdoor lighting that are more appropriate for residential conditions that are associated with multifamily housing.

Scope of Code Change Proposal

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

Table 1: Scope of Code Change Proposal

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Would Compliance Software Be Modified	Modified Compliance Document(s)
Nonresidential Lighting Zone Reclassification	Administrative	10-114	N/A	No	N/A
Nonresidential Lighting Power Allowances for General Hardscapes	Prescriptive	100.1, 140.7	N/A	No	NRCC-LTO-E
Multifamily Outdoor Lighting Power Allowances	Mandatory and Prescriptive	130.2, 140.7 (revised and renumbered to be unique for multifamily)	N/A	No	NRCC-LTO-E (revised and renumbered to be unique for multifamily)

Market Analysis and Regulatory Assessment

The proposed code changes in this document are based on an analysis of LED luminaires currently available on the market. The Statewide CASE Team studied 119 different LED products from 58 different manufacturers to develop the LPA adjustments for general hardscape and multifamily. LED lighting technology has significantly advanced within the last decade and is expected to have a 99 percent adoption by 2023 (Goebes 2018).

Due to stakeholder comments about security concerns in general hardscape applications, an additional allowance has been added for security cameras. This adder would allow higher lighting levels for general hardscape applications than those recommended in IES RP-8-18 Addendum 1 and the tenth edition of the IES Handbook. This allowance for higher lighting levels is intended to increase the sense of safety within the space while ensuring that cameras installed in the 2022 code cycle will have sufficient light to identify colors during nighttime hours.

The statewide lighting zone default locations would be updated in Title 24, Part 6 Section 10-114 to align with the IES and IDA lighting zone definitions listed in the Model lighting Ordinance (MLO). In addition, Title 24, Part 6 Section 140.7 would also include LPAs for multifamily dwellings.

Cost Effectiveness

The proposed code changes in this document were found to be cost effective for all climate zones where they are expected to be required. The benefit-to-cost (B/C) ratio compares the benefits or cost savings to the costs over the 15-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

Lighting zone reclassification: The B/C ratio for this measure is 1.0 since reclassifying the lighting zones to lower lighting zones results in energy savings. See Section 5 for the methodology, assumptions, and results of the cost-effectiveness analysis.

General hardscape LPAs: The B/C ratio for this measure is 1.0 since less lighting equipment is necessary to meet IES RP-8-18 Addendum 1. See Section 5 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Multifamily LPAs: The B/C ratio for this measure is 1.0. See Section 5 for the methodology, assumptions, and results of the cost-effectiveness analysis.

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

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

Table 2: First-Year Statewide Energy and Impacts

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (MMTherms/yr)	TDV Energy Savings (TDV kBtu/yr)
LZ Reclassification (Total)	**2.82**	**0.45**	**N/A**	**85,398,407**
New Construction	0.69	0.11	N/A	20,907,735
Additions and Alterations	2.13	0.34	N/A	64,490,672
General Hardscape LPAs (Total)	**24.30**	**3.11**	**N/A**	**725,628,010**
New Construction	5.91	0.76	N/A	176,358,096
Additions and Alterations	18.40	2.35	N/A	549,269,914
Multifamily (Total)	**11.75**	**2.29**	**N/A**	**373,237,000**
New Construction	2.28	0.45	N/A	72,514,000
Additions and Alterations	9.47	1.85	N/A	300,722,000

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

Table 3: First-Year Statewide GHG Emissions Impacts

Measure	Avoided GHG Emissions (Metric Tons CO2e/yr)	Monetary Value of Avoided GHG Emissions ($2023)
Lighting Zone Reclassification	676.9	71,751
General Hardscape LPAs	5,841.5	619,199
Multifamily	2,812.7	298,146
Total	**9,331.1**	**989,097**

Water and Water Quality Impacts

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

Compliance and Enforcement

Overview of Compliance Process

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors. The compliance process is described in Section 2.5. Impacts that the proposed measure would have on market actors is described in Section 3 and Appendix E. Access to measure updates education and information pertaining to updated lighting zones would be needed for successful compliance and enforcement.

Field Verification and Acceptance Testing

No new field verification or acceptance tests beyond those that currently exist would be required, and there are no new system or technology requirements proposed.

1. Introduction

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

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2022 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency.

The overall goal of this CASE Report is to present a code change proposal for nonresidential outdoor lighting sources. The report contains pertinent information supporting the code change.

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

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

- Section 2 – Measure Description of this CASE Report provides information on the proposal. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 3 – In addition to the Market Analysis, this section includes a review of the current market structure. Section 3.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 4 – Energy Savings presents the per-unit energy, demand reduction, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 5 – This section includes a discussion and presents analysis of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 6 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2022 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material. Statewide water consumption impacts are also reported in this section.
- Section 7 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Manual (ACM) Reference Manual, Compliance Manual, and compliance documents.
- Section 8 – Bibliography presents the resources that the Statewide CASE Team used when developing this report.
- Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.
- Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.
- Appendix C: Environmental Impacts Methodology presents the assumptions used to calculate impacts on GHG emissions and water use and quality.

- Appendix D: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).
- Appendix E: Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.
- Appendix F: Summary of Stakeholder Engagement documents the efforts made to collaborate with market actors and experts.
- Appendix G: Multifamily Light and Health Topics documents how the proposed submeasure would reduce the impact that light at night has on occupant health.
- Appendix H: Multifamily Prototype Characterization documents how the multifamily outdoor lighting savings calculations are made to translate the NR code to MF-specific limits and also to project the savings state-wide.
- Appendix I: Multifamily Calculation Approach documents the methodology and results for calculations in the multifamily general hardscape lighting power allowance submeasure.
- Appendix J: Lighting Zone Calculations documents the calculations for the lighting zone reclassification submeasure.
- Appendix K: General Hardscape Lighting Power Allowance Calculations documents the calculations for the general hardscape LPA submeasure.
- Appendix L: Mapping of IES Criteria documents the special application LPAs to the recommended IES lighting levels.
- Appendix M: Nonresidential Use Schedules lists the nonresidential lighting scheduled used to develop the nominal and PV TDV values.
- Appendix N: Nominal Cost Savings Tables are included in this section until the 2022 TDV values are released by the Energy Commission.
- Appendix O: Security Camera Technology documents how the proposed security camera additional allowance was developed and the lighting requirements for the products studied.
- Appendix P: Ornamental Hardscape LED Conversion documents the analysis to develop the proposed equivalent LED wattage for the hardscape ornamental lighting wattage limit.

2. Measure Description

2.1 Measure Overview

2.1.1 Nonresidential Lighting Zone Reclassification

The outdoor lighting zone reclassification measure is proposed to align the California lighting zones with current industry standards employed across North America. Currently, lighting zones in California are classified with a United States (U.S.) Census-based approach which dictates lighting zones using the population-based classification of an area as "rural" or "urban". This has resulted in over lighting many areas throughout the state. There are five lighting zones:

- Lighting Zone 0 (LZ0): Includes undeveloped areas with essentially no artificial lighting.
- Lighting Zone 1 (LZ1): Includes developed portions of government designated parks, recreation areas, and wildlife preserves.
- Lighting Zone 2 (LZ2): Is defined as “rural” areas.
- Lighting Zone 3 (LZ3): Is defined as “urban” areas.
- Lighting Zone 4 (LZ4): Includes areas with maximum artificial lighting such as Times Square in New York City. Currently, no areas within California fall under LZ4.

This proposal revisits the current population-based approach and aims to provide more discretized lighting zone applications based on the U.S Census classifications; this would reduce energy use throughout California while minimizing sky glow[2] and light trespass.[3] Specifically, this proposal updates the lighting zone definitions to more closely match the Illuminating Engineering Society’s (IES) lighting zone definitions. The updated definitions would still rely on population density, but would specifically shift “rural” areas from LZ2 to LZ1:

- LZ0: This is unchanged.
- LZ1: Would still include developed portions of government designated parks, recreation areas, and wildlife preserves, but “rural” areas previously part of LZ2

[2] Sky glow is additional brightness in the night sky as a result of light from upward facing electric light sources or reflections off airborne particulates. https://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/skyglow.asp

[3] Light trespass is the light from electric sources that is cast where it is unwanted, often due to improper luminaire placement or shielding. https://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/lightTrespass.asp

would now be included here, along with residential and agricultural areas. “Rural” is defined as less than 2,500 people per square mile.

- Lighting Zone 2 (LZ2): Was previously “rural” areas but is now “urban cluster” areas as well as mixed use residential, light commercial, and industrial areas. “Urban clusters” are defined as areas with between 2,500 and 50,000 people per square mile.
- Lighting Zone 3 (LZ3): is still defined as “urban” areas, but now specifically includes high intensity commercial, entertainment centers, and heavy industrial and manufacturing. “Urban” areas are defined as greater than 50,000 people per square mile.
- Lighting Zone 4 (LZ4): This is unchanged.

No change to the lighting power allowances (LPAs) associated with the current lighting zones have been proposed; this submeasure simply seeks to reclassify existing areas into more appropriate lighting zones.[4] This proposed change, which would modify Section 10-114, would impact new construction and alterations and additions in California.

A new section would be added to the nonresidential lighting compliance manual to document that luminaires installed on the project meet the backlight, uplight, and glare (BUG) rating requirements listed in Title 24, Part 11 (CALGreen). Luminaires installed within two mounting heights from the property line would be documented to confirm that they meet the CALGreen backlight and glare ratings based on their orientation towards the property lines. This would not result in additional field verification or acceptance tests beyond those that currently exist.

2.1.2 Nonresidential Lighting Power Allowances for General Hardscape

The LPAs for the general hardscape submeasure would update the existing prescriptive requirements for outdoor lighting and would impact new construction, alterations, and additions across California. This submeasure would update the general hardscape LPAs for areas affected by the light level recommendations in the latest version of the IES Recommended Practice (RP) 8-18 Addendum 1 to Chapter 17 (Illuminating Engineering Society 2020). This submeasure incorporates recent research that suggests task visibility plateaus at lower lighting levels than previously recommended,

[4] Compliance with Title 24, Part 6 includes mandatory, prescriptive, and performance pathways; certain sections in Title 24, Part 6 are mandatory to achieve compliance. For non-mandatory sections, users can choose to follow the performance or prescriptive pathway. Specifically, the prescriptive pathway has some flexibility, but essentially prescribes minimum performance and conditions that a building system must meet in order to comply. The performance pathway allows greater flexibility because users simply need to design a building that meets a certain energy budget. However, the performance pathway is not applicable to outdoor lighting.

which prompted IES to revise the parking lot lighting levels to align with those recommended by IES prior to the IES RP-20-14 publication (republished as ANSI/IES RP-8-18 Chapter 17),[5] which increased the recommended lighting levels. The Statewide CASE Team is proposing to reduce the prescriptive exterior lighting LPAs to reflect the revised parking lot lighting level recommendations.

This submeasure also reassesses the need to distinguish between asphalt and concrete surfaces, which currently have different LPA specifications in Title 24, Part 6. The pavement distinction is proposed to be removed from Table 140.7-A to simplify this code measure. The general hardscape LPAs would be updated to reflect luminaires available on the market at the time of analysis. No new field verification or acceptance tests beyond those that currently exist would be required, and the proposal would not result in new system or technology requirements.

This submeasure includes a new lighting allowance for general hardscape applications with security cameras; this would allow for lighting levels in general hardscape applications to be increased to improve the sense of safety within the area. The allowance would also ensure that the minimum illumination requirements of a security camera with color detection capabilities can be achieved during non-occupied times when the lighting levels have been reduced per Title 24, Part 6, Section 130.2. Security camera technology, available in 2019 at the time of this analysis, is capable of functioning in low nighttime lighting conditions to identify people, animals, and objects of concern within the general hardscape area. The Statewide CASE Team's analysis found that the average cameras with color detection capabilities require an average of 0.33 lux at 50 IRE F1.6, to properly identify colors during nighttime lighting levels. Cameras with black and white detection capabilities require less ambient lighting, while cameras with infrared detection do not require any additional lighting. Refer to Appendix O for more information on current security camera technology.

The Statewide CASE Team is also proposing to update the legacy hardscape ornamental lighting 100-watt limit to 50 watts to align with the current LED baseline.

The Statewide CASE Team is also proposing to replace the term "cutoff" with "shielding" in Section 130.2(b). This is not a substantive update, but it is beneficial as it aligns code language with industry terminology.

[5] Parking lot lighting levels previously appeared in the IES RP-20 document and they were increased in RP-20-14. However, a recently published study concluded that those increased lighting levels were not beneficial which prompted IES to revise the parking lot lighting levels and reduce them to light levels that appeared in RP-20 documents prior to RP-20-14. Additionally, IES has compiled many of their recommended practices into one document, including the parking lot lighting levels. This new document is RP-8-18 and the Chapter 17 Addendum 1 includes the new, lower lighting levels for parking lots.

The ornamental hardscape special application listed in Table 140.7-B is proposed to be amended to reflect the 50-watt luminaire qualification incorporated in the 2019 Title 24, Part 6, Section 100.1 definition.

2.1.3 Multifamily Outdoor Lighting Power Allowances

The Energy Commission is considering consolidation of low-rise and high-rise multifamily requirements under a new multifamily section in 2022 Title 24, Part 6. The multifamily outdoor LPAs submeasure proposes new LPAs for several new code sections that would be placed in the multifamily chapter of code being proposed for the Multifamily Chapter Restructuring Final CASE Report. This submeasure creates limits for outdoor lighting that are more appropriate for circumstances and conditions associated with the residential nature of multifamily buildings.

This proposal was developed using a similar method to previous nonresidential outdoor lighting code updates. The current nonresidential LPA requirements are used as a base case for the analyses. The 2019 nonresidential outdoor lighting power allowance CASE Study, which describes the methodology for the 2019 code cycle, is available on the Title24stakeholders.com website (Statewide CASE Team 2017).

The proposed technology level used to establish the 2022 multifamily LPA values is based on luminaires that are cost effective at the time of the analysis. Costs are expected to continue to decline before the effective date of the standards. The efficacies of the products used to develop the 2019 LPAs have been updated for the applications that fall under the scope of Table 140.7-A and Table 140.7-B.

Target illumination levels are based upon current IES RP documents recommended lighting levels that set light level guidelines for outdoor spaces and other industry standards for all target illuminance levels. The same recommend practice documents are employed for both the nonresidential and the multifamily general hardscape allowance calculations. Certain allowances that are currently included in Table 140.7-B are not included in the proposed multifamily allowance tables as the use of these additional allowances are incompatible with multifamily residential environments.

This submeasure also makes a change to the setback requirements for outdoor lighting controls in Section 130.2 to match the IES recommendations for late-night setback design criteria. The current code was established with a 50 percent reduction, but the IES recommendations include a 60 percent reduction from the main criteria levels. This measure incorporates this 60 percent reduction.

The submeasure also simplifies the LPA calculation approach by moving from a three-factor method (area wattage allowance, perimeter wattage allowance, and initial wattage allowance) to a two-factor approach (area wattage allowance and initial wattage allowance). The removal of the perimeter wattage allowance reduces the documentation for the design and code compliance steps and would make the

calculation of the LPA easier and faster to complete. This modification would result in a substantial change in the allowance values included in the LPA table for general hardscape in Table 140.7-A, but would have no impact to the allowance values in the additional allowances Table 140.7-B.

2.2 Measure History

2.2.1 Nonresidential Lighting Zone Reclassification

In 2011, the International Dark-Sky Association (IDA) and IES jointly published a Model Lighting Ordinance (MLO) (Illuminating Engineering Society and International Dark-Sky Association 2011). The Statewide CASE Team aims to align Title 24, Part 6 with this current industry standard for determining appropriate lighting levels for each outdoor application. This proposed submeasure aims to protect the environment through reduction in over lighting outdoor spaces, and reducing electricity used on outdoor lighting.

The definitions of the current lighting zones and the associated LPAs were added to Title 24, Part 6 in the 2005 code cycle using a population-based approach for identifying lighting zones. At that time, four lighting zones (LZ1 through LZ4) were defined using the definitions of rural and urban areas in U.S. Census. An additional zone, LZ0, was added in the 2016 code cycle for nonlighted areas using the same population-based approach for identifying lighting zones. Lighting zone LPAs are based on the recommended lighting levels established in the IES 10th edition handbook (Illuminating Engineering Society 2011). These lighting levels are based on the ambient illumination of surrounding areas; higher lighting zones allow for more installed wattage with the intent that they fall within areas of brighter surroundings. For example, LZ0 has the lowest wattage allowance because it is intended to encompass areas with little to no artificial light, such as national parks. Likewise, LZ4 has the highest wattage allowance and is intended for areas with maximum artificial lighting, such as Times Square in New York City. Currently, no areas in California are classified as LZ4.

Since the current definitions of lighting zones does not match the MLO, many spaces within California are in higher lighting zones than needed. These spaces tend to experience over lighting because the LPAs allow for higher light levels than needed for the specific spaces. For the 2022 code cycle, the Statewide CASE Team was interested in moving towards a land-use approach for the lighting zones due to benefits of reducing over lighting and electricity use. A land-use approach means the lighting zones would be chosen based on the specific activities that would occur in the area. For example, a residential neighborhood in a rural area has low light level needs versus a heavy commercial area or downtown area that requires high light levels to illuminate late night venues. The proposed approach is a more granular population-based approach that captures some of the benefits of a land-use approach, but ultimately is an

intermediate step. The Statewide CASE Team has chosen to continue with the population-based approach because a suitable approach for moving to a land-use approach has not been found for the 2022 code cycle. Specifically, the Statewide CASE Team explored developing a map that compiled municipal zoning requirements and using those zoning requirements as reference points for assigning areas to lighting zones. However, the Statewide CASE Team ran into several issues locating:

- Comprehensive data that could effectively be used to connect lighting zones to land use characteristics.
- Reliable and accurate data that would be easily accessible and understandable by local code officials.
- A data source that would not require significant Energy Commission staff resources to maintain.

The Statewide CASE Team still plans to pursue updating the lighting zones to be based on land-use for a future code cycle. Please see Section 2.5.1 for additional details on compliance and enforcement issues.

The Statewide CASE Team decided to continue with the proposal to better align with the MLO and use a more granular population-based approach since this approach still provides significant energy savings and other non-energy benefits. While the shifts between lighting zones are expected to occur from LZ2 to LZ1, this still represents a significant decrease in over lighting, which helps mitigate sky glow. Similarly, there is a growing body of literature that points to blue-rich light at night disturbing circadian function in people in addition to animals. Even though the shift from LZ2 to LZ1 represents a small portion of buildings (and therefore, people) in California, it is still a large step towards reducing exposure to blue-rich light at night.[6] See Section 6.5 for additional information on non-energy benefits.

2.2.2 Nonresidential Lighting Power Allowances for General Hardscape

During the 2019 code cycle, the Statewide CASE Team proposed lowered LPAs based on increased efficiency in solid state technology, which was ultimately adopted in full by the Energy Commission (Statewide CASE Team 2018). During the 2019 code cycle the

[6] There are multiple strategies for reducing exposure to blue-rich light at night: moving towards light sources that have lower concentrations of blue light; examining the spectral power distribution of selected light sources to ensure lower blue light content at desired correlated color temperature (CCT) (related to first strategy); reducing time spent exposed to artificial light at night; and reducing the total amount of artificial light at night. Lowering lighting zones aligns with the last strategy since the shift to a lower lighting zone represents lower wattage and lower lumen output luminaires that align with IES's lighting level recommendations for spaces with low ambient lighting levels, and therefore would reduce the overall lighting levels that people could be exposed to.

Statewide CASE Team also accounted for IES's increased parking lot lighting recommendations and distinction between surface material. Since the 2019 code was adopted, IES RP-8-18 (previously published as IES RP-20-14) was updated to include research by the Virginia Tech Transportation Institute (VTTI) which found that visibility improvements in parking lots plateau at lower light levels than those recommended in IES RP-8-18 (Bhagavathula and Gibbons 2019). Due to this research, IES published an addendum to IES RP-8-18 Chapter 17 which decreased the recommended lighting levels by 60 percent for asphalt surfaces and 80 percent for concrete surfaces. These lower lighting level recommendations align with the legacy IES RP-20-98 lighting level recommendations. VTTI's research also indicated that the difference in the light level requirements between asphalt and concrete surfaces in parking lots are insignificant. Therefore, this submeasure proposes to remove the distinction between pavement surfaces. This proposal would realign the code language with the 2013 Title 24, Part 6 requirements by removing the distinction between concrete and asphalt. This change would also result in less complex code language – something the Statewide CASE Team is aiming to accomplish across all proposed code changes for the 2022 code cycle to address stakeholders' requests to simplify.

The proposed general hardscape LPAs for the 2022 code cycle would reduce the general hardscape LPAs by approximately 20 percent. This reduction incorporates the 60 percent to 80 percent parking lot lighting level reduction recommended by IES. The Statewide CASE Team is not proposing to reduce the additional allowances in Title 24, Part 6, Table 140.7-B which were developed with less efficacious, 3000K CCT LED light sources readily available in 2016. The proposed general hardscape LPAs would improve energy savings in California since less energy would be required to provide the illumination service recommended for parking lots.

This submeasure also proposes including a new lighting allowance for general hardscape applications with security cameras. While the IES recommended parking lot lighting levels are conservative – a minimum illumination requirement was established throughout the entire parking lot instead of the average illumination level published by VTTI – these minimum illuminance recommendations do not account for security lighting levels. Security cameras in use in 2019 require higher lighting levels than those recommended by IES RP-8-18 Addendum 1 to identify people, animals, and objects of concern within the general hardscape area. Including an additional allowance for security cameras would ensure that current security camera technology can be applied in general hardscape areas with security concerns.

During the 2019 code cycle the hardscape ornamental lighting definition was changed from a 100-watt limit to a 30-watt limit to align with the LED baseline. While this change was incorporated into 2019 Title 24, Part 6, Section 100.1, the change was not incorporated in the lighting allowances for Table 140.7-B. To resolve this discrepancy,

the Statewide CASE Team is proposing to update the wattage limit in Title 24, Part 6, Section 140.7 to the equivalent wattage of a LED luminaire. The Statewide CASE Team has expanded on the 2019 analysis to consider 35 different LED products that have equivalent initial luminaire lumen output of several 100-watt legacy light sources. These legacy light sources include pulse start metal halide, ceramic metal halide, and incandescent lamps. The proposed 50-watt limit for the LED baseline would be updated in both the hardscape ornamental definition in Section 100.1 and the lighting power allowances listed in Section 140.7. The analysis for the proposed 50 watts can be found in Appendix P.

In addition to updating the LPA requirements, the Statewide CASE Team is recommending a language cleanup to replace the term “cutoff” with “shielding” in Section 130.2(b). The purpose of this update is to align language with industry since IES has deprecated the use of “cutoff” over 10 years ago. Additionally, the term “shielding” accounts for the backlight, uplight, and glare produced by a luminaire, whereas, “cutoff” only accounts for uplight. Therefore, using the term “shielding” makes more sense for Section 130.2(b) because this section deals with Backlight, Uplight, and Glare (BUG) requirements. The Statewide CASE Team proposed to update this term during the 45-Day Language review of the 2019 code cycle, but language update came too late in the code cycle to be adopted.

2.2.3 Multifamily Outdoor Lighting Power Allowances

The multifamily outdoor LPA submeasure develops several new code sections that would be placed in the currently unnumbered multifamily chapter of code being proposed for the Multifamily Chapter Restructuring Final CASE Report. This new chapter is intended only for the multifamily building type and carves this section of coverage away from the current nonresidential chapters of Part 6. This submeasure addresses outdoor lighting needs of multifamily housing and creates limits for outdoor lighting that are more appropriate for circumstances and conditions that are associated with the residential nature of multifamily housing.

For the circumstance of multi-use properties, the project would be required to meet the multifamily outdoor lighting code sections even if there are specifically nonresidential interior spaces in the building (that would be employing the nonresidential interior code sections for those spaces). There is no mixed-use circumstance where the nonresidential version of the outdoor lighting code section would apply within a single permitted project. For this reason, the multifamily outdoor lighting code section is identical in structure to the existing nonresidential code section and the primary changes are the elimination or modifications for certain allowances in Table 140.7-B that are incompatible with residential occupancy as they are currently included in the nonresidential section. An additional substantive change is the simplification of the

lighting allowance calculations to eliminate the Linear Wattage Allowance from the calculation process.

The multifamily outdoor LPA submeasure has been part of the nonresidential outdoor lighting section until this code revision (unless the project was very small, in which case it may have been considered residential construction instead).

2.3 Summary of Proposed Changes to Code Documents

2.3.1 Summary of Changes to the Standards

2.3.1.1 Summary of Changes to the Standards – Nonresidential Lighting Zone Reclassification

Section 10-114 – Determination of Outdoor Lighting Zones and Administrative Rules for Use:

The purpose of these changes is to amend Table 10-114-A statewide default locations to align with the MLO land-use classification. The current U.S. census urban classifications have been updated to provide more discrete lighting zones than those defined in the current 'rural' classification for lighting zone 2 by reclassifying 'rural' locations as lighting zone 1 and including a new classification for 'urban clusters' to provide further distinction for the lighting zone 2 default locations. These changes are necessary to align the statewide default locations with current lighting standards to minimize confusion for users, while reducing over lighting in rural areas which can have adverse impacts on the local environment and uses more electricity than necessary.

2.3.1.2 Summary of Changes to the Standards – Nonresidential Lighting Power Allowances for General Hardscape

Section 100.1(b) – Definitions

The purpose of these changes is to align the definitions with current industry standards and practices. The hardscape ornamental definition would be updated to a 50-watt limit to align with the wattage proposed for an LED baseline in Section 140.7. The wattage limit in these two sections was not aligned during the last code cycle which could cause confusion for users. The publication date for the referenced IES documentation will be removed to align with those published in the IES Online Library; this would clarify the definition of three IES documents (the Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, the American National Standard Practice for Design and Maintenance of Roadway and Parking Facility Lighting, and the Luminaire Classification Systems for Outdoor Luminaires). A new definition for "security camera" is proposed for the new allowance in Section 140.7. These changes are

necessary to provide defensible definitions for the allowances listed in Section 130.2 and Section 140.7.

Section 130.2 – Outdoor Lighting Controls and Equipment

The purpose of this change is to amend Section 130.2(b) to use the term "shielding" instead of "cutoff" to match industry language; "shielding" accounts for the backlight, uplight, and glare produced by the luminaire whereas, "cutoff" only accounts for uplight. This change is necessary to align the code language with the luminaire requirements for backlight, uplight, and glare listed within this section.

Section 140.7 – Prescriptive Requirements for Outdoor Lighting

The purpose of these changes is to amend Table 140.7-A to remove the asphalt/concrete surface distinction and lower LPAs according to the ANSI/IES RP-8-18 Chapter 17 Addendum 1. Table 140.7-B would be amended to reflect the 50-watt hardscape ornamental luminaire qualification defined in Section 100.1 that aligns this section with the new LED baseline implemented during the 2019 code cycle. A new special application allowance for security cameras is proposed for Table 140.7-B to ensure that the lower general hardscape LPAs in Table 140.7-A would not limit the operation of security cameras during nighttime hours. These changes are necessary to align the code with current industry design standards; the changes would also simplify the code for users by consolidating the LPA requirement for various surfaces and aligning this section with the definitions in Section 100.1.

2.3.1.3 Summary of Changes to the Standards – Multifamily Outdoor Lighting Power Allowances

The Energy Commission is considering consolidation of low-rise and high-rise multifamily requirements under a new multifamily section(s) in 2022 Title 24, Part 6. Restructuring the standards for multifamily building may also result in revisions to Reference Appendices, ACM Reference Manuals, compliance manuals, and compliance documents. Location and section numbering of the 2022 standards and supporting documents for multifamily buildings depend on the Energy Commission's approach to and acceptance of a unified multifamily section. For clarity and ease of review, the changes proposed in this CASE Report are demonstrated in terms of the 2019 structure and language.

Section 130.2 – Outdoor Lighting Controls and Equipment

The purpose of these changes is to create a new version of existing nonresidential section in a currently unnumbered section dedicated to the multifamily building type. Additionally, this submeasure would change the

minimum light level setback requirements in Section 130.2(c)3A from 50 percent to 60 percent to match the late night low-activity values as established in the IES design recommendations handbook by the reduction in design criteria for late night parking lots, which is 60 percent for both horizontal illuminance and vertical illuminance.

These changes are necessary to create a new multifamily outdoor lighting controls section that can be suitably tailored to the needs of multifamily housing moving int the future. The intent is to start with the current nonresidential code as the basis and only change those portions that are specifically needed to make it apply better for multifamily housing properties.

Section 140.7 – Prescriptive Requirements for Outdoor Lighting

The purpose of these changes is to create a multifamily housing outdoor lighting section and to simplify the code specifically for multifamily housing projects so that the implementation is easier to achieve. The proposed requirements would create a new version of the existing nonresidential outdoor lighting section with edits dedicated to the multifamily building type. This submeasure would simplify the General Hardscape calculation procedure for multifamily building types and revise the allowances based on multifamily building type conditions by using a two-prong calculation method rather than the current three-prong approach in the current code. This is accomplished by eliminating the perimeter allowance from the calculation and revising the area and initial allowance values to accommodate the changes.

Table 140.7-A requirements would be amended to remove the asphalt/concrete distinction and lower LPAs according to the ANSI/IES RP-8-18 Chapter 17 Addendum 1. LPA values would also be modified based on the improvement of light source efficacy of LED sources. The proposed requirements would amend Table 140.7-B Hardscape Ornamental Lighting definition to reflect the new 50-watt LED baseline and remove some of the “Additional Power Allowances” in Table 140.7-B that permit very high light levels for select retail lighting applications.

These changes are necessary because there are allowances in the nonresidential outdoor lighting section that are inappropriate for use in multifamily housing projects but there is no infrastructure in place to consider the suitability of these allowances in the existing code sections. The changes eliminate these allowances while still permitting all the applications that have been permitted, but with a possible difference in the total allowance for the site under certain circumstances based on the removed allowances in the tables. The creation of a multifamily section in the code permits this introduction of a different outdoor

lighting section that is specifically targeted to multifamily housing needs and conditions.

2.3.2 Summary of Changes to the Reference Appendices

The proposed code change would not modify the structure of Reference Appendices, but the thresholds for lighting setback must be updated in NA 7.8.8 to show the correct level for MF housing.

2.3.3 Summary of Changes to Nonresidential ACM Reference Manual

The proposed code change would not modify the ACM Reference Manual.

2.3.4 Summary of Changes to the Nonresidential Compliance Manual

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

- **Section 1.6 – Mandatory Measures and Compliance Approaches** – The proposed multifamily outdoor LPA measure requires revisions to the existing section, or the creation of a new section for a Multifamily Compliance Manual, based on Section 1.6. If the proposal is accepted, the values in the examples and tables representing General Hardscape LPAs and Specific Application LPAs would be updated to reflect the different allowances associated with the multifamily building type
- **Section 6.3 – Outdoor Lighting Zones** – This section would be updated to reflect the updated lighting zone definitions as well as default lighting zones. Luminaire BUG ratings would be added to the Compliance Manual for engineers and designers to document that the luminaires meet the CALGreen BUG ratings for luminaires installed within two mounting heights of the adjacent property lines.
- **Section 6.4 – Mandatory Requirements** – This section would be updated to switch luminaire “cutoff” requirements to luminaire “shielding” requirements per the updated language that aims to align with industry.
- **Section 6.5 – Prescriptive Measures** – This section would be updated with the LPAs developed for General Hardscape. Likewise, the new security camera LPA would need to be inserted. This would likely be inserted into Section 6.5.2.

  See Section 7.5 of this report for the detailed proposed revisions to the text of the compliance manuals.

2.3.5 Summary of Changes to Multifamily Compliance Documents

The proposed code changes would modify the compliance documents listed below. Examples of the revised documents are presented in Section 7.6.

- **NRCC-LTO-E – Section G (all measures)** – This section would change the term “cutoff” to “shielded” to align with current industry standards.

- **NRCC-LTO-E – Section G (all measures)** – This section would create a new section (G2 or re-number the sections to accommodate) provide documentation that every fixture type on the property that is less than two mounting heights from the property line must be documented in Backlight and Glare ratings must be verified depending on the orientation. It would also check the conditions of each luminaire type that is nearest to the property line in this section. *(for example: there is a Type A fixture and a Type A2 fixture, which has backlight control, but the Type A is only found in the internal portions of the site (greater than two mounting heights). The Type A does not need to be verified for the property line restrictions, but the Type A2 must be checked with a second verification for the fixture that is the nearest to the property line. If this fixture passes, then it meets the BUG limits.)*
- **NRCC-LTO-01-E** – (**nonresidential lighting zone reclassification submeasure)** – This section would revise this document to account for new lighting zone definitions.
- **NRCC-LTO-03-E** – **(nonresidential lighting power allowances for general hardscape submeasure)** – This section would revise the document to account for updated LPAs for general hardscape and the additional wattage allowance per square foot of specific area for security cameras.
- **NRCC-LTO-E** – **(multifamily outdoor LPA submeasure)** – This section would duplicate and revise this document to include proper references to the new multifamily standards, once numbered and ensure that all the proper values are set for the compliance calculations based on the multifamily code sections.
- **NRCC-LTO-E** – **Section I (multifamily outdoor LPA submeasure)** – This section would revise the new multifamily compliance document to account for updated multifamily LPA values in Table 140.7-A General Hardscape for the change to a two-prong calculation approach and to update the document with correct code section cross-referencing.
- **NRCC-LTO-E** – **Section J, K and L (multifamily outdoor LPA submeasure)** – This section would revise the new multifamily compliance document to account for updated new code sections for multifamily buildings. Eliminate all references to “Additional Allowances” that are not permitted in the multifamily building type category. The existing nonresidential outdoor lighting compliance document (NRCC-LTO-E) would remain, but specific language should be inserted specifying that the document is not appropriate for multifamily building type projects.

2.4 Regulatory Context

2.4.1 Existing Requirements in the California Energy Code

Exterior lighting power is already regulated in Title 24, Part 6. This code change increases stringency of existing exterior LPAs in Title 24, Part 6. Current requirements for lighting zone classification in Title 24, Part 6 exist in Section 10-114, which describes

the lighting zones defined in California and the classification methodology. LPAs for general hardscapes exist in Section 140.7 of Title 24, Part 6. Section 10-114 of Title 24, Part 6 applies to new construction, alterations and additions for both nonresidential and multifamily spaces. Section 140.7 of Title 24, Part 6 apply to new construction, alterations and additions for nonresidential spaces; the new multifamily section would similarly apply to the new construction, alterations and additions for multifamily spaces. These CASE proposal measures do not overlap with other CASE proposals during this code cycle.

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

The California Green Building Standards (CALGreen, or Title 24, Part 11) includes mandatory BUG rating requirements. Products selected for installation must meet the BUG rating requirements for the location when the products are installed as specified in Table 5.106.8 of CALGreen. Title 24, Part 6 refers to the CALGreen requirements to help inform code users that they must adhere to requirements in CALGreen and Title 24, Part 6.

2.4.3 Relationship to Local, State, or Federal Laws

There are existing Title 20 California Appliance Efficiency Regulations and federal standards for outdoor lighting products. This proposal does not set efficiency requirements for individual lighting products. Title 20 lighting measures do not overlap with these proposed measures other than to impact the minimum efficacy of some products that may be selected.

Adjusting lighting zones has gained traction with a few municipalities both inside and outside of California. Specifically, the City of Malibu, California; San Jose, California; Los Angeles County, California; and Plymouth, Minnesota have all switched from higher to lower lighting zones.[7] While this represents a small portion of cities and population, a few other municipalities, such as the City of Santa Cruz, California, are also considering a similar switch in lighting zones.

2.4.4 Relationship to Industry Standards

The proposed lighting zone reclassification more closely aligns the current lighting zone definitions with the recommendations from the IES/IDA MLO along with IES RP-33-14 *Lighting for Exterior Environments.*

The proposed nonresidential parking lot LPA values were developed using IES RP-8-18 Chapter 17 Addendum 1 recommended light levels as the basis of design. Refer to

[7] More information can be found on each city's respective website.

Appendix L for the mapping of IES design criteria to the LPA allowance tables. The proposed parking lot lighting levels for nonresidential and multifamily measures also consider security camera technology requirements not described in IES RP-8-18 Chapter 17.

2.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and reduce negative impacts on market actors who are involved. This section describes how to comply with the proposed code change and the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The activities that need to occur during each phase of the project are described below:

2.5.1 Nonresidential Lighting Zone Reclassification

- **Design Phase:** Designers would still determine the applicable lighting zone based on the population density of the project area as defined by the 2010 U.S. Census, unless the local agency has defined alternative lighting zones classifications, in which case the local agency's lighting zone classifications shall take precedence. Users would be able to refer to the U.S. Census, in the same manner as the current code, to determine the population density of the project address.[8] Changes would be made to the applicable compliance documents, but the same forms would still apply. The main change is areas defined as "rural" would now be LZ1 instead of LZ2. LZ2 is now defined as "urban cluster" areas.
- **Permit Application Phase:** Plans examiners would still verify the lighting zone was correctly determined and wattage allowances comply with the revised requirements.
- **Construction Phase:** Contractors would still verify that the installed lighting equipment complies with the lighting zone requirements in the same manner as the current code.

[8] The compliance manual outlines the process for determining lighting zones. A user simply needs to use the link provided in the compliance manual which directs them to U.S. Census data where they can input their address. Once the address has been inputted, the database tells the user whether they fall under a "rural" or "urban" area which is their indicator of their specific lighting zone. The only substantive change being proposed by the Statewide CASE Team is the distinction that "urban cluster" is for LZ2. The Statewide CASE Team does plan to update language in the compliance manual to note this as well as make the process easier to understand. The following is the link provided by the compliance manual to the U.S. Census database: https://ww2.energy.ca.gov/2018publications/CEC-400-2018-018/chapters/06_OutdoorLighting.pdf

- **Inspection Phase:** Inspectors would still verify that the installed lighting equipment complies with the lighting zone requirements in the same manner as the current code.

2.5.2 Nonresidential Lighting Power Allowances for General Hardscape

- **Design Phase:** Lighting designers and energy consultants would use the appropriate lighting zone (determined from the population density of the project address) to calculate the applicable wattage allowance to design and document the outdoor lighting design as being compliant to code. There would no longer be different LPAs depending on whether the surface is asphalt or concrete, which reduces complexity and improves compliance by making it easier to select the appropriate LPA. Designers and consultants must verify if they are allotted the additional allowance for security cameras.
- **Permit Application Phase:** Plans examiners would still verify the wattage allowances are complying with the revised requirements.
- **Construction Phase:** Contractors would still verify that the installed lighting equipment complies with the LPA requirements in the same manner as the current code.
- **Inspection Phase**: Inspectors would still verify that the installed lighting equipment complies with the LPA requirements in the same manner as the current code. The proposed code change would require a security camera allowance to be included in the existing compliance documentation for the security camera LPA. The method of compliance verification and enforcement for this special category would not require changes.

2.5.3 Multifamily Outdoor Lighting Power Allowances

- **Design Phase:** Lighting designers and energy consultants would use the appropriate lighting zone as determined from the revised lighting zone classifications and the tables in Section 140.7 (to be renumbered for the new multifamily sections) to calculate the wattage allowance to design and document outdoor lighting design as being compliant to code. Similarly, the designers/energy consultants would consult Section 130.2 to design the outdoor lighting controls for the project.
- **Permit Application Phase:** Plans examiners would still verify the wattage allowances comply with the new multifamily outdoor LPA requirements in the same manner as the current code.
- **Construction Phase:** Contractors would still verify that the installed lighting equipment complies with the new multifamily outdoor LPA requirements in the same manner as the current code.
- **Inspection Phase:** Inspectors would still verify that the installed lighting equipment complies with the lighting zone requirements in the same manner as the current code.

Appendix E presents a description of how the proposed code changes could impact various market actors.

3. Market Analysis

3.1 Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, Energy Commission staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meetings that the Statewide CASE Team held on September 5, 2019, and March 3, 2020.

3.2 Technical Feasibility, Market Availability, and Current Practices

3.2.1 Nonresidential Lighting Zone Reclassification

The Statewide CASE Team faced a number of challenges while trying to develop a methodology for using a land-use approach for the lighting zone update, including finding a comprehensive data source that is: reliable, easily accessible, and can effectively be used to connect lighting zones to land use characteristics. The original intent of the proposal was to fully connect lighting zones to land use, but the Statewide CASE Team pivoted to continue with a population-based approach due to these issues. Despite continuing with a population-based approach, the updated lighting zone definitions align with the MLO and easily allow for Title 24, Part 6 to be updated again for a land-use approach in a later code cycle. The Statewide CASE Team will continue researching for a way to implement a land-use approach. Please see more details in Section 2.2.1.

The current lighting zone classifications defaults all “rural” areas as LZ2 and all “urban” areas as LZ3. The proposed update switches these defaults to more closely align with the IES/IDA MLO so “rural” would be LZ1, “urban clusters” would be LZ2, and “urban” would be LZ3. Per Section 110-14, local jurisdictions can designate areas to a lower lighting zone without any size limit to align with the current MLO land-use definitions, but this requires a public process and detailed information needs to be submitted to the Energy Commission. This proposal automatically shifts some of the current LZ2 areas to LZ1 as well as updates the lighting zone definitions to align with the MLO land-use definitions. Local jurisdictions can also designate areas to a higher lighting zone, which requires the same public process for moving to a lower lighting zone.

The Statewide CASE Team expects there to be no technical feasibility challenges for lighting zone reclassification. Products from 58 different manufacturers were studied to ensure that products are currently available on the market and could meet the wattage requirements and other lighting needs for all lighting zones. Additionally, moving from higher to lower lighting zones represents a reduction in LPAs for areas encompassed within the lighting zone. Tables 140.7-A and 140.7-B in Title 24, Part 6 both split the LPAs for general hardscape and specific applications by lighting zone, with the lower lighting zones having lower LPAs and the higher lighting zones having higher LPAs.

3.2.2 Lighting Power Allowances for General Hardscape

Recent outdoor lighting market trends are showing that lower (warmer) correlated color temperatures (CCTs) are being installed in outdoor environments. These lower CCTs encompass 2700K CCT and 3000K CCT light sources, which are slightly less efficacious than their higher “cooler” counterparts (4000K CCT or greater). When completing the outdoor lighting analysis, the Statewide CASE Team only considered LED luminaires with either 3000K or 2700K CCT to ensure that the proposed LPA reductions can be met with less efficacious LED products. Most manufacturers provide lower CCTs with LED products by increasing the yellow phosphor coating over the blue LED pump, to convert the blue light source to a board band spectrum light source. As more phosphor is layered over a blue LED chip, the LED efficacy decreases. The Statewide CASE Team studied 49 different LED area lights that could be installed in a general hardscape area to ensure that the proposed LPAs could be met with products currently available. This code does not establish the use of specific color temperatures.

The market continues to make incremental improvements in LED efficacy, LED board technology, optical design, driver capabilities, and cost reductions. This has led to LEDs quickly becoming the standard for many applications, with nearly full LED adoption (99 percent) expected by 2023, and a very high 98 percent or greater of the market by 2020 (Goebes 2018).

Stakeholders have brought up concerns that the reduction of lighting levels for general hardscape applications could cause increased security concerns. An additional LPA has been proposed to ensure that increased lighting levels can be applied for areas with security concerns. Security cameras are being installed in many of these areas to monitor activity within the space. Current camera technology requires an average of 0.33 lux at 50 IRE F1.6, within the camera’s field of view for color identification, which is less light than minimum lighting level recommendations in IES RP-8-18. When the lighting level falls below those required for color detection, the cameras will capture images in black and white. Current camera technology is commonly equipped with infrared imaging which allows the camera to detect people, animals, and objects in the absence of exterior lighting. This additional LPA is for a specific application and therefore, has been added to Table 140.7-B. Stakeholders also noted that the general

hardscape LPA should be updated to account for general hardscape both with and without parking lots. The Statewide CASE Team agrees, however, this feedback was received shortly before the release of the Final CASE Report, so the Statewide CASE Team is considering this update for a proposal in a future code cycle.

3.2.3 Multifamily Outdoor Lighting Power Allowances

The lighting equipment used for multifamily outdoor lighting is identical to that used for nonresidential outdoor lighting in general, although there is typically a lower limit to normally specified wattage, pole heights, and other similar design aspects because the properties are commonly smaller and less commercial in function.

Because there is a not a significant difference in the light source technology, the same conditions described above for the lighting power allowances for general hardscape (Section 3.2.2) applies for this submeasure as well.

3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

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

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 4).[9] In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector, while another 17,000 establishments and 344,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction (industrial sector).

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

Table 4: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2

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

Table 5: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard

Construction Subsector	Establishments	Employment	Annual Payroll (billions $)
Commercial Building Construction	4,508	75,558	$7.0
Nonresidential poured foundation contractors	504	14,917	$1.1
Nonresidential Masonry Contractors	254	5,121	$0.3
Other Nonresidential exterior contractors	277	2,879	$0.2
Nonresidential Electrical Contractors	3,115	66,951	$5.6
Nonresidential plumbing and HVAC contractors	2,394	52,977	$4.5
Other Nonresidential equipment contractors	506	8,884	$0.9
Nonresidential site preparation contractors	1,157	17,059	$1.3
All other Nonresidential trade contractors	988	17,960	$1.4

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

The lighting zone reclassification submeasure would require that builders familiarize themselves with the updated population density-based lighting zone classification specific to the area that the building is located within to ensure compliance with the mandatory backlight, uplight, and glare (BUG) ratings listed in California's mandatory green building standards, Title 24, Part 11 (otherwise known as CALGreen) Table 5.106.8, for luminaires with 6,200 initial luminaire lumens or greater.[10]

[10] Table 5.106.8 in CALGreen can be found here: https://codes.iccsafe.org/content/CGBC2019P3/chapter-5-nonresidential-mandatory-measures

The general hardscape LPA submeasure would require builders to apply the new LPA and consider the potential security camera adder for the general hardscape areas. The proposal includes a simplification in the LPAs by removing the surface material distinction for the general hardscape LPAs.

The multifamily outdoor LPA submeasure would require multifamily builders to apply the new standards instead of the previously applied nonresidential outdoor LPA rules. The new multifamily standards are adapted from the existing nonresidential standards. The proposal includes a simplification in the calculation procedures, and the changes are expected to result in minimal negative impacts on builders.

3.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

The lighting zone reclassification would require building designers to familiarize themselves with the updated population density-based lighting zone classification specific to the area that the building is located. Designers would be required to ensure luminaires with 6,200 initial luminaire lumens or greater comply with the BUG rating requirements for lower lighting zones that listed in CALGreen Table 5.106.8.

The removal of asphalt and concrete pavement classifications within Table 140.7-A would simplify the code compliance documentation. Designers and energy consultants must ensure that each design meets the reduced LPAs in Table 140.7-A.

The multifamily outdoor LPA submeasure would similarly remove the asphalt and concrete pavement classifications within the 2022 version of Table 140.7-A (currently unnumbered as it would be in the new section) to simplify the calculation and documentation of the allowance. Additionally, this measure would move to a two-factor LPA allowance calculation approach for General Hardscape, which would further lower the complexity of the calculations.

There is not a North American Industry Classification System (NAICS)[11] code specific for energy consultants. Instead, businesses that focus on consulting related to building

[11] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of

energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[12] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 6 provides an upper bound indication of the size of this sector in California.

Table 6: California Building Designer and Energy Consultant Sectors

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

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

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;
b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

3.3.3 Impact on Occupational Safety and Health

The recommended parking lot lighting level reduction established in IES RP-8-18 Chapter 17 Addendum 1 is not intended for parking lots with a need for higher security lighting levels. To ensure that parking lots with security concerns – such as hospitals, law enforcement facilities, or other facilities with additional security concerns that require camera technology capable of facial identification within the hardscape area – can install lighting to meet a horizontal average of 3 fc throughout the parking lot.

comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[12] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

The selected luminaires are still required to comply with the BUG ratings listed in CALGreen Table 5.106.8 for luminaires with 6,200 initial luminaire lumens or greater. The reclassification of ‘rural’ areas into both ‘rural’ areas and ‘urban clusters’ would align the lighting requirements with more appropriate quantities of lighting in the nighttime environment within these areas. Reducing the quantity of unnecessary light at night would provide positive impacts to the human circadian rhythm, reduce air pollution, and protect local flora and fauna. Refer to Section 6.5 for more information.

3.3.4 Impact on Building Owners and Occupants (Including Homeowners and Potential First-Time Homeowners)

Commercial Buildings

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

Residential Buildings

According to data from the U.S. Census, American Community Survey (ACS), there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 7). Most housing units (nearly 9.2 million were single-family homes (either detached or attached), while about 2 million homes were in building containing two to nine units and 2.5 million were in multi-family building containing 10 or more units. The U.S. Census reported that 59,200 single-family and 50,700 multifamily homes were constructed in 2019.

Table 7: California Housing Characteristics

Housing Measure	Estimate
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	**Estimate**
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (2018 American Community Survey n.d.)

Table 8 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there no building energy efficiency standards (Kenney 2019).

Table 8: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
Built 2000 to 2009	1,553,769	10.9%	15.0%
Built 1990 to 1999	1,561,579	10.9%	26.0%
Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	**14,277,867**	**100%**	

Source: (2018 American Community Survey n.d.)

Table 9 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 9: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
$15,000 to $19,999	456,076	156,790	299,286
$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total Housing Units	**13,072,122**	**7,165,664**	**5,906,458**
Median household income	**$75,277**	**$99,245**	**$52,348**

Source: (2018 American Community Survey n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single-family or multi-family residences and so the

counts of housing units by building type shown in Table 7 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 8 and Table 9.

Estimating Impacts

All three submeasures discussed in this report may indirectly impact tenants or owners in a positive way. The elimination of certain retail lighting allowances for multifamily, lowering of outdoor lighting levels in parking lots, and the reclassification of lighting zones could result in lower outdoor light levels on some properties (but still meeting the accepted guidelines for safety and security). The lower light levels and potentially lower light source wattage would likely result in reductions in the amount of light trespass that is experienced by the tenants, especially on lower floors of multifamily buildings and in adjacent properties. This change is an improvement in the overall lighting quality and visual environment experienced by building tenants and owners.

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

The lighting zone reclassification would prevent lighting manufacturers and distributors from selling products with high BUG ratings that do not meet the mandatory rating requirements listed in CALGreen Table 5.106.8 for luminaires with 6,200 initial luminaire lumens or greater. This is anticipated to have a minor impact within the industry. Over 75 percent of the 364 luminaires studied have less than 6,200 initial luminaire lumens and are not required to be compliant with the CALGreen Table 5.106.8 BUG ratings. Of the 364 products studied, 347 had BUG ratings that meet the LZ3 BUG rating allowances for a luminaire mounted more than two mounting heights away from a property line.

The updated LPA requirements align with current lighting products available on the market offered by all the 58 different manufacturers studied. The updated LPAs are anticipated to have no impact on the current LED luminaire offers provided by lighting manufactures.

3.3.6 Impact on Building Inspectors

Table 10 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 10: Employment in California State and Government Agencies with Building Inspectors

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

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

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.
b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

The lighting zone reclassification would require that building inspectors familiarize themselves with the updated lighting zones to ensure that the lighting power density is appropriate for the project location.

The removal of asphalt and concrete pavement classifications within Table 140.7-A would simplify building inspections. Inspectors would no longer be required to confirm that the site meets the appropriate LPAs for each pavement type.

If the security camera specific application additional LPA is used, building inspectors would be responsible for confirming that the space meets the total outdoor LPA.

3.3.7 Impact on Statewide Employment

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

3.4 Economic Impacts

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

Economic impact estimates for nonresidential lighting and multifamily measures are estimated from material and labor cost savings from equipment not installed due to LPA reductions. LPA reductions result in the need of fewer poles and luminaires, resulting in a negative incremental cost for this measure. The luminaire and pole reductions were calculated by evaluating 12 site layouts for each designated lot size, large, medium, and small, resulting in the analysis of 36 layouts. Pole and luminaire count for the base case and proposed case were compared to determine equipment reductions for each lot size. For assumptions and analysis on luminaire and pole reduction, see Section 6.4, Statewide Material Impacts. Note, multifamily projects are assumed to only have small and medium lot sizes, at 50 percent weighting for each lot size. The installation of each pole is estimated to require 4.73 hours of general contractor labor and 10 hours of electrician labor. The installation of each luminaire is estimated to require 0.5 hours of electrician labor.

Note, typically economic impacts are estimated based on an Evergreen Economics analysis of IMPLAN V3.1 modeling software. Due to negative incremental costs, which are not supported in the software, economic impacts are instead calculated based on a direct reduction of labor hours, results found in Table 11. Labor rates are the fully loaded costs present in the IMPLAN software: Construction Laborers (SOC[13]: 472061): $72/hour, Electricians (472111): $107/hour.

[13] SOC code: Standard Occupational Classification code -- see http://www.bls.gov/soc/home.htm

Table 11: Estimated Impact that the Adoption of the Proposed Measures Would Have On The California Commercial Construction Sector

Measure	Job Type	Per Unit Labor Hours Reduction (labor hours / sf)	Statewide Labor Reduction (hours)	Full Time Equivalent (2000 hours)	Labor Rate ($/hour)	Statewide Labor Cost Reduction (millions $)
Non-Res. Outdoor LPA General Hardscape	General Contractor	2.02×10^{-3}	253,883	126.94	$72	$18.3
	Electrician	4.49×10^{-3}	562,858	281.43	$107	$60.2
	Total	**NA**	**816,741**	**408.37**	**NA**	**$78.5**
Multifamily	General Contractor	2.3×10^{-3}	53,458	26.73	$72	$3.9
	Electrician	4.9×10^{-3}	116,932	58.47	$107	$12.5
	Total	**NA**	**170,391**	**85.20**	**NA**	**$16.4**
All Measures	General Contractor	NA	307,341	143.66	$72	$22.1
	Electrician	NA	679,790	228.86	$107	$72.7
	Total	**NA**	**987,132**	**372.52**	**NA**	**$94.9**

The multifamily measure is not anticipated to have impacts on building designers, energy consultants, or inspectors. All building designer impacts are estimated to be a result of the lighting zone reclassification measure, and the security camera adder, as part of the specific applications of the non-residential outdoor LPA reduction measure.

Table 12: Estimated Impact that Adoption of the Proposed Measure Would Have On The California Building Designers and Energy Consultants Sectors

Type of Economic Impact	Employment (jobs)	Labor Income (millions $)	Total Value Added (millions $)	Output (millions $)
Direct Effects (Additional spending by Building Designers & Energy Consultants)	13.6	$1.4	$1.4	$2.5
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consult.)	8.6	$0.6	$0.8	$1.2
Induced Effect (Spending by employees of firms experiencing “direct” or “indirect” effects)	10.6	$0.6	$1.1	$1.7
Total Economic Impacts	**32.8**	**$2.57**	**$3.23**	**$5.44**

Source: Analysis by Evergreen Economics of data from the IMPLAN V3.1 modeling software.

The nonresidential outdoor LPA reduction and lighting zone reclassification measures are anticipated to have minor impacts on building inspectors, due to the need to verify the project lighting zone, and verify the location of security cameras if the security camera LPA is used.

Table 13: Estimated Impact that Adoption of the Proposed Measure Would Have On California Building Inspectors

Type of Economic Impact	Employment (jobs)	Labor Income (millions $)	Total Value Added (millions $)	Output (millions $)
Direct Effects (Additional spending by Building Inspectors)	1.0	$0.10	$0.12	$0.15
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.1	$0.01	$0.01	$0.02
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.6	$0.03	$0.06	$0.10
Total Economic Impacts	**1.7**	**$0.15**	**$0.20**	**$0.27**

Source: Analysis by Evergreen Economics of data from the IMPLAN V3.1 modeling software.

3.4.1 Creation or Elimination of Jobs.

The Statewide CASE Team does not anticipate that proposed measures would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 3.3 would lead to modest changes in employment of existing jobs.

3.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.4.1, the proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to outdoor lighting source allowances, which would not excessively burden or competitively disadvantage California businesses – nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes to Title 24, Part 6.

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

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

3.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment in any directly or indirectly affected sectors of California's economy.

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

The Statewide CASE Team does not expect the proposed code changes to have a measurable impact on the California's General Fund, any state special funds, or local government funds.

3.4.6 Impacts on Specific Persons

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

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

4. Energy Savings

4.1 Key Assumptions for Energy Savings Analysis

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

4.1.1 Assumptions for Lighting Zone Reclassification

The Statewide CASE Team calculated per-unit impacts and statewide impacts associated with both new construction and alterations by examining energy use of outdoor LPAs in the different lighting zones that are minimally compliant with the 2019 Title 24, Part 6 Standards. The Statewide CASE Team specifically used the 2019 Title 24, Part 6 LPAs because the LPAs are not being updating in this submeasure, and therefore, all energy savings results only from a change in lighting zone. Changes to the lighting zone classifications result in a larger portion of the state being classified as LZ1 instead of LZ2. The per-unit difference for general hardscape areas and the specific applications[15] were calculated by comparing the differences in the 2019 LZ2 LPAs to

[15] Specific applications are listed in Table 140.7-B and are extra layers of wattage that can be used in addition to the general hardscape LPAs found in Table 140.7-A. Examples of specific applications include Outdoor Sales Frontage, Building Entrances and Exits, and Outdoor Sales Lots.

the 2019 LZ1 LPAs. Energy savings are realized because the LPAs for LZ1 are lower than those for LZ2. Therefore, overall less total wattage can be installed in a LZ1 project versus a LZ2 project.

The Statewide CASE Team studied various LED luminaires commonly available today to ensure that the LPAs for each lighting zone could be met. The Statewide CASE Team studied lower “warm” CCT luminaires (either 3000K CCT or 2700K CCT) that are widely available today to ensure that less efficacious luminaires used in current industry standard practices could be installed in each lighting zone. The LED luminaires were selected from a breadth of products that represent a reasonable cross-section of designs likely to be installed in the 2022 code cycle. The products were then analyzed for each specific application to ensure that the products were available to meet both the lighting level requirements and CALGreen BUG ratings listed in Section 5.108.6 for the updated lighting zone classifications.

The Statewide CASE Team used the same hours of operation in this code cycle as those assumed for the 2019 code cycle to calculate per-unit annual electricity use for each application in both LZ1 and LZ2 as shown in Table 14. More information on the hours of operation schedules can be found in Appendix M. The per-unit electricity savings were determined for each application by comparing the per-unit savings of reducing each application LPA from a LZ2 to an LZ1 classification. The electricity savings for specific applications are classified as per occurrence (e.g. per fuel pump), per linear foot, or per square foot, depending on the application.

Table 14: Nonresidential Outdoor Lighting Hours of Operation per Application

Application	Schedule	Type	Annual Full Load Hours
General Hardscape	General Hardscape with controls (poles heights less than 24 feet)	Dusk-30min to Dawn+30min with bi-level motion sensors	2768
General Hardscape	General Hardscape without controls (pole heights greater than 24 feet)	Dusk-30min to Dawn+30min	4690
Building Entrances and Exits	A	with bi-level motion sensor	4690
Primary Entrances	A	Dusk-30min to Dawn+30min	4690
Drive-Up Windows	Retail	Dusk-30min to Dawn+30min	3193
Uncovered Fuel Dispenser	A	Dusk-30min to Dawn+30min	4690
ATM	ATM	with Partial Off	3311
Outdoor Sales Frontage	C	Dusk-30min to Dawn+30min	1932
Hardscape Ornamental Lighting	A	Dusk-30min to Dawn+30min	4690
Building Facades	D	Dusk-30min to Dawn+30min	3193
Outdoor Sales Lots	Outdoor Sales Lots	Dusk-30min to Dawn+30min	3000
Vehicle Service Station Hardscape	Service Station Hardscape	Dusk-30min to Dawn+30min	3651
Vehicle Service Station Canopies	Service Station Canopies	with Partial Off	3651
Sales Canopies	Retail	Dusk-30min to Dawn+30min	3193
Non-sales Canopies and Pedestrian Tunnels	A	with Partial Off	4690
Guard Stations	A	Dusk-30min to Dawn+30min	4690
Student Pick-up/Drop-off Zones	B	Dusk-30min to Dawn+30min	1567
Outdoor Dining	Outdoor Dining	Dusk-30min to Dawn+30min	1932
Special Security Lighting for Retail Parking and Pedestrian Hardscape	A	with Partial Off	4690
Security Camera	A	Dusk-30min to Dawn+30min	4690

4.1.2 Assumptions for Lighting Power Allowance for General Hardscape

The general hardscape LPAs were developed using a similar approach that was used in both the 2016 and 2019 code cycle. The 10 representative general hardscape layouts are a reasonable approximation of anticipated installations during the 2022 code cycle and are the basis of the new 2022 general hardscape LPAs. These layouts are specific to outdoor lighting and are described in Table 15 and illustrated in Figure 1.

Each general hardscape LPA (for each lighting zone) is also known as the effective area wattage allowance (eAWA), and is a combination of three allowances:

- Initial wattage allowance (IWA): flat wattage allowance for a site. It is expressed in watts.
- Area wattage allowance (AWA): wattage allowance for the area of a site. It is expressed in watts per square foot.
- Linear wattage allowance (LWA): wattage allowance for the perimeter of a site. It is expressed in watts per linear foot.

These three allowances are combined into a single metric, the general hardscape LPA or eAWA, based on the size, shape, and location of the general hardscape area in question. Each of the 10 general hardscape layouts had the new IES recommended lighting levels applied to them and were modeled with “warm” CCT luminaires that are less efficacious than higher CCT luminaires to ensure that these less efficacious luminaires could be used with the new LPAs. New eAWAs were then developed for each of the 10 layouts based on the lower lighting levels and luminaires. The layouts are shown in Figure 1, except for layout k which is a perfect square lot and not shown in the Figure 1. The maximum eAWA for each layout was then used to develop the new proposed general hardscape LPAs. This was completed separately for each lighting zone because each lighting zone has a different lighting level requirement, and therefore, has a different LPA.

The 2022 eAWA values were further adjusted to account for the security camera allowance, expected to apply to a portion of statewide general hardscape area. A camera allowance adjusted eAWA was calculated by computing a weighted average over camera and non-camera equipped regions, between the original 2022 eAWA for non-camera area, and the eAWA plus security camera allowance for camera equipped areas. This calculation results in a single adjusted eAWA per lighting zone that can be used for per-unit and statewide calculations and compared directly with the 2019 base case eAWA.

The per-unit energy savings, including energy cost savings, were developed by comparing the 2019 general hardscape LPA, or 2019 eAWA, with the proposed 2022 general hardscape LPA with weighted camera allowance. Please see Section 4.2.1 for more details on the per-unit and statewide energy savings methodology.

The Statewide CASE Team wanted to confirm that the newly developed general hardscape LPAs were high enough to allow spaces to be lighted to the recommended light levels, so they were validated by using three real site designs.[16] Using lighting design software, the new LPA values were applied to the three parking lot designs and it was confirmed each could be lighted to IES recommended light levels with currently available products. Area lights with Type III, Type IV, and Type V lumen distributions were mounted on poles ranging in height from 15 feet to 45 feet per typical design standards. Figure 2 illustrates the real parking lot designs.

A comparison of the new eAWAs to the average lighting power density (LPD) of each of the real site designs found that the general hardscape eAWA is 30 percent higher than the averaged LPD of the real site designs for each lighting zone. This shows that the new eAWA includes a buffer to allow designers to install decorative, less efficacious luminaires in general hardscape applications.

Key considerations for the three parking lot sites include the expected lumen maintenance of the outdoor luminaires and the appropriate light loss factors. The Statewide CASE Team applied the maintained lumen output of each luminaire at 60,000 hours since this is the less than the typical end of life (L70) for most area lights. Per the general hardscape schedule, luminaires with a 60,000-hour rated life would not reach the reported end of life during the 15-year period of analysis. A luminaire dirt depreciation factor[17] of 0.85 was applied based on the molded acrylic direct deprecation values reported in IES RES-1-16 “Measure and Report Luminaire Dirt Depreciation (LDD) in LED Luminaires for Street and Roadway Lighting Applications” over 15 years.

[16] Real site designs were used for a small, medium, and large parking lot.

[17] This factor accounts for the fact that luminaires get dirty over time in outdoor environments.

Table 15: Description of General Hardscape Layouts Used for Energy, Demand, Cost, and Environmental Impacts Analysis for General Hardscape

Representative Layout ID	Hardscape Area (ft^2)	Hardscape Perimeter (ft)	Perimeter to Area (%)	Notes
Layout A	501,626	6,794	1.4	Long skinny site, big building
Layout B	471,726	5,131	1.1	Square site, irregular building
Layout C	42,828	3,052	7.1	Irregular site, campus buildings
Layout D	28,500	960	3.4	Long skinny site, small building
Layout E	21,000	760	3.6	Square site, small square building
Layout F	61,798	1,940	3.1	Irregular site, long square building
Layout G	21,797	1,408	6.5	Long skinny site, irregular building
Layout H	11,040	1,042	9.4	Square site, large square building
Layout J	34,735	2,593	7.5	Irregular site, large irregular building
Layout K	250,000	2,000	0.8	Ideal square site

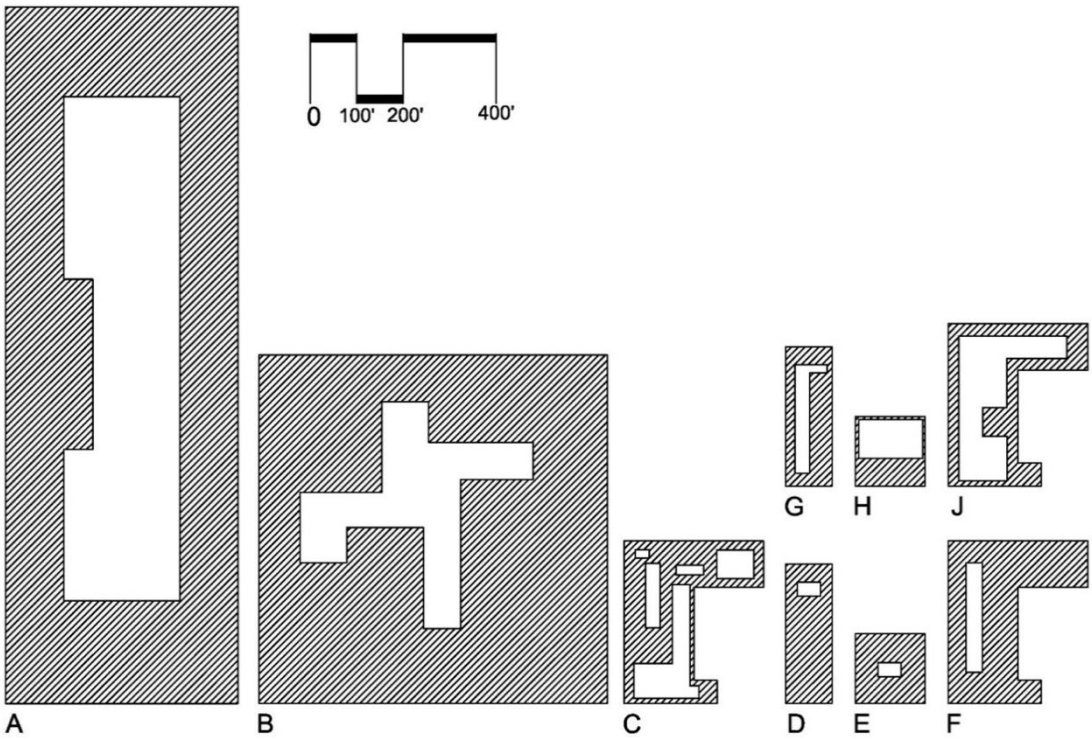

Figure 1: Representation of general hardscape layouts used to determine new lighting power allowances.

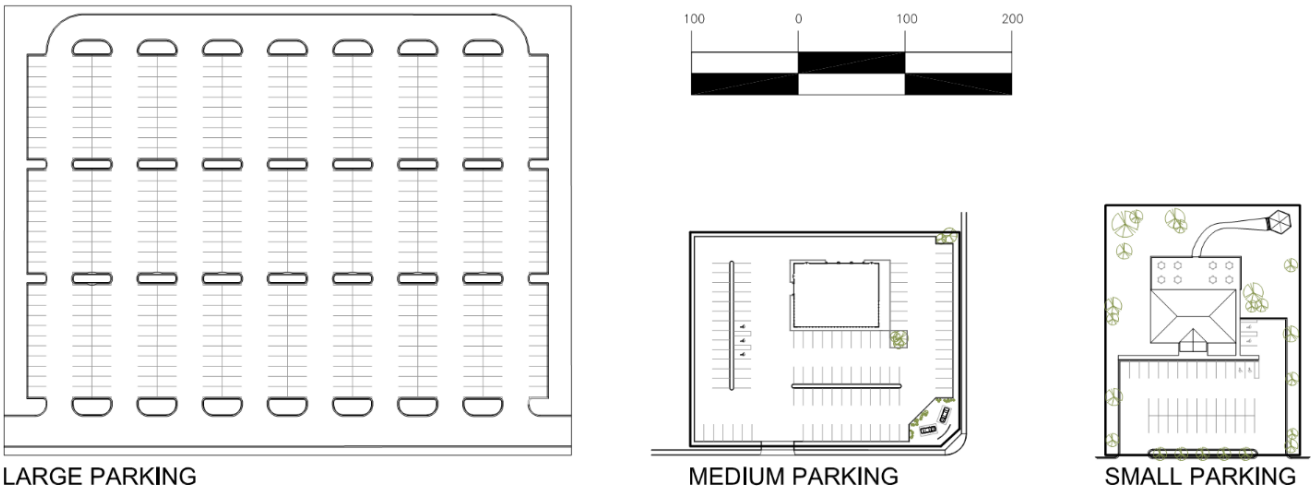

Figure 2: Real parking lot designs used to confirm recommended light levels could be achieved with the proposed lighting power allowances.

4.1.3 Assumptions for Multifamily Lighting Power Allowances

For the multifamily outdoor LPA submeasure, the Statewide CASE Team calculated per-unit impacts and statewide impacts associated with new construction and additions and alterations by comparing energy use of outdoor lighting that is minimally compliant with the 2019 Title 24, Part 6 Standards to the proposed requirements for the 2022 Title 24, Part 6 Standards.

Note that per-unit savings estimates are completed with different units for residential buildings than for nonresidential buildings. The multifamily building category includes the residential models Lowrise Garden, Loaded Corridor, Midrise Mixed, Highrise Mixed.

The analysis for General Hardscapes defines effective area wattage allowances for multifamily ($eAWA_{MF}$) for the 2022 proposal using 3000K LED luminaires that are widely available today and commonly used for multifamily projects. Wattage and pole heights were established for sites that represent a cross-section of what is likely to be installed in multifamily projects in the state during the 2022 code cycle. The Statewide CASE Team used three methods to ensure that the design represents reasonable design practice within the industry: 1.) a survey of lighting practitioners, including designers with multifamily experience, 2.) a review of multifamily projects available for statistical analysis, and 3.) the judgement of lighting experts within the Statewide CASE Team.

The effective area wattage allowance values for multifamily combine the Initial Wattage Allowance and the Area Wattage Allowance into a single value based on the size, shape, and type of the area in question. Note that these all get a “MF” subscript designation to differentiate these formulas from the nonresidential formulas.

The formula for multifamily LPA is as follows:

$$\boldsymbol{eAWA_{MF} = LPA_{MF} = IWA_{MF} + AWA_{MF}}$$

Where:

IWA_{MF} is the Initial Wattage Allowance specifically for multifamily projects (sourced from values in nonresidential outdoor lighting Table 140.7-A).

AWA_{MF} is the Area Wattage Allowance specifically for multifamily projects (sourced from values in the nonresidential outdoor lighting Table 140.7-A).

Note that this formula differs from the formula used in the nonresidential outdoor LPA calculation procedure in that it does not include a Linear Wattage Allowance (LWA) because these values have been absorbed into the new values for AWA_{MF} to simplify the calculation procedure.

4.2 Energy Savings Methodology

4.2.1 Lighting Zone Reclassification

The outdoor lighting applications do not have an interactive effect with HVAC and are not dependent on climate zone. Since savings do not vary by climate zone, the Statewide CASE Team averaged the statewide TDV factors for each climate zone and used that to calculate energy cost impacts.

Each lighting zone has a specific set of general hardscape and specific application LPAs with higher lighting zones having higher LPAs to accommodate higher recommended lighting levels. Updating the lighting zone definitions results in a significant portion of area in LZ2 moving down to LZ1. This results in energy savings due to these areas moving from higher to lower LPAs. The Statewide CASE Team calculated per-unit savings by calculating the total energy usage of one square foot of general hardscape and one unit of each specific application. Each LPA was converted to kWh by applying hours of operation for an entire year to each general hardscape and specific application LPA. These hours of operation assume that the luminaires would be turned on 30 minutes before dawn and turned off 30 minutes after dusk with post occupancy dimming and motion sensor control requirements applied per outdoor lighting control requirements in Section 130.2 of Title 24, Part 6. For luminaires mounted at 24 feet or lower, motion sensors were anticipated to be in use. Luminaires mounted above 24 feet do not require additional motion controls and were assumed to be at full light output until 11:00 PM. The hours of operation are presented in Table 14. This was completed for LZ1 and LZ2 LPAs.

The total per-unit (one square foot of general hardscape and each unit specific application) kWh energy usage for LZ2 was subtracted from the total per-unit kWh

energy usage for LZ1. The resulting kWh is the per-unit savings. The 2019 LPAs for general hardscape and specific applications were used for this analysis.

The per-unit savings were extrapolated to the entire state using estimates of statewide square footage of each type of outdoor hardscape area that would be impacted by the proposed requirements. The total statewide hardscape area was derived by converting the interior building construction forecasts provided by the Energy Commission to exterior construction forecasts. These exterior forecasts applied assumptions about the type and size of hardscaped areas that are associated with typical nonresidential construction of different building types. Refer to Appendix A for information on the percentage of interior construction forecasts applied to each exterior application.

The Statewide CASE Team calculated that statewide savings would occur from approximately five percent of buildings (new construction and alterations) shifting from having a LZ2 designation to LZ1. This is a result of updating the lighting zone definitions to moving “rural” areas to LZ1 and making “urban clusters” now the default LZ2. U.S. Census data shows that approximately five percent of California is designated as “rural” which is why estimated construction activity for LZ1 is increased to five percent. See Table 16 below showing the change in construction activity estimates for each lighting zone.

Table 16: Update to Percent of Construction Activity Per Lighting Zone

Lighting Zone	Percent of Land Mass (Source: 2010 U.S. Census)	Percent of Construction Activity Estimate (base case)	Percent of Construction Activity Estimate (proposed)
LZ0	9%	0.0%	0.0%
LZ1	1%	0.1%	5.0%
LZ2	85%	9.9%	5.0%
LZ3	5%	90.0%	90.0%
LZ4	0%	0.0%	0.0%

4.2.2 Lighting Power Allowance for General Hardscape

The outdoor lighting applications do not have an interactive effect with HVAC and are not dependent on climate zone. Since savings do not vary by climate zone, the Statewide CASE Team averaged the statewide TDV factors for each climate zone and used that to calculate energy cost impacts.

Unlike most 2022 CASE proposals, the outdoor lighting measures do not calculate energy savings associated with prototypical buildings. As described in Section 4.1.2, the Statewide CASE Team used representative layouts for outdoor lighting in general hardscape applications. These layouts include ten site plans that represent a variety of site configurations that account for both the building and hardscape footprint, which vary from an efficient (square) site with a simple building footprint and hardscape layout to a

more complex site with less ideal conditions. These site plans layouts are specific to outdoor lighting and enabled the Statewide CASE Team to compare LPA values in practical lighting layout conditions that represent a reasonable spectrum of conditions that may be encountered in actual site designs.

The LPA estimate average used for savings calculations was adjusted to account for a percentage of general hardscape installations using security cameras. The camera allowance adjusted LPA is calculated as a weighted average of the conventional (no camera) LPA and the conventional LPA plus security camera allowance for installations estimated to have security cameras.

Per-unit savings were developed by calculating the total energy usage of one square foot of general hardscape for each lighting zone. Each lighting zone LPA was converted to kWh by applying hours of operation for an entire year. These hours of operation assume that the luminaires would be turned on 30 minutes before dawn and turned off 30 minutes after dusk with post occupancy dimming and motion sensor control requirements applied per outdoor lighting control requirements in Section 130.2 of Title 24, Part 6. For luminaires mounted at 24 feet or lower, motion sensors were anticipated to be in use. Luminaires mounted above 24 feet do not require additional motion controls and were assumed to be at full light output until 11:00 PM. The hours of operation are presented in Table 14. This was completed for each lighting zone general hardscape LPA.

The Statewide CASE Team then estimated the statewide energy impacts by extrapolating the per-unit impacts to the entire state using estimates of the 2023 construction forecast. The building construction forecasts were developed by converting the interior construction forecasts provided by the Energy Commission to approximate exterior square footage per each space type. Refer to Appendix A for the percentage of interior spaces applied to each outdoor application. The assumptions applied to each of the converted construction forecasts were first developed during the 2016 code cycle. The same assumptions were applied to the 2019 code cycle construction forecasts and further refined. The Statewide CASE Team is applying the same assumptions refined for the 2019 code cycle to the 2023 construction forecasts.

The Statewide CASE Team did not use the updated construction activity estimates in Table 16, but rather the same construction activity estimates as the 2019 code cycle presented in Table 17 below. This was done to prevent double counting of energy savings.

Table 17: Percent of Construction Activity Per Lighting Zone for General Hardscape Lighting Power Allowance

Lighting Zone	Percent of Land Mass (Source: 2010 U.S. Census)	Percent of Construction Activity Estimate
LZ0	9%	0.0%
LZ1	1%	0.1%
LZ2	85%	9.9%
LZ3	5%	90.0%
LZ4	0%	0.0%

4.2.3 Multifamily Outdoor Lighting Power Allowance

For the multifamily outdoor LPA submeasure, the per-unit energy impacts for multifamily buildings are presented in savings per dwelling unit. The Statewide CASE Team developed the savings estimates based on the savings projections for lighting systems modelled to meet the design criteria and projected for the savings by building as discussed in Section 4.2.1 above.

This enabled a projection of statewide savings using construction forecasts to estimate the total energy savings that the state would benefit by adopting this measure. The weighting of the respective prototype models for the multifamily building type and the percentage of the dwelling units impacted by the measure is presented below in Table 19 below.

The Statewide CASE Team developed an understanding of typical hardscape and building conditions by analyzing the site development plans for multifamily projects to establish the ratios of general hardscape compared to square footage of buildings and compared to the number of apartment units within the development projects. These ratios are used to determine the respective statewide impacts of the measure for the respective building category.

Table 18 provides the average characteristics observed through the analysis of approximately 24 different properties to help characterize the multifamily prototypes. Further information on this analysis is provided in Appendix H at the end of the report.

Below that, Table 19 provides the weighting of the four prototype buildings within the overall construction forecasts to calculate the impacts of the proposed code changes. Note that for the analysis of outdoor lighting measures, these prototypes do not include building exterior information, and the Statewide CASE Team developed substitute characteristics based on real-world properties to represent each building prototype using the 24 properties mentioned above.

Table 18: Evaluated Site Characteristics by Prototype

Prototype	Floor Area (ft2)	Unit Count	Building Footprint Area (ft2)	Site Area (ft2)	Hardscape Area (ft2)	Site Perimeter (ft)	Hardscape Perimeter (ft)
High-Rise	143,729	145	43,959	88,801	36,876	1,330	3,255
Mid-Rise	179,832	161	77,048	185,011	74,109	1,742	6,718
Low Rise - Garden	46,150	45	38,584	153,578	66,136	1,608	5,546
Low Rise - Corridor	40,521	70	32,608	92,979	24,087	1,284	2,759

Table 19: Multifamily Building Associated Prototype Weighting

Building Type ID from Statewide Construction Forecast	Building Prototype for Energy Modeling	Weighting Factors of Total Multifamily Dwelling Units	Weighting Factors for Statewide Impacts Analysis
Multifamily	LowRiseGarden	4%	100%
	LoadedCorridor	33%	100%
	MidRiseMixedUse	58%	100%
	HighRiseMixedUse	5%	100%

4.3 Per-Unit Energy Impacts Results

4.3.1 Lighting Zone Reclassification

Energy savings and peak demand reductions per unit are presented in Table 20. There are no anticipated energy impacts for lighting zones 3 and 4 since there are no proposed changes to the weighting factors for these lighting zones. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates.

The following per-unit energy impacts were determined by calculating the difference in energy usage and peak demand reduction over one year, for one unit for each specific application.

Table 20: First-Year Energy Impacts Per Unit – Lighting Zone Reclassification

Lighting Application	Per Unit	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
General Hardscape	Per Square Foot	0.003	3.53×10^{-7}	NA	0.09
Building Entrances or Exits	Each	1.380	2.53×10^{-4}	NA	41.18
Primary Entrances	Each	4.601	8.43×10^{-4}	NA	137.28
Drive Up Windows	Each	2.192	3.85×10^{-4}	NA	67.04
Vehicle Service Station Uncovered Fuel Dispenser	Each Pump Face	5.061	9.27×10^{-4}	NA	151.00
ATM Machine Lighting	Each	0.000	0	NA	0.00
Outdoor Sales Frontage	Per Linear Foot	1.042	2.42×10^{-4}	NA	34.01
Hardscape Ornamental Lighting	Per Square Foot	0.002	2.95×10^{-7}	NA	0.05
Building Facades	Per Square Foot	0.016	2.75×10^{-6}	NA	0.48
Outdoor Sales Lots	Per Linear Foot	0.022	4.14×10^{-6}	NA	0.66
Vehicle Service Station Hardscape	Per Square Foot	0.011	2.07×10^{-6}	NA	0.33
Vehicle Service Station Canopies	Per Square Foot	0.038	7.02×10^{-6}	NA	1.13

Sales Canopies	Per Square Foot	0.074	1.29×10^{-5}	NA	2.25
Non-sales Canopies and Tunnels	Per Square Foot	0.018	3.37×10^{-6}	NA	0.55
Guard Stations	Per Square Foot	0.022	4.00×10^{-6}	NA	0.65
Student Pick-up/Drop-off zone	Per Square Foot	0.004	1.04×10^{-6}	NA	0.14
Outdoor Dining	Per Square Foot	0.002	5.72×10^{-7}	NA	0.08
Special Security Lighting for Retail Parking and Pedestrian Hardscape	Per Square Foot	0.000	4.21×10^{-8}	NA	0.01

4.3.2 Light Power Allowances for General Hardscape

The following per-unit energy impacts were determined by calculating the difference in energy usage and peak demand reduction over one year, for one square foot of area of the 2019 General Hardscape LPAs versus the proposed 2022 General Hardscape LPAs.

Table 21: First-Year Energy Impacts Per Unit – General Hardscape Lighting Power Allowance

General Hardscape	Per Unit	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
Lighting Zone 1	Per Square Foot	0.0043	5.24×10^{-7}	N/A	0.128
Lighting Zone 2	Per Square Foot	0.0407	4.98×10^{-6}	N/A	1.214
Lighting Zone 3	Per Square Foot	0.0478	6.15×10^{-6}	N/A	1.428
Lighting Zone 4	Per Square Foot	0.0340	6.23×10^{-6}	N/A	1.015

4.3.3 Multifamily Lighting Power Allowances

Table 22: Weighted Average First-Year Energy Impacts Per Dwelling Unit – Multifamily Outdoor Lighting Power Allowance

Building Prototype	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
Low Rise Garden	140	0.027	NA	1,301
Loaded Corridor	36	0.007	NA	336
Mid-Rise Mixed Use	43	0.008	NA	404
High Rise Mixed Use	24	0.005	NA	231

5. Cost and Cost Effectiveness

5.1 Energy Cost Savings Methodology

The energy cost savings presented in this section were calculated by applying the TDV energy cost factors to the energy savings estimates that were derived using the methodology described in Section 4.2. TDV is a normalized metric to calculate energy cost savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with how costs are expected to change over the period of analysis (30 years for residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2023 present value dollars and represent the energy cost savings realized over 15 years. TDV cost impacts in nominal dollars are presented in Appendix N.

5.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings that are realized over the 15-year period of analysis are presented in 2023 dollars in the following sections. The nominal per-unit impacts are presented in Appendix N and do not vary by new construction or alterations.

5.2.1 Nonresidential Lighting Zone Reclassification

The per-unit savings are averaged across all the lighting zones. The weighting values used to average the lighting zones are presented in Table 23 below. The 2023 present value per-unit impacts do not vary by new construction or alterations and are presented in Table 24.

Table 23: Update to Percent of Construction Activity Per Lighting Zone

Lighting Zone	Percent of Construction Activity Estimate
LZ0	0.0%
LZ1	5.0%
LZ2	5.0%
LZ3	90.0%
LZ4	0.0%

Table 24: Lighting Zone Reclassification: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Unit – New Construction and Alterations

Lighting Application	Units	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
General Hardscape	Per Square Foot	0.008	N/A	0.008
Building Entrances or Exits	Each	3.665	N/A	3.665
Primary Entrances	Each	12.218	N/A	12.218
Drive Up Windows	Each	5.967	N/A	5.967
Vehicle Service Station Uncovered Fuel Dispenser	Each Pump Face	13.440	N/A	13.440
ATM Machine Lighting	Each	0.000	N/A	0.000
Outdoor Sales Frontage	Per Linear Foot	3.027	N/A	3.027
Hardscape Ornamental Lighting	Per Square Foot	0.004	N/A	0.004
Building Facades	Per Square Foot	0.043	N/A	0.043
Outdoor Sales Lots	Per Linear Foot	0.059	N/A	0.059
Vehicle Service Station Hardscape	Per Square Foot	0.030	N/A	0.030
Vehicle Service Station Canopies	Per Square Foot	0.101	N/A	0.101
Sales Canopies	Per Square Foot	0.200	N/A	0.200
Non-sales Canopies and Tunnels	Per Square Foot	0.049	N/A	0.049
Guard Stations	Per Square Foot	0.058	N/A	0.058
Student Pick-up/Drop-off zone	Per Square Foot	0.013	N/A	0.013
Outdoor Dining	Per Square Foot	0.007	N/A	0.007
Special Security Lighting for Retail Parking and Pedestrian Hardscape	Per Square Foot	0.001	N/A	0.001

5.2.2 Nonresidential General Hardscape Lighting Power Allowance

The per-unit savings are averaged across all the lighting zones. The weighting used to average the lighting zones are presented in Table 25 below. The 2023 present value per-unit impacts do not vary by new construction or alterations and are presented in Table 26.

Table 25: Percent of Construction Activity Per Lighting Zone

Lighting Zone	Percent of Construction Activity Estimate
LZ0	0.0%
LZ1	0.1%
LZ2	9.9%
LZ3	90.0%
LZ4	0.0%

Table 26: General Hardscape Lighting Power Allowance: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot

Lighting Application	Units	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
General Hardscape – New Construction	Per Square Foot	$0.13	N/A	$0.13
General Hardscape – Alterations	Per Square Foot	$0.13	N/A	$0.13

5.2.3 Multifamily General Hardscape Lighting Power Allowance

The per-unit savings are averaged across all the lighting zones. The weighting used to average the lighting zones are presented in Table 27 below. The 2023 present value per-unit impacts do not vary by new construction or alterations and are presented in Table 28.

Table 27: Percent of Construction Activity Per Lighting Zone

Lighting Zone	Percent of Construction Activity Estimate
LZ0	0.0%
LZ1	0.1%
LZ2	9.9%
LZ3	90.0%
LZ4	0.0%

Table 28: Multifamily Outdoor Lighting Power Allowance 2023 Present Value TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Dwelling Unit – New Construction and Alterations

Building Prototype	Units	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
Low Rise Garden	Dwelling Unit	$115.78	N/A	$115.78
Loaded Corridor	Dwelling Unit	$29.94	N/A	$29.94
Mid-Rise Mixed Use	Dwelling Unit	$35.96	N/A	$35.96
High Rise Mixed Use	Dwelling Unit	$20.59	N/A	$20.59

5.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices

5.3.1 Lighting Zone Reclassification

The Statewide CASE Team reached out to 58 different manufacturers and referenced distributor pricing to obtain data on the cost of currently available lighting products. The same lighting products were compared in LZ1 and LZ2 applications, which resulted in no incremental costs for the lighting zone reclassification measure.

5.3.2 General Hardscape Lighting Power Allowance

There are no incremental costs associated with the update to the general hardscape LPAs. The same LED technology is used for both the base and proposed case which does not result in any incremental cost. Additionally, the proposed case uses less equipment per square foot to achieve the new recommended light levels, which means costs for the proposed case are lower than the base case. The Statewide CASE Team compared the average system cost per square foot of each prototype building between the 2019 and the 2022 code cycles. Three different general hardscape sites (large, medium, and small parking lots) were used to verify costs as well as determine the typical quantity of luminaires and luminaire spacing necessary to meet IES recommended minimum lighting levels and uniformity while lighting each parking lot at various mounting heights with multiple luminaire distributions. The differences in the quantity of equipment necessary to meet the lighting levels in the 2019 and 2022 codes was used to determine the equipment cost savings between the code cycles. Fewer

luminaires, light poles, foundations, control equipment, wiring, and conduit is required to meet the lower lighting levels throughout the general hardscape areas.

5.3.3 Multifamily Outdoor Lighting Power Allowance

There are no incremental costs associated with the introduction of the multifamily code section for general hardscape LPAs. The same LED technology is used for both the base and proposed case which does not result in any incremental cost. Additionally, the proposed case uses less equipment per square foot to achieve the new recommended light levels as the base case, which means costs for the proposed case is lower than the base case.

The same calculations that determined no additional costs occur in the Nonresidential LPA measure applies for this measure as the lighting equipment is generally the same and the application in the field are comparable. Fewer luminaires, light poles, foundations, control equipment, wiring, and conduit is required to meet the lower lighting levels throughout the general hardscape areas.

5.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the 15-year period of analysis.

The nonresidential outdoor lighting for both the 2019 and 2022 code cycles use an LED baseline. The average end of life (L70) for LED technology is greater than the 15-year period of analysis. During this time period, no equipment maintenance is expected for any of the LED lighting since the products would still be within their life expectancy. The cleaning maintenance schedules would remain the same between the 2019 and 2022 code cycles which results in no changes to incremental cleaning costs. Due to this, there are no anticipated maintenance costs for the nonresidential outdoor lighting submeasures.

5.5 Cost Effectiveness

These submeasures propose a prescriptive requirement. As such, a cost analysis is required to demonstrate that the measure is cost effective over the 15-year period of analysis. The Energy Commission establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with Energy Commission staff to confirm that the methodology in this report is consistent with Energy Commission guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 15-year period of analysis were included. The TDV energy cost savings from electricity savings were also included in

the evaluation. Design costs were not included nor were the incremental costs of code compliance verification.

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

Results of the per-unit cost-effectiveness analyses are presented in Table 29 and

Table 30 for new construction and alterations, respectively. The B/C ratio for the lighting zone reclassification and general hardscape LPA submeasures are infinite since the submeasures would save energy without any increase to the incremental costs.

Table 29: 15-Year Cost-Effectiveness Summary Per Unit – New Construction

Measure	Units	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
Lighting Zone Reclassification	Per Square Foot	$0.06	$ 0	Infinite
General Hardscape LPA	Per Square Foot	$0.36	$ 0	Infinite
Multifamily LPA	Per Dwelling Unit	$36.40	$ 0	Infinite

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2020). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost. PV maintenance cost savings are included if PV of proposed maintenance costs is less than PV of current maintenance costs.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate. Costs include incremental first cost if proposed first cost is greater than current first cost. Costs include PV of maintenance incremental cost if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no Total Incremental PV Costs, the Benefit-to-Cost ratio is infinite.

Table 30: 15-Year Cost-Effectiveness Summary Per Unit – Alterations

Measure	Units	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
Lighting Zone Reclassification	Per Square Foot	$0.06	$ 0	Infinite
General Hardscape LPA	Per Square Foot	$0.36	$ 0	Infinite
Multifamily LPA	Per Dwelling Unit	$36.40	$ 0	Infinite

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2020). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost. Present value maintenance cost savings are included if PV of proposed maintenance costs is less than PV of current maintenance costs.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate. Costs include incremental first cost if proposed first cost is greater than current first cost. Costs include PV of maintenance incremental cost if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no Total Incremental Present Valued Costs, the Benefit-to-Cost ratio is infinite.

6. First-Year Statewide Impacts

6.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction by multiplying the per-unit savings, which are presented in Section 4.3, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. The statewide new construction forecast for 2023 is presented in Appendix A as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal.

The first-year statewide savings were calculated by applying the per-unit energy savings for each application by the difference in weighting for each occurrence of space type. The difference in GWh between the 2019 code cycle weighting and the 2022 code cycle weighting were used to determine the total GWh energy savings per each application.

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

6.1.1 Lighting Zone Reclassification

Given data regarding the new construction forecast and expected additions and alterations in 2023, the Statewide CASE Team estimates that the proposed lighting zone reclassification code change would reduce annual statewide electricity use by 2.82 GWh with an associated demand reduction of 0.45 MW. No natural gas reductions are expected from this measure. The energy savings for buildings constructed in 2023 are associated with a present valued energy cost savings of approximately $7.6 million in (discounted) energy costs over the 15-year period of analysis.

Table 31: Statewide Energy and Energy Cost Impacts – Lighting Zone Reclassification – New Construction (NC), Alterations and Additions (A)

Lighting Application[b]	Statewide New Construction Impacted by Proposed Change in 2023 (unit[b])	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
General Hardscape **(NC)**	125.49 (MM ft2)	0.36	0.04	N/A	0.96
Building Entrances or Exits **(NC)**	33,415 (ea.)	0.05	0.01	N/A	0.12
Primary Entrances **(NC)**	64 (ea.)	0.00	0.00	N/A	0.00
Drive Up Windows **(NC)**	886 (ea.)	0.00	0.00	N/A	0.01
Vehicle Service Station Uncovered Fuel Dispenser **(NC)**	32 (ea.)	0.00	0.00	N/A	0.00
ATM Machine Lighting **(NC)**	128 (ea.)	0.00	0.00	N/A	0.00
Outdoor Sales Frontage **(NC)**	0.1 (MM lin. ft)	0.10	0.02	N/A	0.29
Hardscape Ornamental Lighting **(NC)**	4.84 (MM ft2)	0.01	0.00	N/A	0.02
Building Facades **(NC)**	1.99 (MM ft2)	0.03	0.01	N/A	0.08
Outdoor Sales Lots **(NC)**	0.96 (MM lin. ft)	0.02	0.00	N/A	0.06
Vehicle Service Station Hardscape **(NC)**	3.52 (MM ft2)	0.04	0.01	N/A	0.10
Vehicle Service Station Canopies **(NC)**	0.38 (MM ft2)	0.01	0.00	N/A	0.04
Sales Canopies **(NC)**	0.16 (MM ft2)	0.01	0.00	N/A	0.03
Non-sales Canopies and Tunnels **(NC)**	2.69 (MM ft2)	0.05	0.01	N/A	0.13
Guard Stations **(NC)**	0.04 (MM ft2)	0.00	0.00	N/A	0.00
Student Pick-up/Drop-off zone **(NC)**	0.18 (MM ft2)	0.00	0.00	N/A	0.00
Outdoor Dining **(NC)**	0.62 (MM ft2)	0.00	0.00	N/A	0.00
Special Security Lighting for Retail Parking and Pedestrian Hardscape **(NC)**	0.53 (MM ft2)	0.00	0.00	N/A	0.00
Total – New Construction	N/A	**0.69**	**0.11**	**N/A**	**1.86**
General Hardscape **(A)**	390.83 (MM ft2)	1.13	0.14	N/A	3.00
Building Entrances or Exits **(A)**	103,660 (ea.)	0.14	0.03	N/A	0.38
Primary Entrances **(A)**	192 (ea.)	0.00	0.00	N/A	0.00
Drive Up Windows **(A)**	2,591 (ea.)	0.01	0.00	N/A	0.02
Vehicle Service Station Uncovered Fuel Dispenser **(A)**	96 (ea.)	0.00	0.00	N/A	0.00

ATM Machine Lighting **(A)**	385 (ea.)	0.00	0.00	N/A	0.00
Outdoor Sales Frontage **(A)**	0.29 (MM lin. ft)	0.30	0.07	N/A	0.87
Hardscape Ornamental Lighting **(A)**	14.92 (MM ft2)	0.02	0.00	N/A	0.06
Building Facades **(A)**	6.19 (MM ft2)	0.10	0.02	N/A	0.26
Outdoor Sales Lots **(A)**	2.89 (MM lin. ft)	0.06	0.01	N/A	0.17
Vehicle Service Station Hardscape **(A)**	10.59 (MM ft2)	0.12	0.02	N/A	0.31
Vehicle Service Station Canopies **(A)**	1.16 (MM ft2)	0.04	0.01	N/A	0.12
Sales Canopies **(A)**	0.48 (MM ft2)	0.04	0.01	N/A	0.10
Non-sales Canopies and Tunnels **(A)**	8.39 (MM ft2)	0.15	0.03	N/A	0.41
Guard Stations **(A)**	0.13 (MM ft2)	0.00	0.00	N/A	0.01
Student Pick-up/Drop-off zone **(A)**	0.68 (MM ft2)	0.00	0.00	N/A	0.01
Outdoor Dining **(A)**	1.86 (MM ft2)	0.00	0.00	N/A	0.01
Special Security Lighting for Retail Parking and Pedestrian Hardscape **(A)**	1.63 (MM ft2)	0.00	0.00	N/A	0.00
Total – Alterations	**N/A**	**2.13**	**0.34**	**N/A**	**5.74**
Total – All	**N/A**	**2.82**	**0.45**	**N/A**	**7.60**

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

b. MM ft2: Million Square Feet; ea.: Each; MM lin. ft: Million Linear Feet. NC – New Construction, A – Alterations.

6.1.2 General Hardscape Lighting Power Allowance

Given data regarding the new construction forecast and expected additions and alterations in 2023, the Statewide CASE Team estimates that the proposed general hardscape reclassification code change would reduce annual statewide electricity use by 24.30 GWh with an associated demand reduction of 3.11 MW. No natural gas reductions are expected from this measure. The energy savings for buildings constructed in 2023 are associated with a present valued energy cost savings of approximately $64.58 million in (discounted) energy costs over the 15-year period of analysis.

Table 32: Statewide Energy and Energy Cost Impacts – General Hardscape – New Construction, Alterations, and Additions

Lighting Application	Statewide New Construction Impacted by Proposed Change in 2023 (million square feet)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
General Hardscape – New Construction	125.49	5.91	0.76	N/A	$15.70
General Hardscape - Alterations	390.83	18.40	2.35	N/A	$48.89
Total	**516.32**	**24.30**	**3.11**	**N/A**	**$64.58**

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

6.1.3 Multifamily Outdoor Lighting Power Allowance

Given data regarding the new construction forecast and expected additions and alterations in 2023, the Statewide CASE Team estimates that the proposed multifamily outdoor LPA code introduction would reduce annual statewide electricity use by 2.28 GWh with an associated demand reduction of 0.45 MW. Natural gas use would not be impacted. The statewide energy savings for buildings constructed in 2023 are associated with a present valued energy cost savings of approximately $1.89 million in (discounted) energy costs over the 15-year period of analysis. This information is shown in Table 33 and Table 34 below.

Table 33: Statewide Energy and Energy Cost Impacts Multifamily Outdoor Lighting Power Allowance – New Construction

Building Prototype	Statewide New Construction Impacted by Proposed Change in 2023 Dwelling Units	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
Low Rise Garden	2,079	0.29	0.06	NA	$0.24
Loaded Corridor	17,149	0.62	0.12	NA	$0.51
Mid-Rise Mixed Use	30,140	1.31	0.26	NA	$1.08
High Rise Mixed Use	2,598	0.06	0.01	NA	$0.05
TOTAL	**12,992**	**2.28**	**0.45**	**NA**	**$1.89**

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

Table 34: Statewide Energy and Energy Cost Impacts Multifamily Outdoor Lighting Power Allowance – Alterations

Building Prototype	Statewide Alterations Impacted by Proposed Change in 2023 Dwelling Units	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
Low Rise Garden	8,620	1.20	0.24	NA	$1.00
Loaded Corridor	71,118	2.57	0.50	NA	$2.13
Mid-Rise Mixed Use	124,993	5.43	1.06	NA	$4.49
High Rise Mixed Use	10,776	0.27	0.05	NA	$0.22
TOTAL	**215,506**	**9.47**	**1.85**	**NA**	**$7.84**

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

6.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions assuming the emissions factors specified in the United States Environmental Protection Agency (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion.[18] Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42). See Appendix C for additional details on the methodology used to calculate GHG emissions. In short, this analysis assumes an average electricity emission factor of 240.4 metric tons CO2e per GWh based on the average emission factors for the CACX EGRID subregion.

Table 35 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 9,331 metric tons of carbon dioxide equivalents (metric tons CO2e) would be avoided.

Table 35: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (MMtherms/ yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
Lighting Zone Reclassification	2.82	676.91	N/A	N/A	676.91
General Hardscape LPA	24.30	5,841.46	N/A	N/A	5,841.46
Multifamily Outdoor LPA	11.75	2,812.68	N/A	N/A	2,812.68
TOTAL	**38.87**	**9,331**	**N/A**	**N/A**	**9,331**

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

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

GHG first year savings from avoided material use are summarized below in Table 36. Overall CO2e reduction for both material types (i.e., concrete, aluminum) results in a

[18] When evaluating the impact of increasing the Renewable Portfolio Standard from 20 percent renewables by 2020 to 33 percent renewables by 2020, the California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The incremental emissions were calculated by dividing the difference between California emissions in the CARB high and low generation forecasts by the difference between total electricity generated in those two scenarios.

total avoided emissions of 40,342 metric tons CO2e. Note that the GHG impact (in avoided CO2e) for concrete is 180 kg CO2e per m^3 (Lafarge 2010) based on a concrete density of 143 lb per ft^3 (Polebase 2014). Avoided emissions from aluminum is 3.12 kg CO2e per lb aluminum (Building Transparency 2020). Detailed calculations for these material impacts are located in Materials Impacts, Section 6.4.

Table 36: GHG First-Year Reductions from Materials Impacts

Measure	Reduced GHG Emissions from Concrete Material Use Reduction (Metric Tons CO2e)	Reduced GHG Emissions from Aluminum Material Use Reduction (Metric Tons CO2e)	Total Reduced GHG Emissions from Materials Impacts (Metric Tons CO2e)
General Hardscape LPA	5,685	27,563	33,248
Multifamily Outdoor LPA	1,201	5,892	7,093
TOTAL	**6,886**	**33,456**	**40,342**

6.3 Statewide Water Use Impacts

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

6.4 Statewide Material Impacts

The lighting zone reclassification submeasure is not anticipated to result in a reduction of the equipment quantity installed in nonresidential outdoor applications. The Statewide CASE Team anticipates that the same products, except with lower luminaire lumen outputs, would be installed in project areas that have been reclassified from a LZ2 application to an LZ1 application. This reduction in lumen outputs is not anticipated to result in material savings.

The general hardscape submeasure would reduce the infrastructure required throughout the general hardscape area due to the 2022 Title 24, Part 6 code realignment with IES RP-8-18 Addendum 1. The general hardscape can be illuminated with fewer luminaires, spaced further apart, and still provide a quality lighting design that aligns with IES recommended lighting levels. This greater spacing reduces the quantity of luminaires, poles, foundations, motion sensors, conduit, and wiring installed in each general hardscape area.

The Statewide CASE Team estimated material impacts using the following methodology:

- Estimate material composition of a luminaire;
- Estimate material composition of an outdoor light pole, including wiring;
- Estimate the average reduction of luminaires and poles based on the lower LPAs. This analysis was completed for a small, medium, and large parking lot to account for different general hardscape designs and resulted in per unit, pounds per square foot results.
- Apply the per-unit savings to new construction and alterations estimates to develop statewide savings.

The Statewide CASE Team estimated material composition for luminaires by looking at the manufacturer specifications of an average outdoor, pole mounted luminaire. Unfortunately, the specifications only provided the total weight (31 pounds) of the luminaire and composition of the luminaire housing (aluminum). The Statewide CASE Team estimated that approximately 80 percent of the weight of the luminaire would be from the aluminum housing, recognizing that materials for the lens, screws, fasteners, and other miscellaneous materials would not be accounted for. This estimate also did not provide any information on the LEDs within the luminaire itself, so the Statewide CASE Team used a 2012 study that looked at the potential impacts from metals within different lamp types, including LEDs (Lim, et al. 2013). The study included estimated amounts of different types of metals within an LED luminaire (Lim, et al. 2013). The Statewide CASE Team recognized that this is an older study and material composition may differ in light sources and luminaires produced in 2020 versus those produced nearly 10 years ago. However, the Statewide CASE Team was unable to locate a comprehensive current study. The Statewide CASE Team used this information to estimate the total amount of materials contained within one luminaire (housing and LEDs).

The Statewide CASE Team used a single manufacturer's specifications for a 20-foot light pole. While many light poles would be greater than 20 feet in height (and 20-foot poles would have light controls attached), the Statewide CASE Team assumed poles would be 20 feet with no attached controls to simplify the calculation. The specific manufacturer sells light poles made from various materials, but the Statewide CASE Team decided an aluminum pole was the most common type. This assumption was based on professional lighting design experience and judgement. Based on the specifications, one aluminum light pole contains 140 pounds of aluminum. Based again on professional lighting design experience and judgement, the Statewide CASE Team estimated that each light pole would also require three 20-foot strands of #12 American wire gauge (AWG) copper conductors for internal wiring, and three 70-foot strands of #8

AWG copper conductors to connect to the next nearest light pole. The copper wiring adds up to approximately 7.1 pounds of copper.

The concrete pole foundation for a conventional outdoor luminaire is estimated to be a 7-foot tall (3-foot above grade), 2-foot diameter cylindrical foundation, with 5000 psi at 28 day strength benchmark. The composition of this concrete is Type I or Type III Portland cement in accordance with ASTM C150, fly ash or other pozzolans (e.g. blast furnace slag) in accordance with ACI 318-11-Table 4.4.2, aggregate in accordance with ASTM C33, Size 57, Class 4S, with a water to cementitious material max ratio of 0.40 in accordance with ASTM C143 (Polebase 2014). This concrete mixture has a manufacturer estimated density of 143 lb/ft^3, and an estimated CO2e impact of 180 kg CO2e per m^3 concrete (Lafarge 2010).

The Statewide CASE Team used three parking lot designs to estimate the number of light poles and luminaires that would be reduced as a result of the lower proposed LPAs. Specifically, the Statewide CASE Team used designs for a small, medium, and large parking lots. The Statewide CASE Team assumed different building types were likely to be associated with the different parking lot sizes. Refer to Table 37 below for mapping of building types to parking lot size. Based on the different parking lot size designs, the Statewide CASE Team also estimated the average number of luminaires and light poles that would be reduced for each parking lot size. Please see Table 38 for details on the reduced number of luminaires and light poles for each parking lot size.

Table 37: Mapping Building Types to Associated Parking Lot Size

Building Type	Associated Parking Lot Size	Percent Applied
Small Office	Small Parking Lot	100%
Large Office	Medium Parking Lot	100%
Restaurant	Small Parking Lot	100%
Retail	Large Parking Lot / Small Parking Lot	50% / 50%
Grocery Store	Medium Parking Lot / Small Parking Lot	50% / 50%
Non-Refrigerated Warehouse	Medium Parking Lot / Small Parking Lot	50% / 50%
Refrigerated Warehouse	Medium Parking Lot / Small Parking Lot	50% / 50%
Schools	Medium Parking Lot	100%
Colleges	Large Parking Lot	100%
Hospitals	Large Parking Lot	100%
Hotel/Motels	Medium Parking Lot	100%
Miscellaneous	Large Parking Lot / Medium Parking Lot / Small Parking Lot	33.33% / 33.33% / 33.33%

Table 38: Estimated Reduction in Luminaires and Light Poles per Different Sized Parking Lots, General Hardscape

Parking Lot	Parking Lot Size (ft^2)	Reduced Number of Luminaires	Reduced Number of Light Poles
Large Parking Lot	197,018	34	31
Medium Parking Lot	36,321	13	21
Small Parking Lot	15,536	10	8

Table 39: Estimated Reduction in Luminaires and Light Poles per Different Sized Parking Lots, Multifamily

Parking Lot	Parking Lot Size (ft^2)	Reduced Number of Luminaires	Reduced Number of Light Poles
Medium Parking Lot	36,321	14	16
Small Parking Lot	15,536	10	8

Most of the materials savings result from the reduction of light poles; each of which accounts for 140 pounds of aluminum and over seven pounds of copper saved. This per-pole material savings is converted into pounds of material saved per square foot of hardscape based on the number of poles reduced, versus the parking lot nominal size. The Statewide CASE Team then applied these unit savings to the same new construction estimates used for the energy and energy cost savings estimates. The statewide material impacts results show a significant reduction in aluminum and copper. The results of this analysis are outlined in Table 40 through Table 42, where material savings are tabulated for NR Outdoor LPA measure, Multifamily measure, and total impacts, respectively.

Table 40: First-Year Statewide Impacts on Material Use for General Hardscape Lighting Power Allowance

Material	Impact (I, D, or NC) [a]	Impact on Material Use (pounds/year)	
		Per-Unit Impacts (pounds/ft^2)	First-Year[b] Statewide Impacts
Aluminum	D	0.07	8,834,406.66
Antimony	D	1.83×10^{-8}	2.50
Barium	D	5.39×10^{-8}	7.36
Cerium	D	1.12×10^{-9}	0.15
Chromium	D	1.77×10^{-8}	2.41
Concrete	D	1.28	159,502,587.50
Copper	D	2.98×10^{-3}	382,344.15
Gallium	D	1.60×10^{-8}	2.18
Gold	D	3.45×10^{-10}	0.05
Iron	D	1.82×10^{-6}	248.11
Lead	D	2.50×10^{-9}	0.34
Mercury	D	8.63×10^{-11}	0.01
Nickel	D	2.24×10^{-8}	3.06
Phosphorus	D	1.88×10^{-8}	2.57
Silver	D	2.36×10^{-8}	3.21
Tungsten	D	1.73×10^{-10}	0.02
Yttrium	D	2.59×10^{-10}	0.04
Zinc	D	6.73×10^{-7}	91.82

a. Material Increase (I), Decrease (D), or No Change (NC) compared to base case (lbs/yr).

b. First-year savings from all buildings completed statewide in 2023, including new construction and alterations.

Table 41: First-Year Statewide Impacts on Material Use for Multifamily Hardscape Lighting Power Allowance

Material	Impact (I, D, or NC) [a]	Impact on Material Use (pounds/year)	
		Per-Unit Impacts (pounds/ft^2)	First-Year[b] Statewide Impacts
Aluminum	D	0.08	1,888,538.28
Antimony	D	2.40×10^{-8}	0.57
Barium	D	7.09×10^{-8}	1.68
Cerium	D	1.47×10^{-9}	0.03
Chromium	D	2.33×10^{-8}	0.55
Concrete	D	1.42	33,691,968.58
Copper	D	3.41×10^{-3}	80,773.78
Gallium	D	2.10×10^{-8}	0.50
Gold	D	$4.54x\ 10^{-10}$	0.01
Iron	D	2.39×10^{-6}	56.55
Lead	D	3.29×10^{-9}	0.08
Mercury	D	$1.13x\ 10^{-11}$	0.00
Nickel	D	2.95×10^{-8}	0.70
Phosphorus	D	2.47×10^{-8}	0.59
Silver	D	3.10×10^{-8}	0.73
Tungsten	D	2.27×10^{-10}	0.01
Yttrium	D	3.40×10^{-10}	0.01
Zinc	D	8.85×10^{-7}	20.93

a. Material Increase (I), Decrease (D), or No Change (NC) compared to base case (lbs/yr).

b. First-year savings from all buildings completed statewide in 2023, including new construction and alterations

Table 42: First-Year Statewide Impacts on Material Use for All Measures

Material	Impact (I, D, or NC) [a]	First-Year[b] Statewide Impacts (pounds/year)
Aluminum	D	10,722,944.94
Antimony	D	3.07
Barium	D	9.04
Cerium	D	0.19
Chromium	D	2.96
Concrete	D	193,194,556.08
Copper	D	463,117.93
Gallium	D	2.67
Gold	D	0.06
Iron	D	304.65
Lead	D	0.42
Mercury	D	0.01
Nickel	D	3.76
Phosphorus	D	3.15
Silver	D	3.95
Tungsten	D	0.03
Yttrium	D	0.04
Zinc	D	112.75

a. Material Increase (I), Decrease (D), or No Change (NC) compared to base case (lbs/yr).

b. First-year savings from all buildings completed statewide in 2023, including new construction and alterations

6.5 Other Non-Energy Impacts

Realigning the lighting zone classifications with IES and IDA definitions, along with reducing the amount of light required to meet IES recommended lighting levels in general hardscape applications would positively impact the ecosystem. Light at night has increased by 1.8 to 2.2 percent each year since 2012 (Benes 2018), with 83 percent of the human population living under light polluted skies (Falchi et al. 2016). As Travis Longcore and Catherine Rich stated in Artificial Night Lighting and Protected Lands: Ecological Effects and Management Approaches “The disruption of natural patterns of light and dark, which have been more or less reliable for millions of years, has a range of adverse consequences for wildlife across taxonomic groups and landscape types” (Longcore and Rich 2016).

6.5.1 Air Quality

A study completed by the Cooperative Institute for Research in Environmental Sciences at University of Colorado (CIRES) with the National Oceanic and Atmospheric

Administration (NOAA) in 2010 determined that light at night increased air pollution the next day (Stark, et al. 2011). CIRES measured the light intensity at night along with nitrate radical loss over the City of Los Angeles. In areas of high light pollution (sky glow) the studies showed that the nitrate radical levels were reduced by up to four percent while nitrate oxide levels were increased by up to 3.5 percent. Free nitrate radicals, within the air, break down particles that can result in air pollution such as smog; whereas, nitrate oxide can result in oxidation which can increase the acidity of water particles within the air (Stark, et al. 2011).

6.5.2 Impacts to Fauna

Numerous studies have shown that electric lights at night increase light trespass and light pollution (sky glow), resulting in animal behavioral changes. Gaston, Davies, Nedelec, and Holt published a study titled *Impacts of Artificial Light at Night on Biological Timings* which discusses artificial light at night and its effects on flora and fauna. These researchers point out the strong biological impacts that electric light at night have by disrupting the Earth's natural night-dark light cycles. The increase of light at night changes foraging, reproductive behavior, migration, hibernation, and molting of fauna (Gaston 2017).

The use of electric lighting at night changes the typical behavior to pollinators such as the moth. Moths and other photosensitive insects and are drawn to electric lighting installed at typical heights of ten to fifty feet above pollinating plants. The pollination transport of the moth and other nocturnal insects is disrupted by the moths flying above typical flowering plant heights (Macgregor, Evans, et al. 2016). These lighted areas also draw moths from adjacent communities, which limits the pollen transfer in unlighted areas. These factors have resulted in a decline in the moth population which would have an adverse effect on ecosystem stability as the number of pollinating transporters are reduced (Macgregor, Pocock, et al. 2014).

Furthermore, the presence of electric lighting also changes the foraging and prey-predator behaviors of diurnal and nocturnal animals. The increased lighting levels at dusk and dawn extend the duration of foraging for diurnal animals, while shortening the foraging period for nocturnal animals. These changes to foraging patterns result in an increased predation risk for small mammals and other prey (Longcore and Rich, Ecological light pollution 2004). A study by Minnaar et al. 2015, found that bats in lighted areas ate six times more moths than those in unlighted areas due to the moths photosensitive nature (Minnaar, et al. 2015).

6.5.3 Impacts to Flora

Light at night impacts the flowering and maturation of plants. Scientists at the University of Exeter found that low levels of ambient light, such as sky glow from electric lighting at night, disrupt the plant growth cycle which results in early or late flowering of plants. The

research noted that while vegetation immediately adjacent to a light source displays delayed maturation, sky glow may have an impact on plants hundreds of miles away (Bennie 2018). The increase of light at night impacts bud bursting, fragrance emission, germination and growth patterns of flora (Gaston 2017).

Similarly, soybean growth adjacent to streetlights were studied by the Illinois Department of Transportation (IDOT) and the Virginia Transportation Technical Institute (VTTI) to determine the impact that light at night has on soybean plant development. Seven different locations were analyzed to compare the plant growth, maturity, and yield. The study found that the maturation of soybeans adjacent to streetlights were delayed by up to seven weeks (Palmer, et al. 2017).

6.5.4 Multifamily

For the multifamily outdoor LPA submeasure, there are additional non-energy benefits associated with the removal of allowances that are inconsistent with residential neighborhoods that would result in a reduction in light trespass and excessive light levels. Since this is situationally dependent, some situations may not see a difference, but others may benefit from this measure.

This measure proposes to simplify the compliance process for multifamily buildings by eliminating the three-factor LPA calculation approach and moving to a simpler two-factor approach. This approach would eliminate the Linear Wattage Allowance (LWA) in Table 140.7-A and recalculating the Area Wattage Allowance (AWA) to compensate for the difference, which would be designated as the AWA_{MF} to differentiate this allowance from the AWA in the nonresidential sections. The Initial Wattage Allowance (IWA) would remain, but would have different values from the nonresidential allowance, and thus be designated IWA_{MF}.

7. Proposed Revisions to Code Language

7.1 Guide to Markup Language

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

7.2 Standards

7.2.1 Standards: Nonresidential Lighting Zone Reclassification

SECTION 10-114 – DETERMINATION OF OUTDOOR LIGHTING ZONES AND ADMINISTRATIVE RULES FOR USE

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

Zone	Ambient Illumination	Statewide 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 areas of government designated parks, recreation areas, and wildlife preserves can be designated as LZ1 or LZ2 if they are contained within such a zone.	Not applicable
LZ1	Low	Rural areas, as defined by the 2010 U.S. Census. These areas include: single or dual family residential areas, parks, and agricultural zone districts, d~~D~~eveloped portion of government designated parks, recreation areas, and wildlife preserves. Those that are wholly contained within a higher lighting zone may be considered by the	Retail stores, located in a residential neighborhood, and rural town centers, as defined by the 2010 U.S. Census, can be designed as LZ2 if the business operates during hours of darkness. Developed portion of a government designated park, recreation area, or wildlife preserve, can be designated as LZ2 ~~or LZ3~~ if they are	Not applicable.

Zone	Ambient Illumination	Statewide Default Location	Moving Up to Higher Zones	Moving Down to Lower Zones
		local government as part of that lighting zone.	contained within such a zone.	
LZ2	Moderate	Urban clusters ~~Rural areas,~~ as defined by the 2010 U.S. Census. The following building types are likely to occur here: multi-family housing, mixed use residential neighborhoods, religious facilities, schools, and light commercial business districts or industrial zoning districts.	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 mixed-use residential area or city center. ~~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	Moderately High	Urban areas as defined by the 2010 U.S. Census. The following building types are likely to occur here: high intensity commercial corridors, entertainment centers, and heavy industrial or manufacturing zone districts.	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.

NOTE: Authority: Sections 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

7.2.2 Standards: Nonresidential Lighting Power Allowances for General Hardscape

SECTION 100.1 - DEFINITIONS AND RULES OF CONSTRUCTION

IES LM-79 ~~08~~ is the Illuminating Engineering Society document titled, "~~IES~~ Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products" ~~(2008)~~.

IES RP-8 is the Illuminating Engineering Society document titled, "American National Standard Practice for Design and Maintenance of Roadway and Parking Facility Lighting".

IES TM-15-11 is the Illuminating Engineering Society document titled, "Luminaire Classification Systems for Outdoor Luminaires" ~~(2011)~~.

Ornamental, Luminaires installed outdoor which are rated for 50 ~~100~~ watts or less that are post-top luminaires, lanterns, pendant luminaires, chandeliers, and marque lighting, not providing general lighting or task lighting

Security cameras are any operational camera used to enhance the safety and security within a general hardscape area.

SECTION 130.2 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(b) Luminaire ~~Cutoff~~ Shielding Requirements: All outdoor luminaires of 6,200 initial luminaire lumens or greater, shall comply with Backlight, Uplight, and Glare (collectively referred to as "BUG" in accordance with IES TM-15-11, Addendum A) requirements as follows

SECTION 140.7 – PRESCRIPTIVE REQUIREMENTS FOR OUTDOOR LIGHTING

TABLE 140.7-A GENERAL HARDSCAPE LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0[3]	Lighting Zone 1[3]	Lighting Zone 2[3]		Lighting Zone 3[3]		Lighting Zone 4[3]
	~~Asphalt/Concrete~~	~~Asphalt/Concrete~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt/Concrete~~
Area Wattage Allowance (AWA)	No allowance[1]	0.016 ~~0.018~~ W/ft²	0.019 ~~0.023~~ W/ft²	~~0.025 W/ft²~~	0.021 ~~0.025~~ W/ft²	~~0.03 W/ft²~~	0.024 ~~0.03~~ W/ft²
Linear Wattage Allowance (LWA)	No allowance[1]	0.13 ~~0.15~~ W/lf	0.15 ~~0.17~~ W/lf	~~0.4 W/lf~~	0.20 ~~0.25~~ W/lf	~~0.4 W/lf~~	0.29 ~~0.35~~ W/lf
Initial Wattage Allowance (IWA)	No allowance[1]	150 ~~180~~ W	200 ~~250~~ W	~~250 W~~	250 ~~350~~ W	~~350 W~~	320 ~~400~~ W

[1]Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an 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 installed shall meet the maximum zonal lumen limits as specified in Section 130.2(b).

~~[2]Where greater than 50% of the paved surface of a parking lot is finished with concrete. This does not extend beyond the parking lot, and does not include any other General Hardscape areas.~~

[2]Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna – shall be allowed a 2.0 lighting power allowance multiplier.

TABLE 140.7-B ADDITIONAL LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS

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.		Not applicable	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care Facilities, Police Stations, Healthcare Facilities, 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.		Not applicable	20 watts	40 watts	57 watts	60 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.		Not applicable	16 watts	30 watts	50 watts	75 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.		Not applicable	55 watts	77 watts	81 watts	135 watts
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for		Not applicable	100 watts for first ATM machine, 35 watts for each additional ATM machine.			

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
this allowance shall be within 50 feet of the dispenser.					
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.	Not applicable	No Allowance	11 W/linear ft	19 W/linear ft	25 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 50 ~~100~~ watts or less as determined in accordance with Section 130.0(d), and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicable	No Allowance	0.007 W/ft²	0.013 W/ft²	0.019 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	Not applicable	No Allowance	0.100 W/ft²	0.170 W/ft²	0.225 W/ft²

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
without obstruction or interference by permanent building features or other objects.					
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.	Not applicable	0.060 W/ft²	0.210 W/ft²	0.280 W/ft²	0.485 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.	Not applicable	0.006 W/ft²	0.068 W/ft²	0.138 W/ft²	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.	Not applicable	0.220 W/ft²	0.430 W/ft²	0.580 W/ft²	1.010 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.	Not applicable	No Allowance	0.470 W/ft²	0.622 W/ft²	0.740 W/ft²

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not applicable	0.057 W/ft²	0.137 W/ft²	0.270 W/ft²	0.370 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.	Not applicable	0.081 W/ft²	0.176 W/ft²	0.325 W/ft²	0.425 W/ft²
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.	Not applicable	No Allowance	0.056 W/ft²	0.200 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	Not applicable	0.004 W/ft²	0.030 W/ft²	0.050 W/ft²	0.075 W/ft²

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
within 2 mounting heights of the hardscape area of outdoor dining.					
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.	Not applicable	0.004 W/ft²	0.005 W/ft²	0.010 W/ft²	No Allowance
Security Camera. This additional allowance is for the illuminated general hardscape area. This allowance shall apply when a security camera is installed within 2 mounting heights of the general hardscape area and mounted more than 10 feet away from a building.	Not applicable	No Allowance	0.018 W/ft²	0.018 W/ft²	0.018 W/ft²

7.2.3 Standards: Multifamily Outdoor Lighting Power Allowances

Create a new code section in 2022 Title 24, Part 6 that uses Sections 130.2 and 140.7 as the genesis. These changes are specific to multifamily buildings and not indicative of changes that may apply to residential or nonresidential building code sections that would remain.

Note that in the code language listed below, the current nonresidential code section citations are being used in lieu of new proposed code sections since they have not been determined yet.

SECTION 130.2 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT FOR MULTIFAMILY BUILDING TYPE

[Section numbers will be revised once new section assignment is complete.]

~~Nonresidential, high-rise residential~~ Multifamily ~~and hotel/motel~~ buildings shall comply with the applicable requirements of Sections 130.2(a) through 130.2(c).

Projects that include residential units (apartments, condos, or similar) that meet the general requirements as a multifamily building per the definitions in Section 100.1 are subject to the outdoor lighting requirements provided in this section. Hotels and motels are excluded from the classification. Projects that include nonresidential interior building areas (commonly called "mixed-use buildings") must follow the requirements of this section of the code. Refer to Section

X (section number to be determined) for specific information on the classification of a project as a multifamily building project.

(a)**RESERVED**

(b)**Luminaire ~~Cutoff~~ Shielding Requirements.** All outdoor luminaires of 6,200 initial luminaire lumens or greater, shall comply with Backlight, Uplight, and Glare (collectively referred to as "BUG" in accordance with IES TM-15-11, Addendum A) requirements as follows:

1.Maximum zonal lumens for Backlight, Uplight, and Glare shall be in accordance with Title 24, Part 11, Section 5.106.8.

EXCEPTION 1 to Section 130.2(b): Signs.

EXCEPTION 2 to Section 130.2(b): Lighting for building facades, public monuments, statues, and vertical surfaces of bridges.

EXCEPTION 3 to Section 130.2(b): Lighting not permitted by a health or life safety statute, ordinance, or regulation to be a cutoff luminaire.

EXCEPTION 4 to Section 130.2(b): Temporary outdoor lighting**.**

EXCEPTION 5 to Section 130.2(b): Replacement of existing pole mounted luminaires in hardscape areas meeting all of the following conditions:

A. Where the existing luminaire does not meet the luminaire BUG requirements in Section 130.2(b); and

B. Spacing between existing poles is greater than six times the mounting height of the existing luminaires; and

C. Where no additional poles are being added to the site; and

D. Where new wiring to the luminaires is not being installed; and

E. Provided that the connected lighting power wattage is not increased.

EXCEPTION 6 to Section 130.2(b): Luminaires that illuminate the public right of way ~~on publicly maintained~~ (including all roadways, sidewalks, and bikeways that are owned or maintained by the public municipality or utility).

EXCEPTION 7 to Section 130.2(b): Outdoor lighting attached to a ~~high-rise residential or hotel/motel building and separately controlled from the inside of a dwelling unit or guest room.~~ multifamily building and separately controlled from inside of a dwelling unit.

(c)**Controls for Outdoor Lighting.** Outdoor lighting shall be independently controlled from other electrical loads, and the controls for outdoor lighting shall meet the following functional requirements:

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

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

1. **Daylight Availability.** All installed outdoor lighting shall be controlled by a photo control, astronomical time-switch control, or other control capable of automatically shutting OFF the outdoor lighting when daylight is available.

2. **Automatic Scheduling Controls.**

   A. Automatic scheduling controls shall be capable of reducing the outdoor lighting power by at least ~~50~~ 60 percent and no more than 90 percent, and separately capable of turning the lighting OFF, during scheduled unoccupied periods.

   B. Automatic scheduling controls shall allow scheduling of a minimum of two nighttime periods with independent lighting levels and may include an override function that turns lighting ON during its scheduled dim or OFF state for no more than two hours when an override is initiated.

   C. Acceptance tests of outdoor lighting controls shall verify the scheduled occupied and unoccupied periods, as specified in Section 130.4(a)6.

   D. Automatic scheduling controls shall be installed for all outdoor lighting and may be installed in combination with motion sensing controls or other outdoor lighting controls.

3. **Motion Sensing Controls.**

   A. Motion sensing controls shall be capable of reducing the outdoor lighting power of each controlled luminaire by at least ~~50~~ 60 percent and no more than 90 percent, and separately capable of turning the luminaire OFF, during unoccupied periods.

   B. Motion sensing controls shall be capable of reducing the lighting to its dim or OFF state no longer than 15 minutes after the area has been vacated, and of returning the lighting to its ON state when the area becomes occupied.

   C. No more than 1,500 watts of lighting power shall be controlled by a single sensor.

   D. Motion sensing controls shall be installed for the following luminaires, and may be installed for other outdoor lighting and in combination with other outdoor lighting controls:

      i. Outdoor luminaires other than Building Façade, Ornamental Hardscape, or Outdoor Dining, ~~or Outdoor Sales Frontage lighting,~~ where the bottom of luminaire is mounted 24 feet or less above grade; and,

      ii. Outdoor wall mounted luminaires installed for Building Façade, Ornamental Hardscape or Outdoor Dining lighting that have a bilaterally symmetric distribution as described in the IES Handbook (typically referred to as “wall packs”) mounted 24 feet above grade or lower.

EXCEPTION 1 to Section 130.2(c)3: Luminaires with a maximum rated wattage of 40 watts each are not required to have motion sensing controls.

EXCEPTION 2 to Section 130.2(c)3: Applications listed as Exceptions to Section 140.7(a) are not required to have motion sensing controls.

EXCEPTION 3 to Section 130.2(c)3: Lighting subject to a health or life safety statute, ordinance, or regulation may have a minimum time-out period longer than 15 minutes or a minimum dimming level above 50 percent when necessary to comply with the applicable law.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 140.7 – PRESCRIPTIVE REQUIREMENTS FOR OUTDOOR LIGHTING FOR MULTIFAMILY BUILDING TYPE

[Section numbers will be revised once new section assignment is complete.]

Projects that include residential units (apartments, condos, or similar) that meet the general requirements as a multifamily building per the definitions in Section 100.1 are subject to the outdoor lighting requirements provided in this section. Hotels and motels are excluded from the classification. Projects that include nonresidential interior building areas (commonly called "mixed-use buildings") must follow the requirements of this section of the code. Refer to Section X (section number to be determined) for specific information on the classification of a project as a multifamily building project.

(a) A multifamily 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 owned or maintained by the local municipality or utility.
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 of public monuments.

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

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

9. Landscape lighting.

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

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 multi-scene or theatrical cross-fade control station accessible only to authorized operators.

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.

(b)**Outdoor Lighting Power Trade-offs.** Outdoor lighting power trade-offs shall be determined as follows:

1. Allowed lighting power determined according to Section 140.7(d)1 for general hardscape lighting allowance may be traded to specific applications in Section 140.7(d)2, provided the hardscape area from which the lighting power is traded continues to be illuminated in accordance with Section 140.7(d)1A.

2. Allowed lighting power determined according to Section 140.7(d)2 for additional lighting power allowances for specific applications shall not be traded between specific applications, or to hardscape lighting in Section 140.7(d)1.

3. Trading off lighting power allowances between outdoor and indoor areas shall not be permitted.

(c)**Calculation of Actual Lighting Power.** The wattage of outdoor luminaires shall be determined in accordance with Section 130.0(c).

(d)**Calculation of Allowed Lighting Power.** The allowed lighting power shall be the combined total of the sum of the general hardscape lighting allowance determined in accordance with Section 140.7(d)1, and the sum of the additional lighting power allowance for specific applications determined in accordance with Section 140.7(d)2.

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), bridge(s), tunnel(s), and other improved area(s) that are illuminated. Roadway(s) that are illuminated by a lighting system owned or operated by the local municipality or utility shall not be included in the area calculations. 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.

~~B. Determine the perimeter length of the general hardscape area. The total perimeter shall not include portions of hardscape that is not illuminated according to Section 140.7(d)1A. Multiply the hardscape perimeter by the Linear Wattage Allowance (LWA) for hardscape from Table 140.7-A for the appropriate lighting zone. The perimeter length for hardscape around landscaped areas and permanent planters shall be determined as follows:~~

~~i. Landscaped areas completely enclosed within the hardscape area, and which have a width or length less than 10 feet wide, shall not be added to the hardscape perimeter length.~~

~~ii. Landscaped areas completely enclosed within the hardscape area, and which width or length is a minimum of 10 feet wide, the perimeter of the landscaped areas or permanent planter shall be added to the hardscape perimeter length.~~

~~iii. Landscaped edges that are not abutting the hardscape shall not be added to the hardscape perimeter length.~~

C. Determine the Initial Wattage Allowance (IWA) for general hardscape lighting from Table 140.7-A for the appropriate lighting zone. The hardscape area shall be permitted one IWA per site.

D. The general hardscape lighting allowance shall be the sum of the allowed watts determined from (A), ~~(B)~~ and (C) above.

2. **Additional Lighting Power Allowance for Specific Applications.** Additional lighting power for specific applications shall be the smaller of the additional lighting allowances for specific

applications determined in accordance with TABLE 140.7-B for the appropriate lighting zone, or the actual installed lighting power meeting the requirements for the allowance.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

TABLE 140.7-A GENERAL HARDSCAPE MULTIFAMILY LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0[3]	Lighting Zone 1[3]	Lighting Zone 2[3]		Lighting Zone 3[3]		Lighting Zone 4[3]
	~~Asphalt/Concrete~~	~~Asphalt/Concrete~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt~~	~~Concrete[2]~~	~~Asphalt/Concrete~~
Area Wattage Allowance (AWA)	No allowance[1]	0.026 ~~0.018~~ W/ft²	0.030 ~~0.023~~ W/ft²	~~0.025 W/ft²~~	0.038 ~~0.025~~ W/ft²	~~0.03 W/ft²~~	0.055 ~~0.03~~ W/ft²
~~Linear Wattage Allowance (LWA)~~		~~0.15 W/lf~~	~~0.17 W/lf~~	~~0.4 W/lf~~	~~0.25 W/lf~~	~~0.4 W/lf~~	~~0.35 W/lf~~
Initial Wattage Allowance (IWA)		300 ~~180~~ W	350 ~~250~~ W	~~250 W~~	400 ~~350~~ W	~~350 W~~	450 ~~400~~ W

[1]Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an 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 installed shall meet the maximum zonal lumen limits as specified in Section 130.2(b).

~~[2]Where greater than 50% of the paved surface of a parking lot is finished with concrete. This does not extend beyond the parking lot, and does not include any other General Hardscape areas.~~

[2]Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna – shall be allowed a 2.0 lighting power allowance multiplier.

TABLE 140.7-B ADDITIONAL MULTIFAMILY 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.	Not applicable	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care Facilities, Police Stations, Healthcare Facilities, 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.	Not applicable	20 watts	40 watts	57 watts	60 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.~~	~~Not applicable~~	~~16 watts~~	~~30 watts~~	~~50 watts~~	~~75 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.~~	~~Not applicable~~	~~55 watts~~	~~77 watts~~	~~81 watts~~	~~135 watts~~
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	Not applicable	100 watts for first ATM machine, 35 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~~	~~Not applicable~~	~~No Allowance~~	~~11 W/linear ft~~	~~19 W/linear ft~~	~~25 W/linear ft~~

~~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.~~					
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~~ 50 watts or less as determined in accordance with Section 130.0(d), and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicable	No Allowance	0.007 W/ft²	0.013 W/ft²	0.019 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. This allowance calculation shall not include portions of the building facades within 20 feet of residence bedroom windows.	Not applicable	No Allowance	0.100 W/ft²	0.170 W/ft²	0.225 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.~~	~~Not applicable~~	~~0.060 W/ft²~~	~~0.210 W/ft²~~	~~0.280 W/ft²~~	~~0.485 W/ft²~~
~~**Vehicle Service Station Hardscape.** Allowance for the total illuminated hardscape area less area of~~	~~Not applicable~~	~~0.006 W/ft²~~	~~0.068 W/ft²~~	~~0.138 W/ft²~~	~~0.200 W/ft²~~

~~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.~~					
~~**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.~~	~~Not applicable~~	~~0.220 W/ft²~~	~~0.430 W/ft²~~	~~0.580 W/ft²~~	~~1.010 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.~~	~~Not applicable~~	~~No Allowance~~	~~0.470 W/ft²~~	~~0.622 W/ft²~~	~~0.740 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.	Not applicable	0.057 W/ft²	0.137 W/ft²	0.270 W/ft²	0.370 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.~~	~~Not applicable~~	~~0.081 W/ft²~~	~~0.176 W/ft²~~	~~0.325 W/ft²~~	~~0.425 W/ft²~~

CONTINUED: 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
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-	Not applicable	No Allowance	0.056 W/ft²	0.200 W/ft²	No Allowance

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.					
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.	Not applicable	0.004 W/ft²	0.030 W/ft²	0.050 W/ft²	0.075 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.	Not applicable	0.004 W/ft²	0.005 W/ft²	0.010 W/ft²	No Allowance

7.3 Reference Appendices

There are no proposed changes to the Reference Appendices for the three submeasures.

7.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual for the three submeasures.

7.5 Compliance Manuals

The Nonresidential Compliance Manual would need to be revised to account for the lighting zone reclassification and updated general hardscape LPAs.

- Chapter 6.3 – The compliance manual U.S. Census definitions need to be revised to refer users to the U.S. Census for new LZ1 “rural” area and the LZ2 “urban cluster” classifications.

- Chapter 6.7 – The proposed changes would revise the compliance documentation NRCC-LTO-E to include the updated general hardscape LPAs and the additional allowance for security cameras along with including documentation of luminaire BUG ratings for luminaires installed within two mounting heights of a property line.

Chapter 6 of the Nonresidential Compliance Manual would need to be revised to accommodate the multifamily building code sections. Provided below is a list of the proposed revisions:

- All sections – The Manual would need to add references to the new multifamily code sections to alert the reader that there is more than one location in the code that details the appropriate outdoor lighting and controls approaches, depending on the building type.
- Chapter 6.2.1 – The proposed changes would add a second diagram to show the two-prong calculation approach that eliminates the Linear Wattage Allowance (LWA). Add language to describe the two-prong calculation approach.
- Chapter 6.4.2 – A clarification is proposed for the scheduling and motion sensing requirements that the minimum setback level is now 60 percent for multifamily projects, an increase from 50 percent.
- Chapter 6.5.2 – The proposed changes would add language to describe the difference in calculation procedure for multifamily buildings and detail the two-prong calculation approach. This is a simplification of the older three-prong approach, so the mechanics of calculating the LPA would be very similar. Additionally, new tables for the general hardscape calculation allowances for multifamily buildings would be added, including an example question and solution for multifamily buildings.
- Chapter 6.5.3 – Proposed language would be added to describe and explain reasons for the difference in the Additional Lighting Power Allowance tables (Table 140.7-B and the new multifamily version of that table) between the nonresidential and multifamily tables. Additionally, a new table that presents the information in the multifamily building Additional Lighting Power Allowance table (Table 170.7-B in the nonresidential code section but would be renumbered in the new multifamily code sections) would be added.
- Chapter 6.6.5 – The proposed changes would add language to describe the increase in the setback requirement from 50 percent to 60 percent for scheduling and motion sensing controls.
- Chapter 6.7 – The proposed changes would add specific information to detail the new compliance document (currently unnumbered but revised from NRCC-LTO-E as the basis).

7.6 Compliance Documents

Compliance document NRCC-LTO-E would need to be updated to reference the proposed general hardscape LPAs and include the additional allowance for security cameras, along with including documentation of luminaire BUG ratings for luminaires installed within two mounting heights of a property line.

Compliance document NRCC-LTO-E would also need to be revised to accommodate the multifamily measure. Proposed revisions to compliance document NRCC-LTO-E are provided below:

- Create a new document and revise all code section citations to include the relevant new code sections for multifamily buildings (currently unnumbered).
- Revise the compliance document listing and cross-referencing to include the newly created multifamily version of NRCC-LTO-E.
- **Section I -** Remove the three-factor calculation approach used for the General Hardscape calculation and document the two-factor approach as detailed in Table 140.7-A.
- **Sections J, K, and L -** Eliminate references to Additional Lighting Power Allowances that are not included in the multifamily outdoor Table 140.7-B.

8. Bibliography

n.d. http://bees.archenergy.com/Documents/Software/CBECC-Com_2016.3.0_SP1_Prototypes.zip.

2018 American Community Survey. n.d. *1-Year Estimates.* https://data.census.gov/cedsci/.

American Medical Association. 2016. "Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting." Accessed November 12, 2019. https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/AMA_Report_2016_60.pdf.

Benes, Kylla. 2018. *Is Light Pollution Changing How Plants Do – and Don't – Grow?* 01 4. Accessed 03 27, 2020. massivesci.com/articles/light-pollution-plants-grow-rest/.

Bennie, J., et. al. 2018. "Artificial light at night alters grassland vegetation species composition and phenology." *Journal of Applied Ecology* 55: 442–450. https://doi.org/10.1111/1365-2664.12927.

Bhagavathula, Rajaram, and Ronald B. Gibbons. 2019. "Light Levels for Parking Facilities Based on Empirical Evaluation of Visual Performance and User Perceptions." *Leukos.* https://www.tandfonline.com/doi/abs/10.1080/15502724.2018.1551724?journalCode=ulks20.

Brainard, et al. 1988. "Dose response relationship between light irradiance and the suppression of plasma melatonin in human volunteers." (Brain Research) (454): 212-218.

Building Transparency. 2020. *EC3 Database, Aluminum.*

BW Research Partnership. 2016. *Advanced Energy Jobs in California: Results of the 2016 California Advanced Energy.* Advanced Energy Economy Institute.

California Air Resouces Board. 2019. "Global Warming Potentials." https://www.arb.ca.gov/cc/inventory/background/gwp.htm#transition.

California Department of Water Resources. 2016. "California Counties by Hydrologic Regions." Accessed April 3, 2016. http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf.

California Energy Commission. 2015. *2016 Building Energy Efficiency Standards: Frequently Asked Questions.* http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/2016_Building_Energy_Efficiency_Standards_FAQ.pdf.

—. 2022. "Energy Code Data for Measure Proposals." *energy.ca.gov.* https://www.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2019. "Housing and Commercial Construction Data - Excel." https://ww2.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2018. "Impact Analysis: 2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings." *energy.ca.gov.* June 29. https://www.energy.ca.gov/title24/2019standards/post_adoption/documents/2019_Impact_Analysis_Final_Report_2018-06-29.pdf.

California Public Utilities Commission (CPUC). 2015b. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

California Public Utilities Commission. 2015a. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. . http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350.

Energy + Environmental Economics. 2016. "Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs." Prepared for the California Energy Commission. July. http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf.

—. 2020. "Title 24 2022 TDV Updates." Prepared for the California Energy Commission. April. http://docketpublic.energy.ca.gov/PublicDocuments/19-BSTD-03/TN232659_20200403T161120_Title%2024%202022%20TDV%20Updates.pdf.

Ettenson, Lara , and Christa Heavey. 2015. *California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals.* Natural Resources Defense Council & Environmental Entrepreneurs (E2).

Gaston, Kevin J. 2017. "Impacts of Artificial Light at Night on Biological Timings." *Annual Review of Ecology, Evolution, and Systematics* 48 (1): 49–68. doi:10.1146/annurev-ecolsys-110316-022745.

Goebes, M., et al. 2018. "Exterior Lighting Standard Practice Baseline and Work Paper Support - Final Report." Prepared for Southern California Edison in support of the California electric IOUs., TRC Energy Services. http://www.calmac.org/publications/TRC_-_SCE_Ext_Lighting_SP_and_WP_Support_Final_Report.pdf.

Goldman, Charles, Merrian C. Fuller, Elizabeth Stuart, Jane S Peters, Marjorie McRay, Nathaniel Albers, Susan Lutzenhiser, and Mersiha Spahic. 2010. *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth.* Lawrence Berkeley National Laboratory.

Illuminating Engineering Society. 2020. "Addendum 1 for ANSI/IES RP-8-18, Recommended Practice for Design and Maintenance of Roadway adn Parking Facilities Lighting Chapter 17." http://media.ies.org/docs/errata/ANSI-IES RP-8-18-Addendum-1_20200123.pdf.

Illuminating Engineering Society and International Dark-Sky Association. 2011. "Model Lighting Ordinance." https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_MLO_FINAL_JUNE2011.PDF.

Illuminating Engineering Society. 2011. "The Lighting Handbook, 10th Edition."

Kenney, Michael, Heather Bird, and Heriberto Rosales. 2019. *2019 California Energy Efficiency Action Plan.* Publication Number: CEC - 400 - 2019 - 010 - CMF, California Energy Commission.

Lafarge. 2010. "10th Annual Sustainability Report." Report. https://www.lafargeholcim.com/sites/default/files/import/publication/05042011-publication_sustainable_development-Sustainable_report_2010-uk.pdf.

Lim, Seong-Rin, Daniel Kang, Oladele A Ogunseitan, and Julie M Schoenung. 2013. "Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs." *Environmental Science & Technology.*

Longcore, Travis, and Catherine Rich. 2016. *Artificial night lighting and protected lands: ecological effects and management approaches.* Natural Resource Report NPS/NRSS/NSNS/NRR—2016/1213, National Park Service, US Department of the Interior.

Longcore, Travis, and Catherine Rich. 2004. "Ecological light pollution." *Frontiers in Ecology and the Environment* 2: 191-198. doi:https://doi.org/10.1890/1540-9295(2004)002%5b0191:ELP%5d2.0.CO;2.

Macgregor, Callum, Darren Evans, Richard Fox, and Michael Pocock. 2016. "The dark side of street lighting: impacts on moths and evidence for the disruption of nocturnal pollen transport." *Global Change Biology* 23: 2, 697-707. doi:https://doi.org/10.1111/gcb.13371.

Macgregor, Callum, Michael Pocock, Richard Fox, and Darren Evans. 2014. "Pollination by nocturnal Lepidoptera, and the effects of light pollution: a review." *Ecological Entomology* 40: 3, 187-198. doi:https://doi.org/10.1111/een.12174.

McIntyre, et al. 1989. "Human Melatonin Suppression by Light is Intensity Dependant." *Journal of Pineal Research* (6): 149-156.

Minnaar, C., J.G. Boyles, I.A Minnaar, C.L. Sole, and A.E. McKechnie. 2015. "Stacking the odds: light pollution may shift the balance in an ancient predator–prey arms race." *J Appl Ecol* 52: 522-531. doi:10.1111/1365-2664.12381.

National Energy Assistance Directors' Association. 2011. *2011 National Energy Assistance Survey Final Report.* http://www.appriseinc.org/reports/Final%20NEADA%202011%20Report.pdf.

Palmer, Matthew, Ronald Gibbons, Rajaram Bhagavathula, and David Holshouser. 2017. *Roadway Lighting's Impact on Altering Soybean Growth: Volume 1. A report of the findings of ICT-R27-172.* Research Report No. FHWA-ICT-17-010, Illinois Center for Transportation Series.

Phipps Nelson, et al. 2010. "Blue Light Exposure Reduces Objective Measures of Sleepiness during Prolonged Nighttime Performance Testing." *Chronobiology International* 26 (5): 891-912.

Polebase. 2014. *Design Resource Manual.* https://www.polebase.com/documents/Technical_Resources/Design_Resource_Manual/PoleBaseDRM-Full-Web.pdf.

Stark, H., S. Brown, K. Wong, and et al. 2011. "City lights and urban air." *Nature Geosci* 4, 730-731. https://doi.org/10.1038/ngeo1300.

State of California, Employment Development Department. n.d. https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry .

Statewide CASE Team. 2017. "Outdoor Lighting Power Allowances – Final Report." http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_NR-Outdoor-Light-Sources_Final_September-2017.pdf.

Statewide CASE Team. 2018. "Outdoor Lighting Power Allowances - Results Report." http://title24stakeholders.com/wp-content/uploads/2016/10/T24-2019-CASE-Study-Results-Report-Outdoor-Sources_Final_with-Attachments.pdf.

Stone, Nehemiah, Jerry Nickelsburg, and William Yu. 2015. *Codes and Standards White Paper: Report - New Home Cost v. Price Study.* Pacific Gas and Electric Company. Accessed February 2, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/Migration-12-22-2015/Non-Regulatory/15-BSTD-01/TN%2075594%20April%202015%20Codes%20and%20Standards%20White%20Paper%20-%20Report%20-%20New%20Home%20Cost%20v%20Price%20Study.pdf.

Thornberg, Christopher, Hoyu Chong, and Adam Fowler. 2016. *California Green Innovation Index - 8th Edition.* Next 10.

U.S. Census Bureau, Population Division. 2014. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

U.S. EPA (United States Environmental Protection Agency). 2011. "Emission Factors for Greenhouse Gas Inventories." Accessed December 2, 2013. http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

United States Environmental Protection Agency. 1995. "AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources." https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors#5thed.

United States Environmental Protection Agency. 2018. "Emissions & Generation Resource Integrated Database (eGRID) 2016." https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

West, et al. 2011. "Blue light from light emitting diodes elicits a dose dependent supression of melatonin in humans." *Journal of Applied Physiology* 110 (3). Accessed September 3, 2019. https://www.physiology.org/doi/pdf/10.1152/japplphysiol.01413.2009.

Zabin, Carol, and Karen Chapple. 2011. *California Workforce Education & Training Needs Assessment: For Energy Efficiency, Distributed Generation, and Demand Reponse.* University of California, Berkeley Donald Vial Center on Employment in the Green Economomy. Accessed February 3, 2017. http://laborcenter.berkeley.edu/pdf/2011/WET_Appendices_ALL.pdf.

Zeitzer, et al. 2000. "Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression." *The Journal of Physiology* 526 (Pt 3): 695-702.

Appendix A: Statewide Savings Methodology

The Energy Commission Building Standards Office provided the nonresidential construction forecast, which is available for public review on the Energy Commission's website: https://www.energy.ca.gov/title24/participation.html.

The construction forecast presents total floorspace of newly constructed buildings in 2023 by building type and climate zone. The building types included in the Energy Commissions' forecast are summarized in Table 43: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2023, by General Hardscape and Specific Application and Building Type (Million Square Feet). This table also identifies the prototypical buildings that were used to model the energy use of the proposed code changes. This mapping was required because the building types the Energy Commission defined in the construction forecast are not identical to the prototypical building types that the Energy Commission requested that the Statewide CASE Team use to model energy use. This mapping is consistent with the mapping that the Energy Commission used in the Final Impacts Analysis for the 2019 code cycle (California Energy Commission 2018).

The Energy Commission's forecast allocated 19 percent of the total square footage of new construction in 2023 to the miscellaneous building type, which is a category for all space types that do not fit well into another building category. It is likely that the Title 24, Part 6 requirements apply to the miscellaneous building types, and savings would be realized from this floorspace. The new construction forecast does not provide sufficient information to distribute the miscellaneous square footage into the most likely building type, so the Statewide CASE Team redistributed the miscellaneous square footage into the remaining building types so that the percentage of building floorspace in each climate zone, excluding the miscellaneous square footage, will remain constant. See Table 45 for a sample calculation for redistributing the miscellaneous square footage among the other building types.

After the miscellaneous floorspace was redistributed, the Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 43 presents the assumed percentage of floorspace that would be impacted by the proposed code change by building type. If a proposed code change does not apply to a specific building type, it is assumed that zero percent of the floorspace would be impacted by the proposal. If the assumed percentage is non-zero, but less than 100 percent, it is an indication that no buildings would be impacted by the proposal. Table 47 presents percentage of floorspace assumed to be impacted by the proposed change by climate zone. The proposed code

change is not dependent on climate zone and is applicable to all new construction. The Statewide CASE Team assumed a rate of lighting retrofits to be once in 15 years.[19]

[19] Once in 15 years is 1/15 or roughly seven percent. This aligns with the same rate of lighting retrofits assumptions used for the 2019 Title 24, Part 6 outdoor lighting code change analysis.

Table 43: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2023, by General Hardscape and Specific Application and Building Type (Million Square Feet)

Application	Small Office	Large Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel/ Motel	TOTAL
General Hardscape	8.623	30.330	4.426	18.268	6.899	7.618	0.393	7.145	5.404	7.632	6.373	103.111
Building Entrances or Exits	0.002	0.006	0.001	0.000	0.001	0.005	N/A	0.002	0.001	0.002	0.002	33.415
Primary Entrances	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Drive-up Windows	N/A	N/A	0.001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001
Vehicle Service Station Uncovered Fuel Dispenser	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ATM Machine Lighting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Outdoor Sales Frontage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.096 from Misc.
Hardscape Ornamental Lighting	0.431	1.516	0.221	1.305	0.172	N/A	N/A	0.255	0.135	0.190	0.455	4.842
Building Facades	0.111	0.391	0.114	0.673	0.089	N/A	N/A	0.132	0.070	0.098	0.235	1.994
Outdoor Sales Lots	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.959 from Misc.
Vehicle Service Station Hardscape	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.516 from Misc.
Vehicle Service Station Canopies	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.384 from Misc.
Sales Canopies	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.160 from Misc.
Non-sales Canopies and Tunnels	0.216	0.758	0.111	0.652	0.172	N/A	N/A	0.255	0.135	N/A	0.228	2.687
Guard Stations	0.004	0.013	N/A	N/A	N/A	0.011	0.001	N/A	0.002	N/A	N/A	0.044
Student Pick-up/ Drop-off Zones	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.177	N/A	N/A	N/A	0.177
Outdoor Dining	N/A	N/A	0.443	0.130	0.035	N/A	N/A	N/A	N/A	0.015	N/A	0.0623

Application	Small Office	Large Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel/ Motel	TOTAL
Special Security Lighting for Retail and Pedestrian Tunnels	N/A	N/A	0.004	0.261	0.069	N/A	N/A	N/A	N/A	N/A	N/A	0.534
TOTAL	9.386	33.014	5.361	21.294	7.438	7.634	0.394	7.966	5.748	7.937	7.292	119.161

Table 44: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2023 (Alterations), by General Hardscape and Application and Building Type (Million Square Feet)

Application	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel/ Motel	Large Office	TOTAL
General Hardscape	25.9	13.0	56.6	21.4	22.8	1.2	27.5	20.6	26.6	17.2	90.6	323.4
Building Entrances or Exits	0.005	0.002	0.016	0.004	0.015	0.0008	0.008	0.004	0.005	0.005	0.018	0.104
Primary Entrances	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.000
Drive-Up Windows	N/A	0.003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.003
Vehicle Service Station Uncovered Fuel Dispenser	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.000
ATM Machine Lighting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.000
Outdoor Sales Frontage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.289 from Misc.
Hardscape Ornamental Lighting	1.295	0.648	4.045	0.535	N/A	N/A	0.984	0.516	0.664	1.228	4.529	14.924
Building Facades	0.334	0.334	2.085	0.276	N/A	N/A	0.507	0.266	0.342	0.633	1.167	6.191
Outdoor Sales Lots	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.888 from Misc.
Vehicle Service Station Hardscape	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.591 from Misc.
Vehicle Service Station Canopies	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.155 from Misc.
Sales Canopies	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.481 from Misc.
Non-sales Canopies and Tunnels	0.647	0.324	2.023	0.535	N/A	N/A	0.984	0.516	N/A	0.614	2.265	8.388
Guard Stations	0.011	N/A	N/A	N/A	0.033	0.002	-	0.009	N/A	N/A	0.039	0.135
Student Pick-up/ Drop-off Zone	N/A	N/A	N/A	N/A	N/A	N/A	0.681	N/A	N/A	N/A	N/A	0.681
Outdoor Dining	N/A	1.295	0.405	0.107	N/A	N/A	N/A	N/A	0.053	N/A	N/A	1.860

Application	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel/ Motel	Large Office	TOTAL
Special Security Lighting for Retail and Pedestrian Tunnel	N/A	1.295	0.405	0.107	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.634
TOTAL	28.192	15.687	66.015	23.066	22.861	1.235	30.707	21.955	27.622	19.665	98.596	372.76

Table 45: Example of Redistribution of Miscellaneous Category - 2023 New Construction in Climate Zone 1

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

The calculation of the effective area wattage allowances (eAWA) with the security camera allowance also requires assumptions on the prevalence of security cameras. The Statewide CASE Team approached this set of assumptions based on the following rationale:

- Office Small: Would be unlikely to purchase hardscape cameras except in extreme circumstances, such as known high risk areas.
- Office Large: A mixture of secured facilities and low risk facilities would make hardscape cameras applicable to some installations.
- Restaurants: Chain restaurants would be more likely than independent shops for camera usage. Camera usage would be a crime deterrent and insurance benefit.
- Retail: Loss prevention and insurance considerations would make this space type a prime user of cameras, especially for national chains. Smaller shops may not follow this pattern.
- Grocery: Loss prevention and insurance considerations would make this space type a prime user of cameras, for national chains. Note that independent shops may not follow this pattern

- Non-Refrigerated Warehouse: Warehouses are anticipated to have cameras on key locations, such as yard entrances and exits, loading docks, building entrances and exits, but are not anticipated to have hardscape wide camera installation except under extreme circumstances.
- Refrigerated Warehouse: Expected to follow the Non-Refrigerated Warehouse design principles
- Schools: Schools can vary widely in security, from almost no camera usage to ubiquitous usage.
- College: Colleges are anticipated to follow similar design principles as schools.
- Hospital: Some hospitals are anticipated to have higher security, especially if located in known high risk areas. Other hospitals are anticipated to have considerable interior security but limited hardscape camera usage.
- Hotel: Anticipated to be similar to retail, as hardscape camera usage would be expected to have insurance benefits and serve as a deterring to possible vandalism and theft.
- Other: Some high security applications anticipated to be located in the miscellaneous category.

Based on these assumptions, the Statewide CASE Team estimated the following factors, applicable to general hardscape for both new construction and alterations:

Table 46: Estimated Security Camera Prevalence in General Hardscape, by Building Type.

Building Type	Percent using Security Camera
Small Office	10%
Large Office	25%
Restaurant	20%
Retail	33%
Grocery Store	25%
Non-Refrigerated Warehouse	5%
Refrigerated Warehouse	5%
Schools	25%
Colleges	25%
Hospitals	20%
Hotel/Motels	33%
Miscellaneous [D] (Other)	15%

Table 47: Percent of Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	Percent of Square Footage Impacted	
	New Construction	Existing Building Stock (Alterations)[a]
1	100%	7%
2	100%	7%
3	100%	7%
4	100%	7%
5	100%	7%
6	100%	7%
7	100%	7%
8	100%	7%
9	100%	7%
10	100%	7%
11	100%	7%
12	100%	7%
13	100%	7%
14	100%	7%
15	100%	7%
16	100%	7%

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

Appendix B: Embedded Electricity in Water Methodology

There are no on-site water savings associated with the proposed code change.

Appendix C: Environmental Impacts Methodology

Greenhouse Gas (GHG) Emissions Factors

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

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

GHG Emissions Monetization Methodology

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

Water Use and Water Quality Impacts Methodology

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

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

There are no recommended revisions to the compliance software as a result of this code change proposal.

Appendix E: Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. Table 48 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing work flow, and ways negative impacts could be mitigated. The information contained in Table 48 is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. Appendix F summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

The Statewide CASE Team expects minimal impact on industry and others impacted by the relevant nonresidential code sections as a result of this proposal. For the nonresidential lighting zone reclassification submeasure, the Statewide CASE Team anticipates minimal adjustment to changes in calculations of the appropriate lighting zone based on population density, a related metric to the population figures currently employed by the technique based on the U.S. Census. No additional tasks to calculate the lighting zones, no new coordination between market actors, and no additional documentation is expected. In order for this submeasure to be a success, the Statewide CASE Team must ensure that proper education in the new technique comes to fruition. Education might be facilitated by cooperation with relevant professional organizations (such as the IES) and/or through collaboration with the Energy Commission.

For the nonresidential LPA for parking lots submeasure, the Statewide CASE Team has suggested changes to the general hardscape allowances for each lighting zone as well as the addition of an adder for security camera equipment to offset lowered light levels where warranted. The Statewide CASE team does not anticipate changes to the calculation of the allowed wattage but do expect that the allowed adders for certain situations would be altered to avoid the unnecessary over lighting of some areas. No additional tasks to calculate the allowed wattage in general areas (without allowed adders), no new coordination between market actors, and no additional documentation is expected. The Statewide CASE Team has based the additional security camera allowance on the specified recommended illuminance levels of existing security equipment to avoid over lighting while providing sufficient illumination and anticipates working with various professional organizations to limit allowable adders for some spaces while preserving the ability to implement proper outdoor lighting design practices.

For the multifamily LPA for general hardscape submeasure, the Statewide CASE Team has suggested changes to the general hardscape allowances for each lighting zone. The lighting allowance tables for outdoor lighting for multifamily buildings also has a proposed reduced list of retail lighting additional allowances which would reduce some lighting allowance wattage under some potential circumstances, but the Statewide CASE Team does not anticipate that most of these allowances were used much, if at all in typical multifamily housing projects. The Statewide CASE Team also proposed a simplification to the calculation method of the allowed wattage for outdoor lighting. The Statewide CASE team does not anticipate that this change would result in any confusion about how the calculation process would occur as it is a simplification of the existing process.

Other than identifying that a project is a multifamily project, there are no additional tasks required to calculate the allowed wattage in general hardscape areas and no new coordination between market actors and no additional documentation is expected.

Table 48: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Workflow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Lighting Designer	• Understand wattage and control requirements so that design can meet code (there is no option to "trade" outdoor lighting with other building features hence little flexibility if design exceeds wattage requirements) • Be aware of the lighting zone applicable to the project and how that would determine wattage allowance.	• Be able to design outdoor lighting to meet the code requirements. • Maintain photometric design parameters within the wattage allowances of the Energy Code.	• Security cameras could be an issue because lighting levels may be too low for camera use. • Impacts on alterations vs. new construction: existing poles may remain in place. • Most of LZ3 would drop to LZ2 by redefining LZ. This may be an issue for alterations. • Standardizing LZ across state (this could be positive). • Multifamily – apply a different code section for outdoor lighting and outdoor controls.	• Consider a threshold value on the rezoning criteria for alterations. Be aware of current triggers for LTO alts. & maybe align this with an existing trigger. • Coordinate with some cities who have rezoned to see how it's impacting alterations, and any unforeseen issues with rezoning. • Rely on existing wattage adders when possible • Multifamily – keep the code sections as similar as possible to ensure the same basic approach and structure for both.

Owner	Provide guidance to designer on desired photometric requirements and be aware of how wattage allowance may impact that request.	Work with professional organizations to ensure proper education and proper allocation of adders.	• Large retail might have issues showing compliance to LTO lighting allowance due to liability concerns. • Some cities have minimum illumination requirements for safety, must ensure measure doesn't conflict with health and safety concerns. • Multifamily – Owners would need to consider the suitability of certain retail applications in the MF context.	• Early outreach to security camera designers, retailers, and realtors. • Multifamily – education of design team and owners to the limits of additional retail lighting allowances in the MF context.
Energy Consultants	Work with designer to document compliance to the Energy Code.	• Clearly communicate to designer wattage allowances based on lighting zone and other factors such as concrete/ non-concrete surfaces and "specific allowances." • Coordinate control requirements with designer so that compliance documentation accurately represents control design.	• Ensure projects are being developed with the LPA from proper LZ. • Multifamily – Ensure energy consults are applying the MF code sections for the calculations.	• Clear documentation of project lighting zone. • Multifamily – ensure the industry has suitable documentation of the proposed MF code sections.
Contractor	May be acting as the "designer", really	• They are responsible for following what is in the design – if they do	Ensure luminaires meet the BUG rating requirements.	• Clear documentation of Title 24, Part 6 compliant products.

	replacing the existing luminaires.	not, the system can end up being out of compliance. They complete installation compliance documents. • Coordinate with lighting designer in case issues with installation arise. • They purchase/install products specified by design. It is helpful for them to know what products meet compliance in case they need to substitute products.		• Clear documentation illustrating difference between old standards and new one. • Clear documentation explaining who they can speak with for help on code compliance. • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they are not.

Electrician	• Need to understand the code as they might be responsible for designing lighting systems. • They might play a similar role to contractor/builder and follow lighting design/install lighting equipment.	• If designing the system, they are responsible for ensuring it follows the code. They would also be responsible for filling out design compliance documents. • If building the system, they are responsible for following what is in the design – if they do not, the system can end up out of compliance. They would complete installation compliance documents. • Coordinate with lighting designer in case issues with installation arise. • Purchase/install products specified by design that are compliant.	Ensure projects are being developed with the proper LPA per the project LZ.	• Clear documentation of Title 24, Part 6 compliant products. • Clear documentation illustrating difference between old standards and new one. • Clear documentation explaining who they can speak with for help on code compliance. • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they are not. • Ensure responsible designers know about the distinction and introduction of the MF building sections of code.

Title 24 Consultant	• Experts on Title 24, Part 6 and compliance / compliance documents / compliance steps. • They are hired by designers/building owners to help interpret the code/ensure compliance / fill out paperwork.	• Coordinate with designers, installers, building owners, and compliance agencies. • They generate compliance documentation as well as assist in code interpretation.	• Direct designers, installers, and building owners to the proper LPA per the project LZ. • Direct designers, installers, and building owners to the maximum BUG ratings allowed per the project LZ.	• Document explaining Title 24 process and where documents go/who needs to sign what. • Modeling software would need to be updated to include proposed values. Software training updates. • Clear code requirements that apply to the project. • Designation on products about whether or not they meet code requirements. How to/direction on how to specify the products that meet the code (lighting designer is not purchasing the lighting fixtures, the contractor purchases). • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they are not. • Documents explaining who they can speak with for help on code compliance.
Plans Examiner	• Identify relevant requirements. • Confirm data on documents is compliant. • Confirm plans/ specifications match data on documents. • Provide correction comments if necessary.	• Quickly and easily determine requirements based on scope. • Quickly and easily determine if data in documents meets requirements. • Quickly and easily determine if plans/ specs match documents.	• Would need to verify calculations are compliant with new standards. • Would need to verify existing conditions baseline.	• Clear code language that is easily understandable. Clear instructions on where to find everything in the plans. • Clear documentation of what paperwork they need to receive and/or other tasks they need to perform. • Clear documentation of how the new code differs from the old. • Compliance document could auto-verify data is compliant with the standards.

		• Quickly and easily provide correction comments that would resolve issue. • Coordinate with building owners/designers/inspectors.		• Existing conditions documented via as-builts or photos or ATT. Do not require additional field visit by Authority Having Jurisdiction. • Document compliance on documents in a way easily compared to plans. • Examples of plans that comply. • Examples of plans that are not in compliance and reasons why they are not.
Building Inspector	• Identify relevant requirements. • Confirm installed equipment matches documents/plans. • Provide correction comments if necessary.	• Quickly and easily determine requirements based on scope. • Quickly and easily determine if installation meets requirements and matches documents/plans. • Quickly and easily provide correction comments that would resolve issue. • Coordinate with building owners/designers/plan checkers.	• Would need to verify installations are compliant with new standards.	• Clear documentation of code requirements, although they probably rely more on the plan checker to make sure everything in the plan is up to code. • Clear documentation of how the new code differs from the old. • Clear documentation of the different types of technologies that might be used/installed and equivalences – if something installed is different from the plans, then the inspector needs to know whether or not it is still in code compliance. • Clear documentation of what paperwork they need to receive and/or other tasks they need to perform.

Appendix F: Summary of Stakeholder Engagement

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

This appendix summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

Utility-Sponsored Stakeholder Meetings

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

a. Proposed code changes
b. Draft code language
c. Draft assumptions and results for analyses
d. Data to support assumptions
e. Compliance and enforcement, and
f. Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for nonresidential and multifamily outdoor lighting sources via webinar. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting. Such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Nonresidential and Multifamily Outdoor Lighting Sources and Daylighting Utility-Sponsored Stakeholder Meeting	Thursday, September 5, 2019	https://title24stakeholders.com/event/lighting-utility-sponsored-stakeholder-meeting/
Second Round of Nonresidential and Multifamily Outdoor Lighting Sources and Daylighting Utility-Sponsored Stakeholder Meeting	Thursday, March 3, 2020	https://title24stakeholders.com/event/lighting-utility-sponsored-stakeholder-meeting-2/

The first round of utility-sponsored stakeholder meetings occurred from August to November 2019 and were important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued by the Statewide CASE Team. The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2022 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and to understand potential technical and market barriers. The Statewide CASE Team also presented initial draft code language for stakeholders to review.

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

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the entire Title 24 Stakeholders listserv, totaling over 1,900 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page[20] (and cross-promoted on the Energy Commission LinkedIn page) two weeks before each meeting to reach out to individuals and larger organizations and channels outside of the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted into the listserv. Exported webinar meeting data captured attendance numbers and individual comments,

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

and recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report. The Statewide CASE Team was able to engage in conversation with representatives from several townships and cities in California and nationwide including Plymouth, Minnesota; San Diego, California; Los Angeles County, California; Bakersfield, California; and Walnut Creek, California. The Statewide CASE Team also contacted IDA and lighting designers to obtain feedback on the feasibility of the lighting zone reclassification measure.

The Statewide CASE Team also contacted 58 different manufacturers to select products that meet both the lighting zone reclassification submeasure and general hardscape LPA submeasure to ensure that the proposed changes could be met with products currently available on the market from multiple manufacturers. The product manufacturers include, but are not limited to: Acuity, Signify ALW, Architectural Area Light, Axis Lighting, Beacon, Cooper Lighting, Ecosense, Finelite, Cyclone, ERCO, GE Lighting, Hess, Hubbell Lighting, Lucifier Lighting, Lumenwerx, Luminii, Nova Flex, Pinnacle, PMC, Selux, RAB, Sistemalux, Spectrum, TCP, Tech Lighting, Tivoli, Visionaire, WAC, and WE-EF. These products were employed for both the nonresidential LPA submeasure and the multifamily submeasure based on the suitability of the product for both applications.

The Statewide CASE Team contacted retail management agencies and security camera system engineers to understand current security camera limitations in low lighting levels along with how these systems are typically deployed in general hardscape applications. The minimum illumination requirements of various security cameras were compared to determine an appropriate allowance to enable the detection of people, animals, and objects of concern during low light conditions.

In addition to these resources, the Statewide CASE Team also met with IES and the International Association of Lighting Designers (IALD) to explain the 2022 CASE Report outline and garner feedback.

Lighting Survey

The Statewide CASE Team (via subcontractor Evergreen Economics) conducted a stakeholder survey from November 2019 to January 2020. This survey aimed to gather feedback from industry experts regarding the 2019 code cycle, both for the Codes and Standards Enhancement (CASE) process and the California Energy Commission Rulemaking process, to inform changes in 2022.

Survey Results

Surveyed Stakeholder Background

Survey respondents were asked their experience with various lighting types and their lighting role.

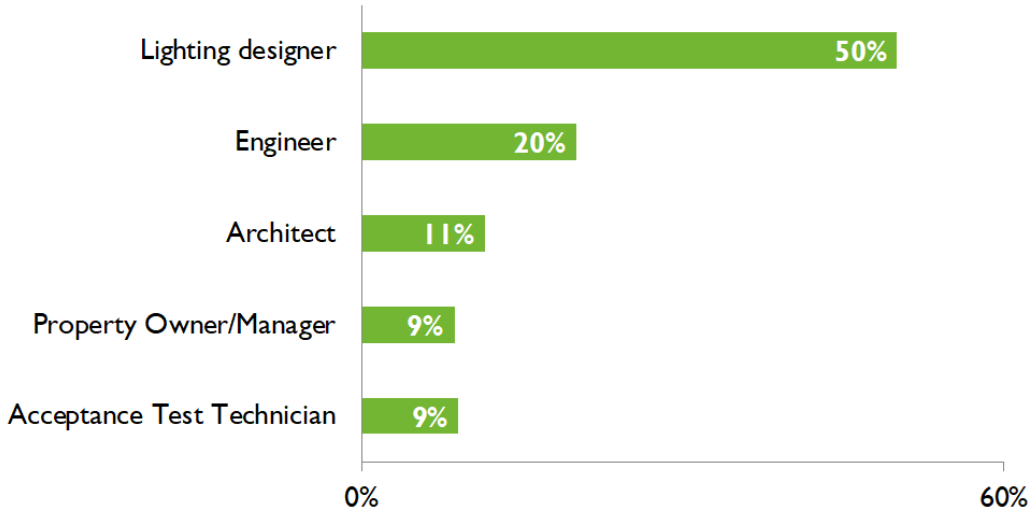

Figure 3: Top five respondent roles (n=54).

Figure 4: Percent of respondents with experience with various lighting types (n=62).

Outdoor Lighting

Survey respondents who indicated they were familiar with outdoor lighting were asked a series of questions in regard to outdoor lighting allowances for general hardscapes and lighting zone reclassification.

General Hardscape

Nearly all outdoor lighting respondents (87 percent) said they were at least somewhat familiar with the Illuminating Engineering Society (IES) and the specific standards that it sets.

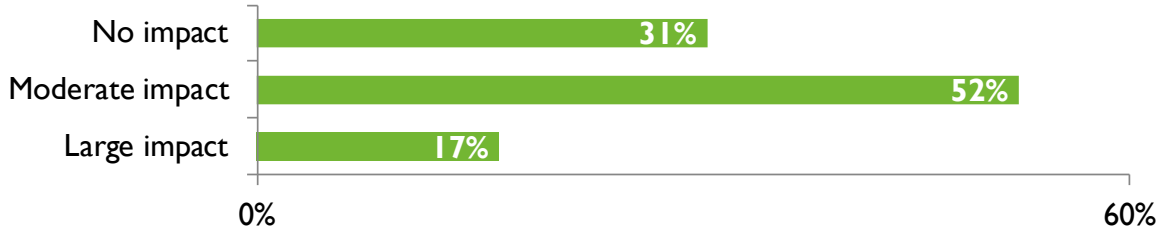

Figure 5: Impact on designed lighting levels if IES decreased lighting level recommendations (n=42).

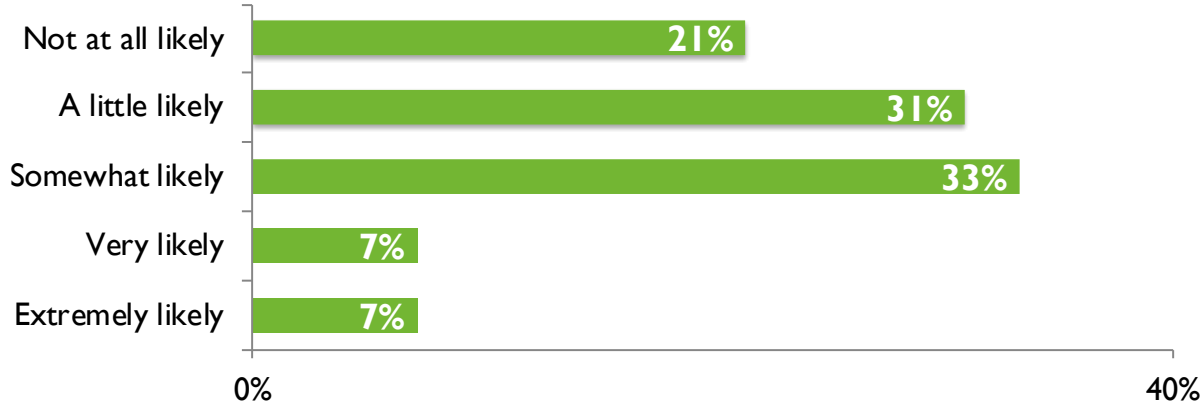

Figure 6: Likelihood of security issues from applying IES recommendations for projects in non-secure environments (n=42).

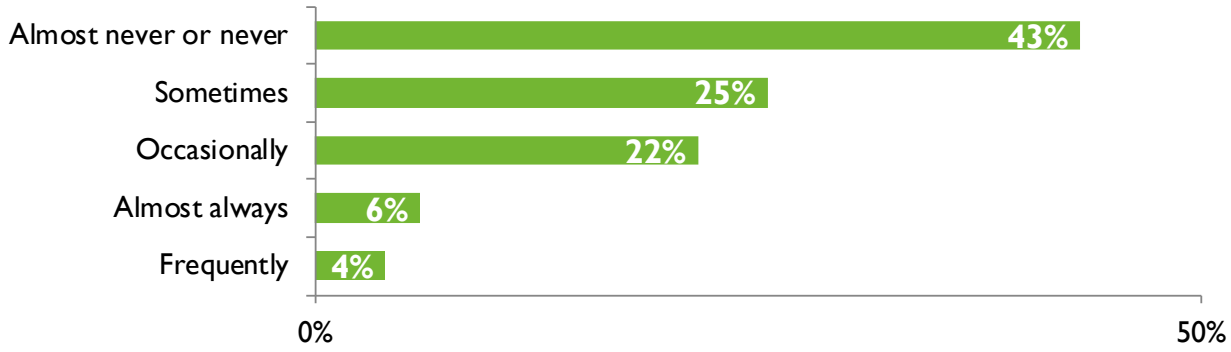

Figure 7: How often respondents think IES-recommended lighting levels would negatively affect their lighting projects (n=51).

Respondents who reported that the IES-recommended lighting levels would negatively affect their projects at least sometimes, frequently, or almost always noted that:

- Recommended levels that are higher than necessary for safety and functionality can increase payback time and make projects harder to sell.
- For areas that operate 24 hours, the IES-recommended levels are insufficient and pose a safety hazard, especially when in an industrial or commercial setting.
- In urban areas, security will override any energy savings in terms of importance.

Lighting Zone Reclassification

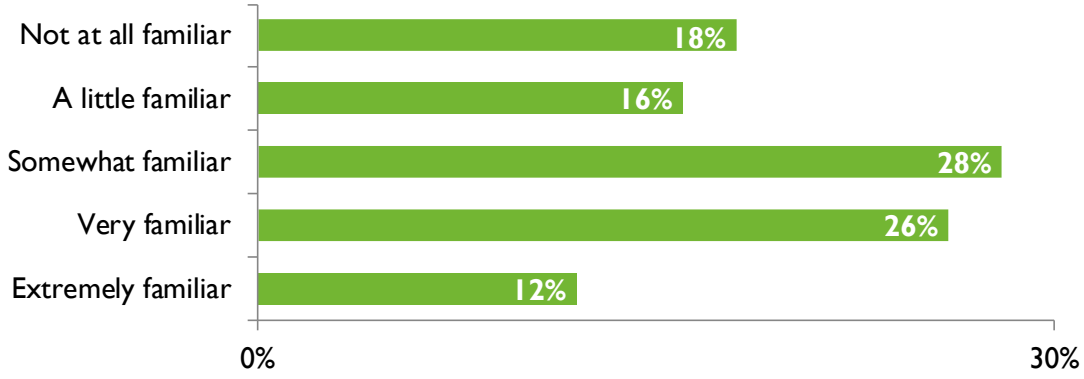

Figure 8: Familiarity with Dark-Sky Association (IDA) and the Illuminating Engineering Society Model Lighting Ordinance (MLO) (n=50).

A follow-up question to Figure 8 indicated that 72 percent of respondents reported that they are at least somewhat familiar with the IES RP-33-14 Lighting for Exterior Environments lighting zone definitions.

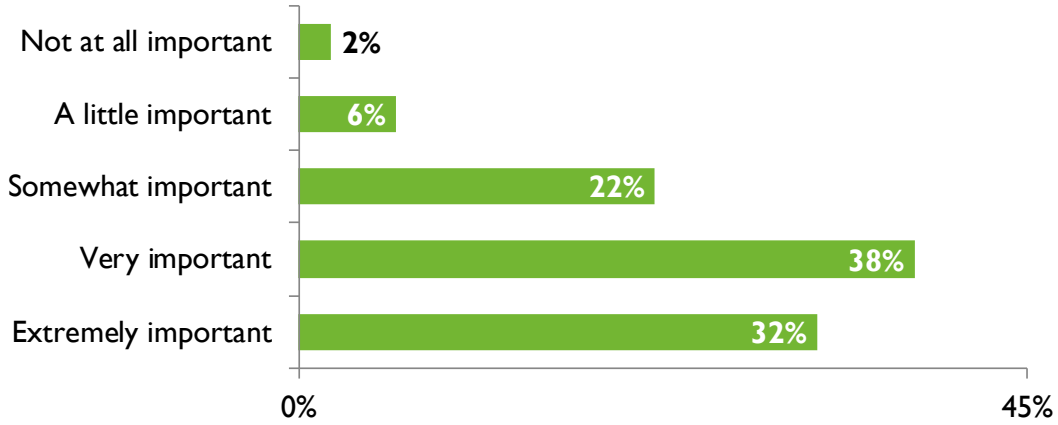

Figure 9: Overall importance of considering light pollution or light trespass for outdoor lighting design (n=50).

A follow-up question to Figure 9 asked respondents which specific steps they took to minimize light pollution and / or light trespass. Respondents who reported that considering light pollution or light trespass was somewhat, very, or extremely important were then asked what specific steps they take to minimize light pollution or light trespass in their own projects. Specific steps respondents reported included the following:

- Change the mounting height, and the house shield.
- Have minimum light levels, careful locations of luminaires, fully shielded luminaires with optional add-on shields.
- Use fixtures and mounting techniques that aim the light down and design to the lower end of the IESNA standards.
- Avoid lights with poor backlight, uplight, and glare (BUG) ratings, choose optically efficient fixtures to better control where light goes, reduce light levels where possible, and use low level integrated lights if possible.

Additionally, respondents were asked whether or not there are any published standards or guidelines that they use to help minimize light pollution or light trespass. Seventeen of the 30 respondents indicated that yes, they do utilize published standards or guidelines to help minimize light pollution or light trespass, including: California Title 24, the Illuminating Engineering Society handbook, IES-RP-33-14 Lighting for Exterior Environments, International Dark-Sky Association, CALGreen, LEED, and manufacturer data.

Respondents were also given the opportunity to provide their preferences for how lighting zones are established. Of the 32 respondents, 41 percent preferred establishment of lighting zones to be project specific and to be selected by the designer based on the MLO/IES-RP-33-14 lighting definitions. Thirty-eight percent of respondents said they preferred they be established by the local jurisdictions. Additionally, the 13 percent of respondents who reported "other" noted they would prefer:

- Using U.S. Census data (n=2)
- Lighting zones to be established by use type. When designing a shopping center in a rural city, you do not want to be limited. Likewise, a city park in a busy city should not be different than a rural park (n=1)
- Using a combination of IES-RP-33-14 lighting definitions with local jurisdiction in tandem would be good in some instances. (n=1)

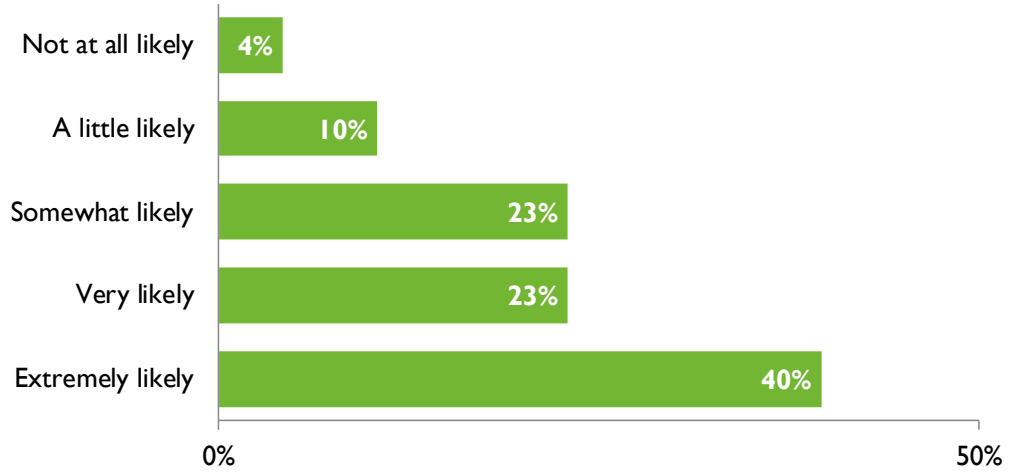

Figure 10: Likelihood of installing luminaires with appropriate lumen outputs, distribution, and shielding instead of installing additional equipment (n=48).

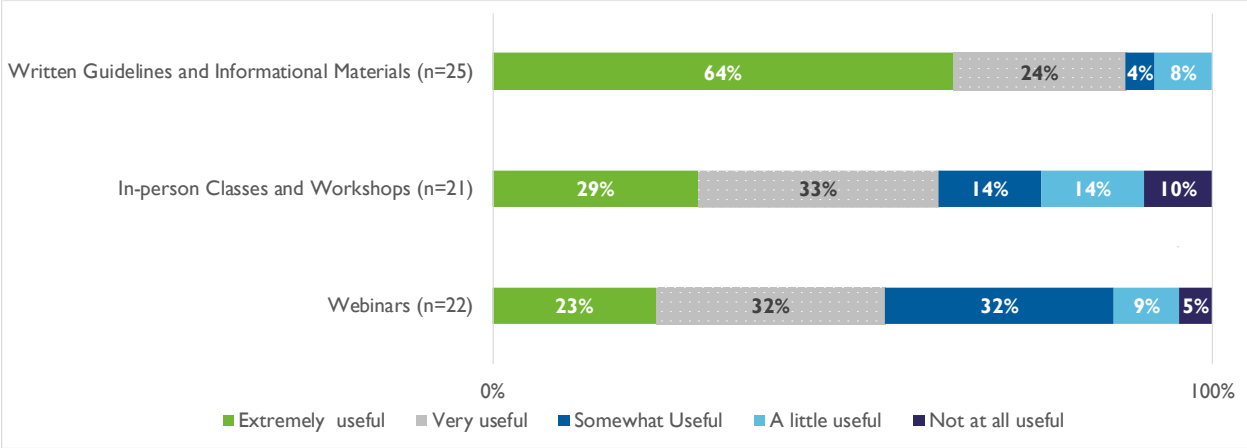

Figure 11: Desired assistance in determining lighting zones.

Multifamily Typical Lighting Design Practice

Survey respondents who indicated working with outdoor lighting in multifamily applications were asked a set of questions related to their experiences within the last six years.

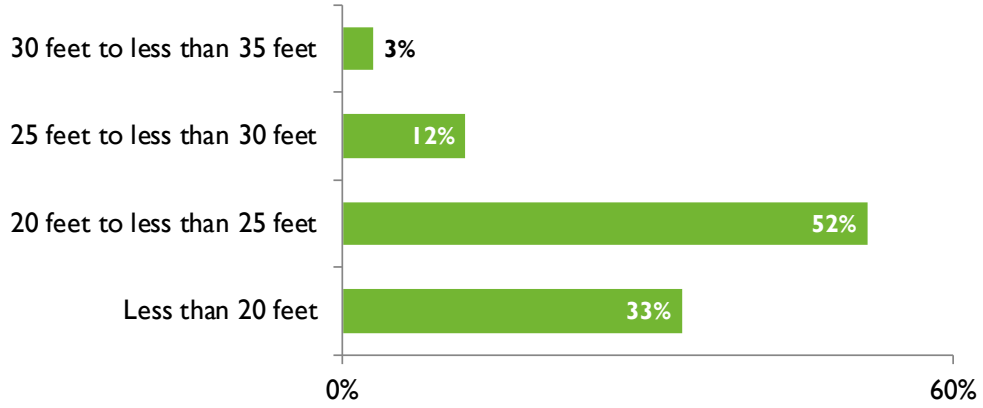

Figure 12: Typical mounting height for parking poles (n=33).

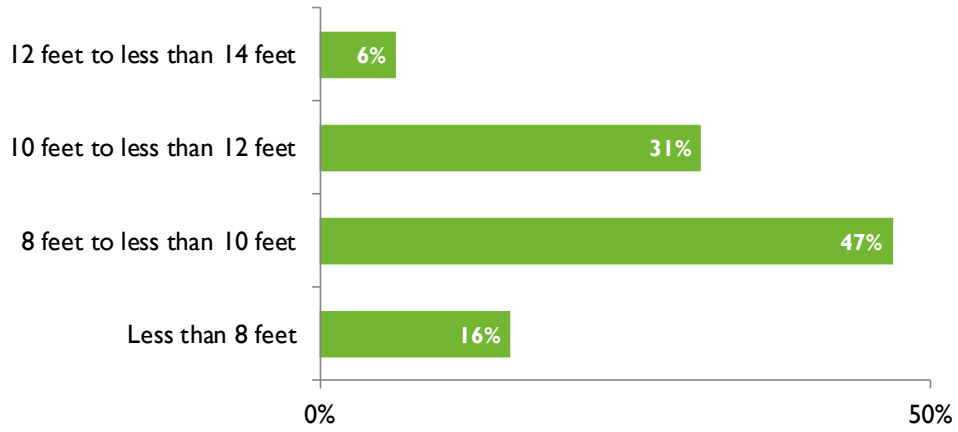

Figure 13: Typical mounting height for building entrances (n=32).

There was much more consensus regarding the mounting height for pedestrian poles, with 84 percent of the 25 respondents reporting the mounting height to be between 10 and 15 feet.

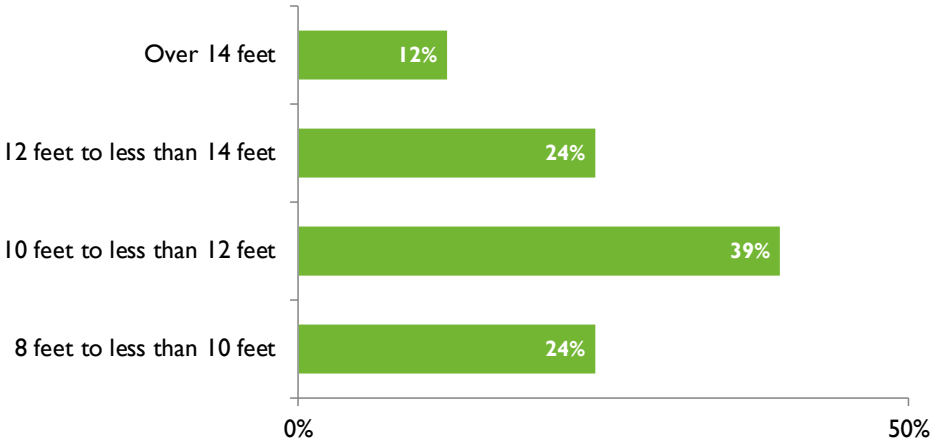

Figure 14: Typical mounting height for building mounted area lights (n=33).

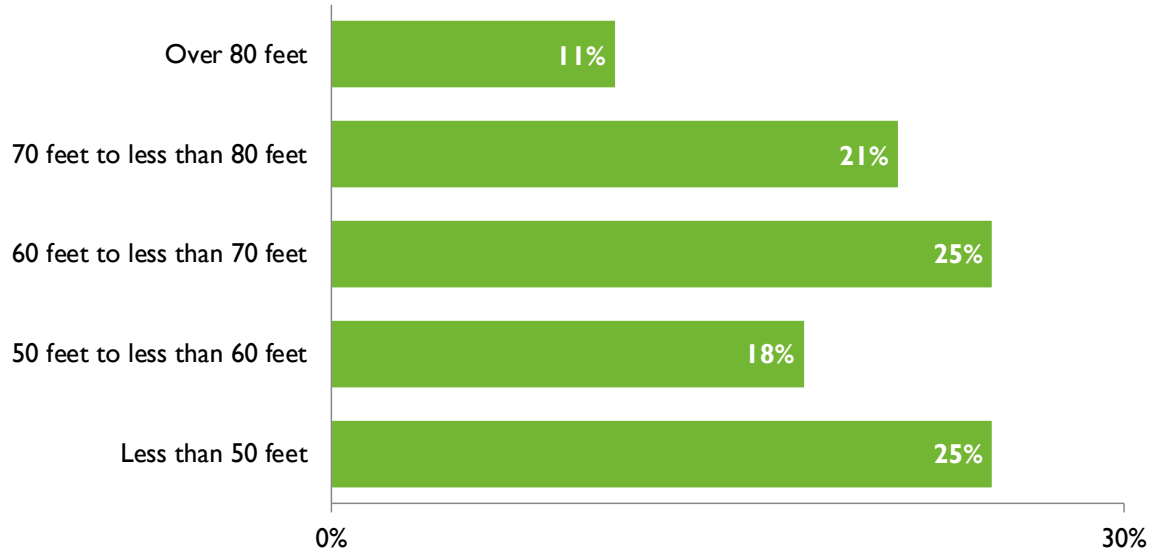

Figure 15: Typical pole-to-pole spacing for parking poles (n=28).

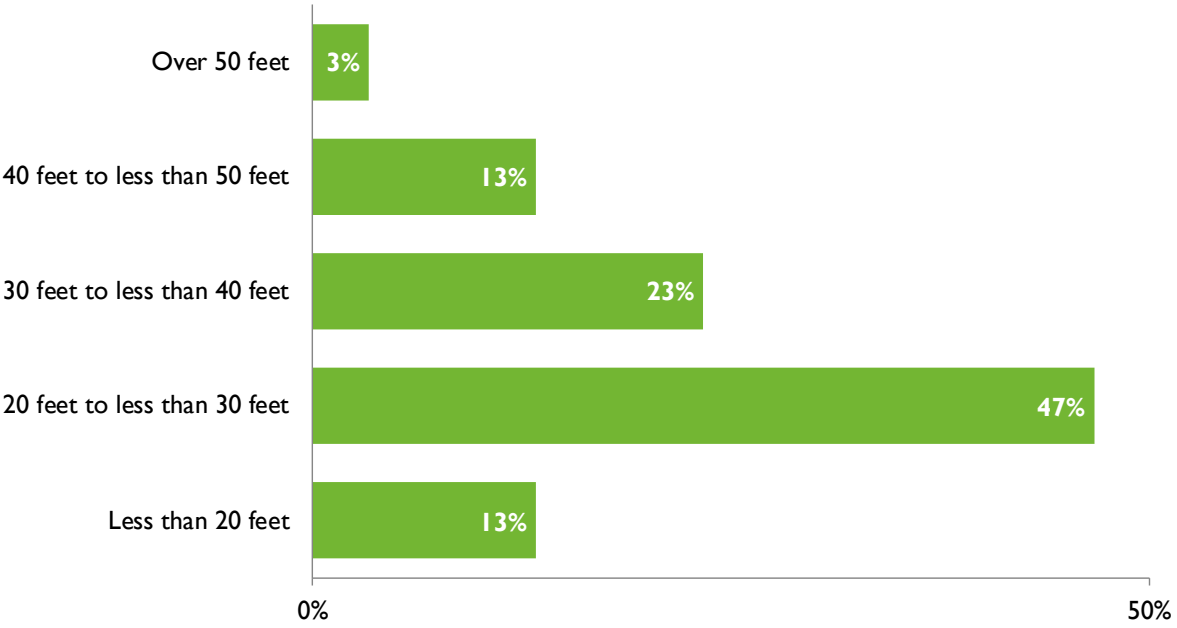

Figure 16: Typical pole to pole spacing for pedestrian poles (n=30).

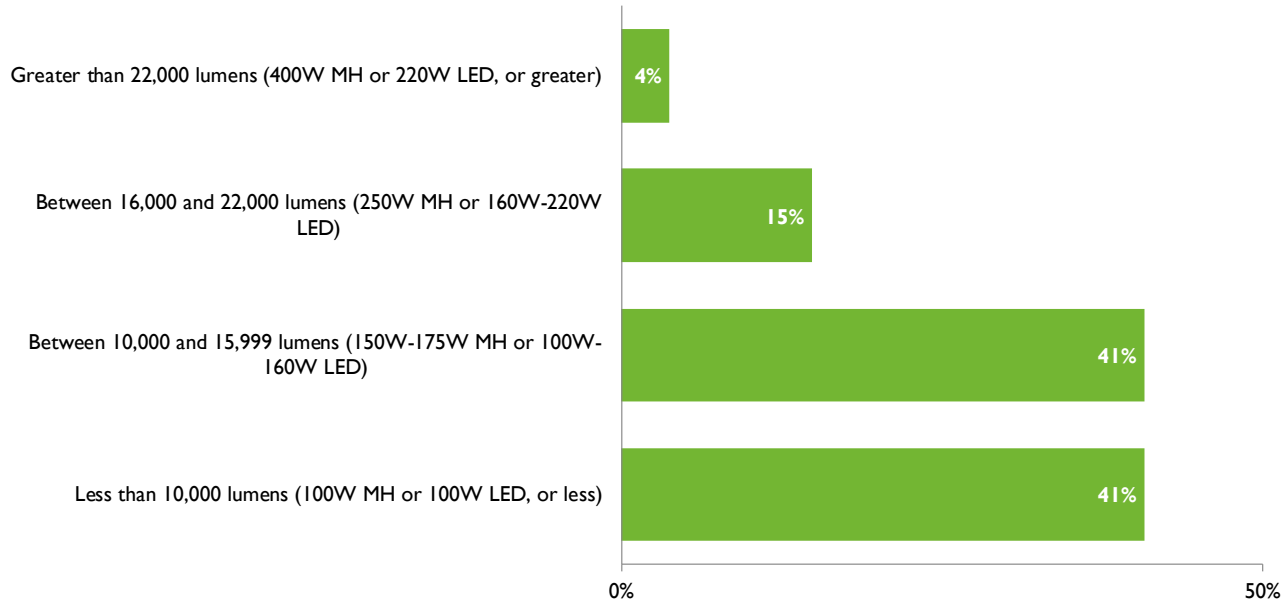

Figure 17: Typical lighting output for parking poles for projects completed in past six months (n=27).

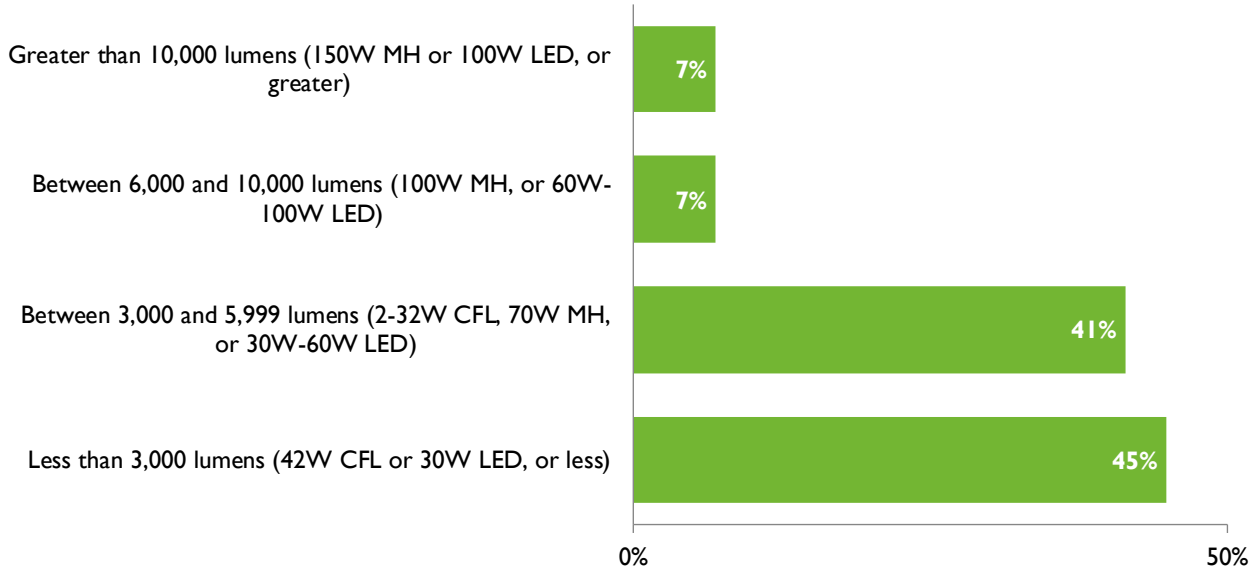

Figure 18: Typical lighting output for building entrances for projects completed in past six months (n=29).

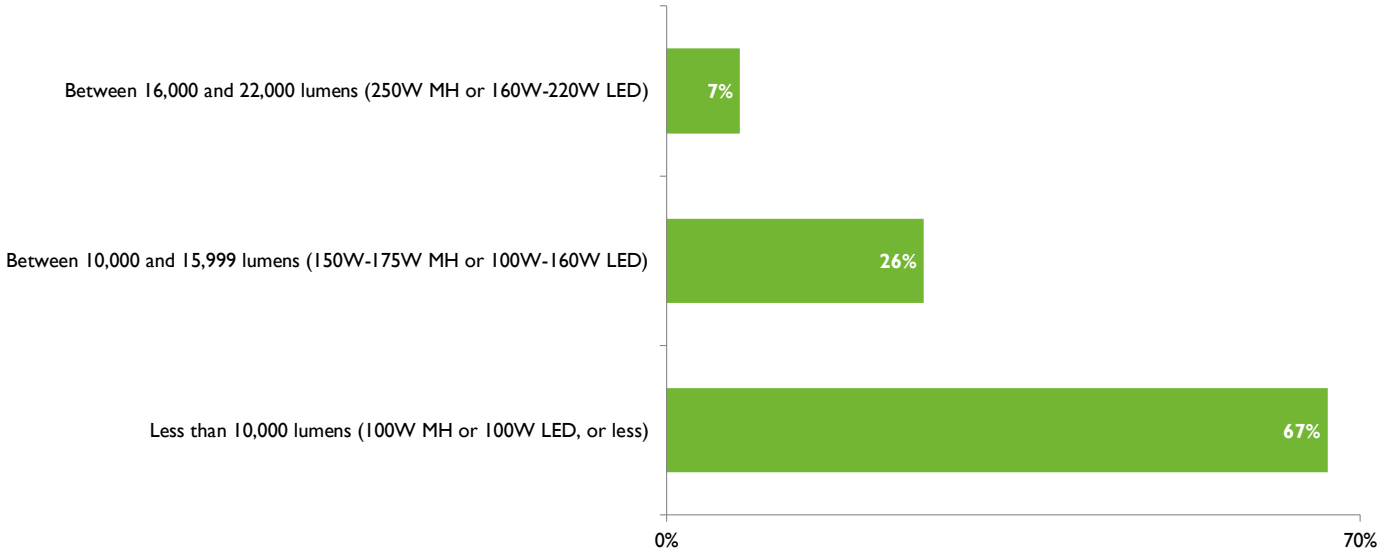

Figure 19: Typical lighting output for pedestrian poles for projects completed in past six months (n=24).

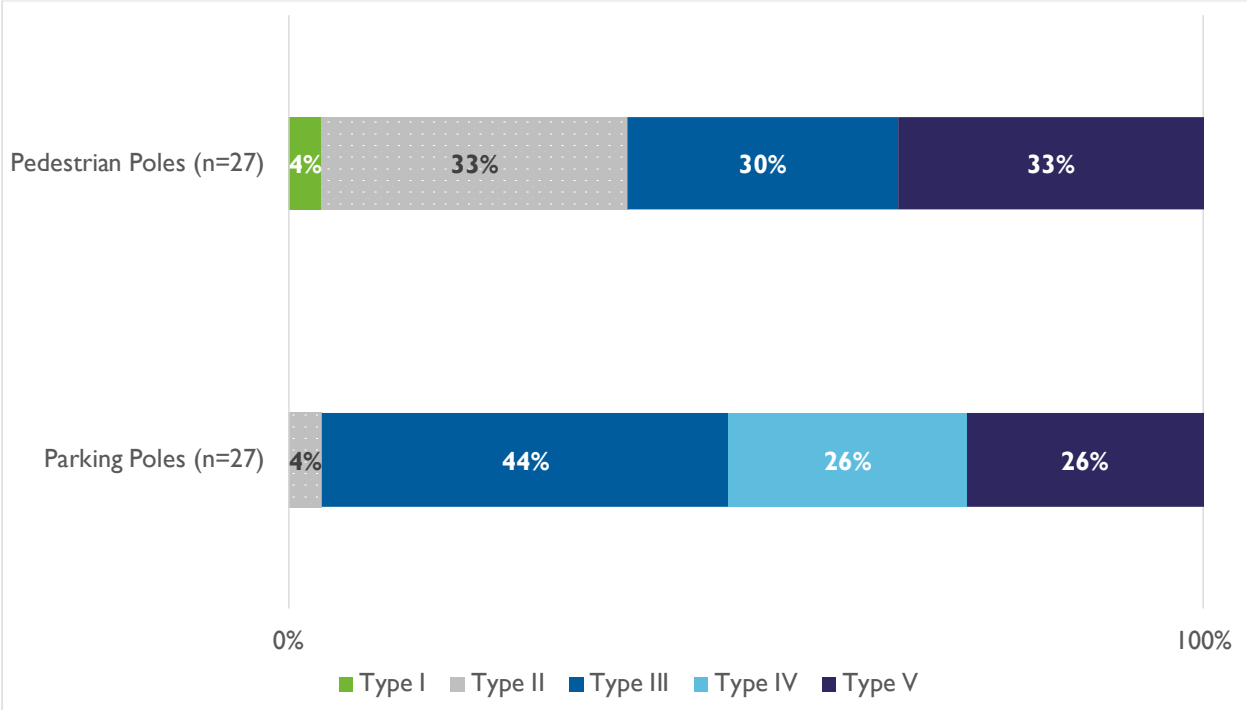

Figure 20: Typical light distribution for pedestrian and parking poles for projects completed in past six months.

Multifamily Human Health

In addition to multifamily outdoor design practices, survey respondents who indicated working on multifamily outdoor lighting projects were also asked questions regarding outdoor lighting and the impacts that it may have on human health.

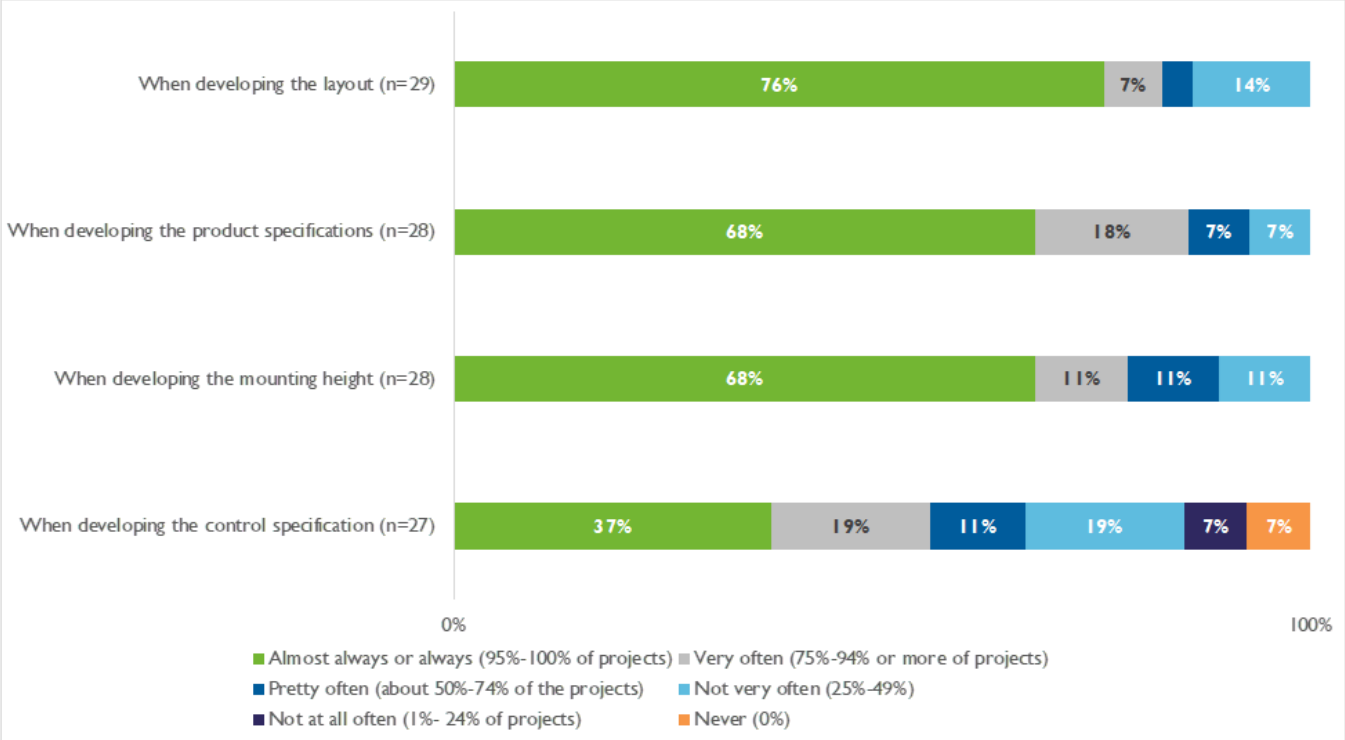

Figure 21: Frequency of consideration of light trespass in different scenarios.

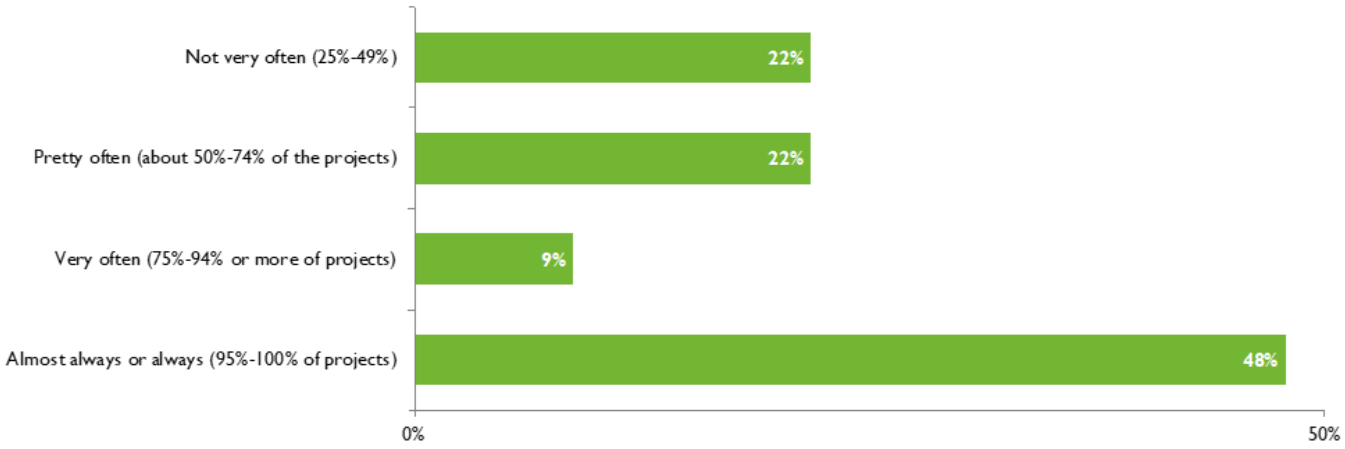

Figure 22: Frequency of generation of site photometric calculation to analyze potential light trespass into residential units (n=23).

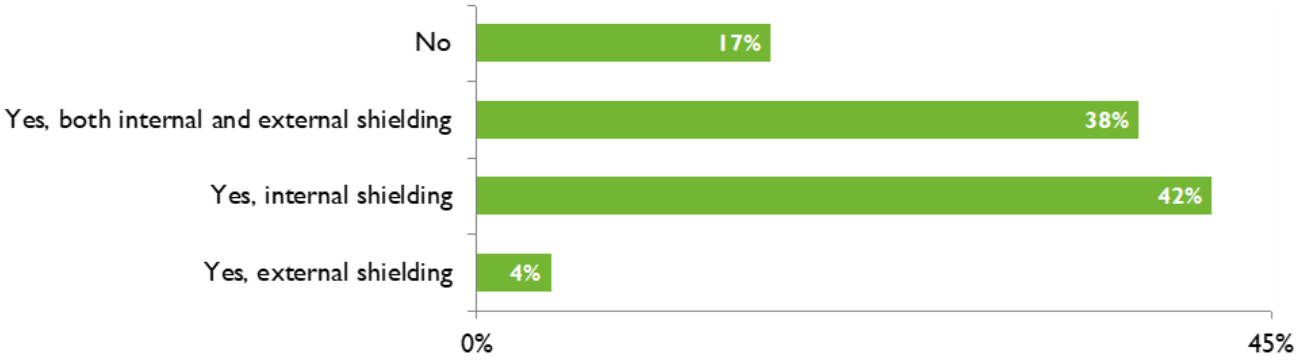

Figure 23: Use of internal and external shielding to ensure no light shines above 90 degrees from horizontal (n=29).

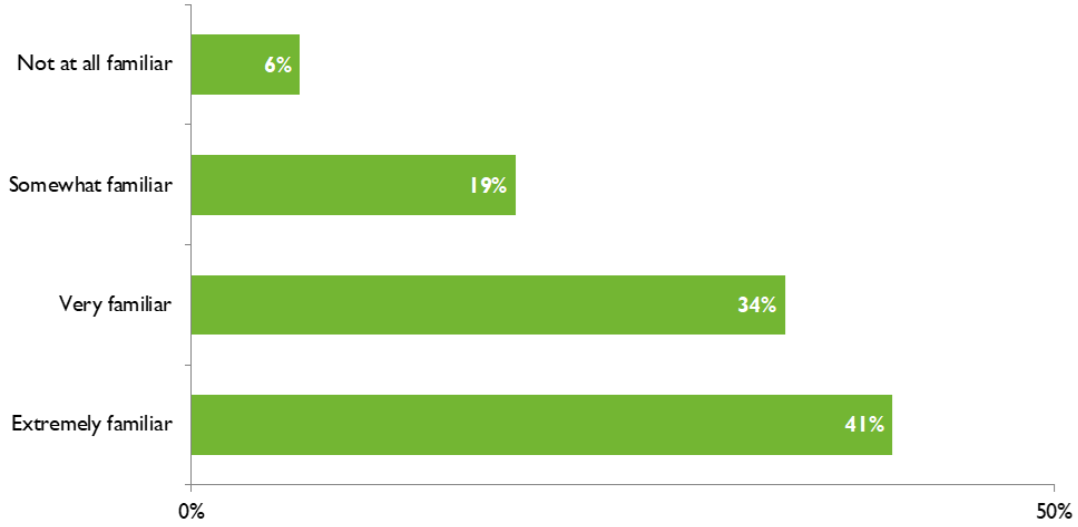

Figure 24: Familiarity with IES Backlight, Uplight, and Glare (BUG) rating system (n=32).

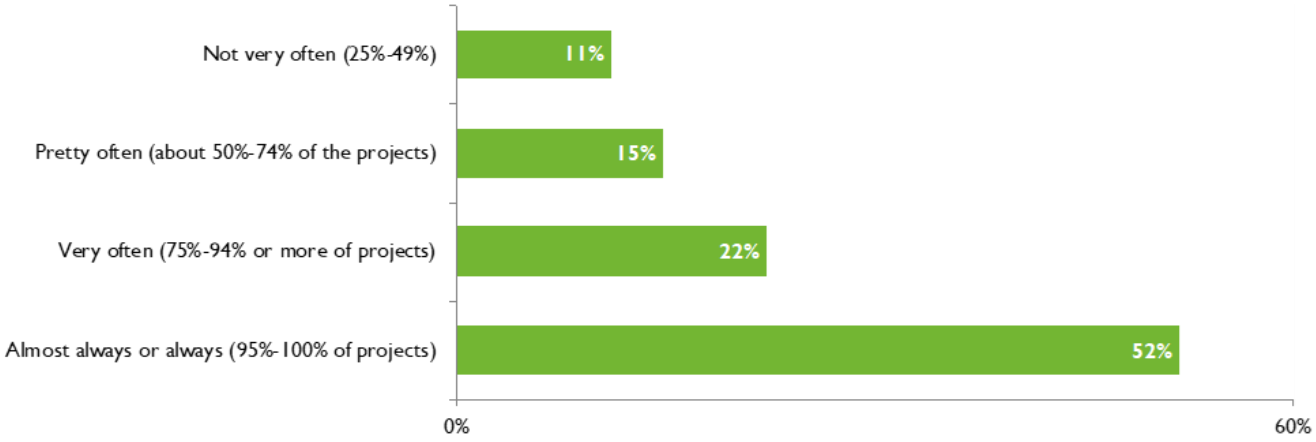

Figure 25: Frequency of specification or implementation of lighting products with specific cutoff attributes on multifamily lighting design projects to address light trespass concerns for residents (n=27).

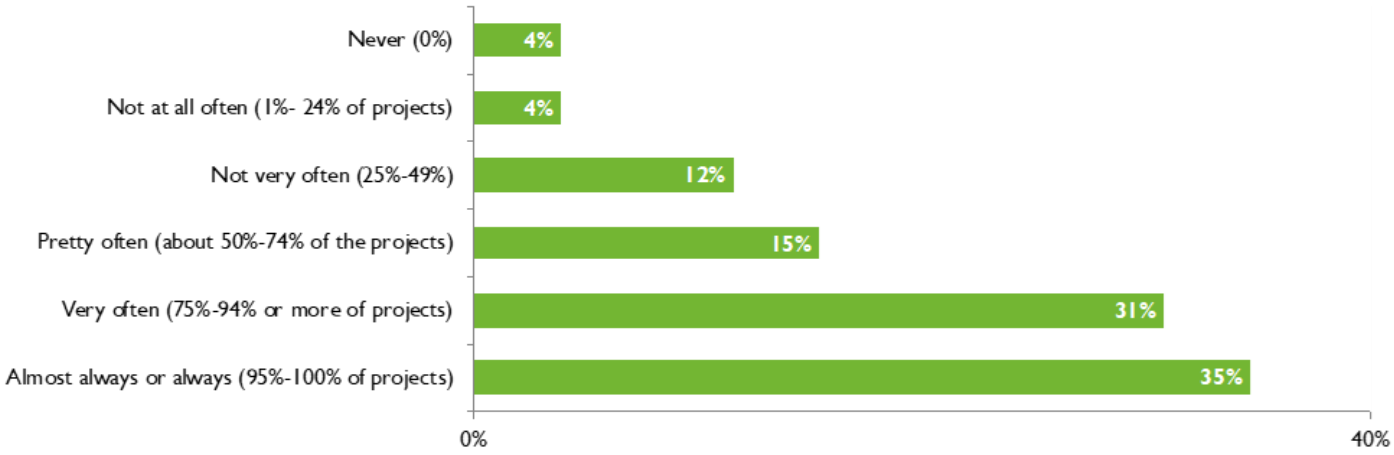

Figure 26: How often respondents specify or implement lighting with specific BUG attributes to address light trespass concerns (n=27).

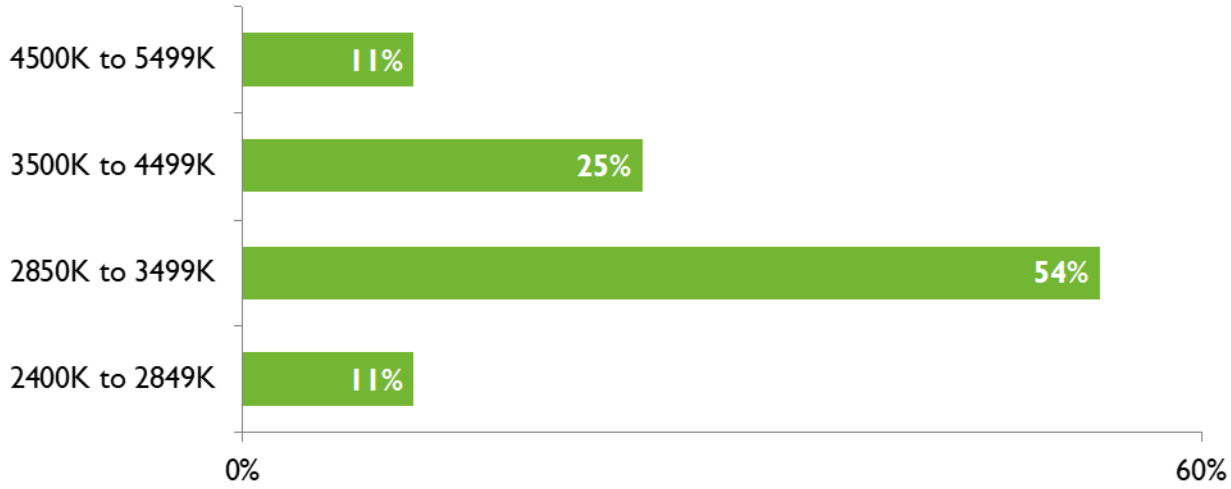

Figure 27: Color temperature preferences for outdoor lighting projects (n=28).

Sixty-four percent of respondents reported that the color temperature they use varies by different nonresidential outdoor lighting projects (e.g., commercial vs. industrial vs. retail vs. schools), compared to 36 percent who reported that the color temperature does not change by outdoor projects.

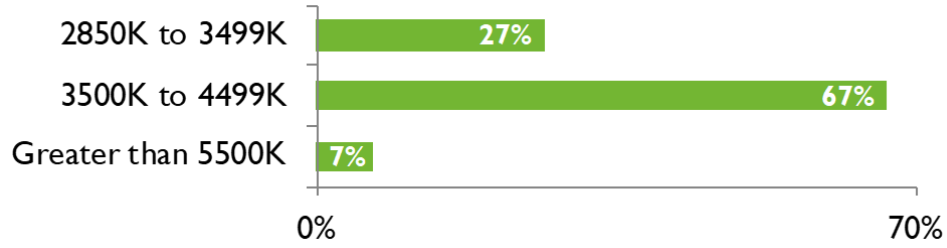

Figure 28: Color temperature preferences for nonresidential outdoor lighting projects (n=15).

Eighty percent of respondents reported that they do design or implement lighting controls for outdoor lighting. Of the 80 percent of respondents who design or implement lighting controls, 60 percent use dimmers, 55 percent use on-off controls, and 40 percent use bi-level lighting.

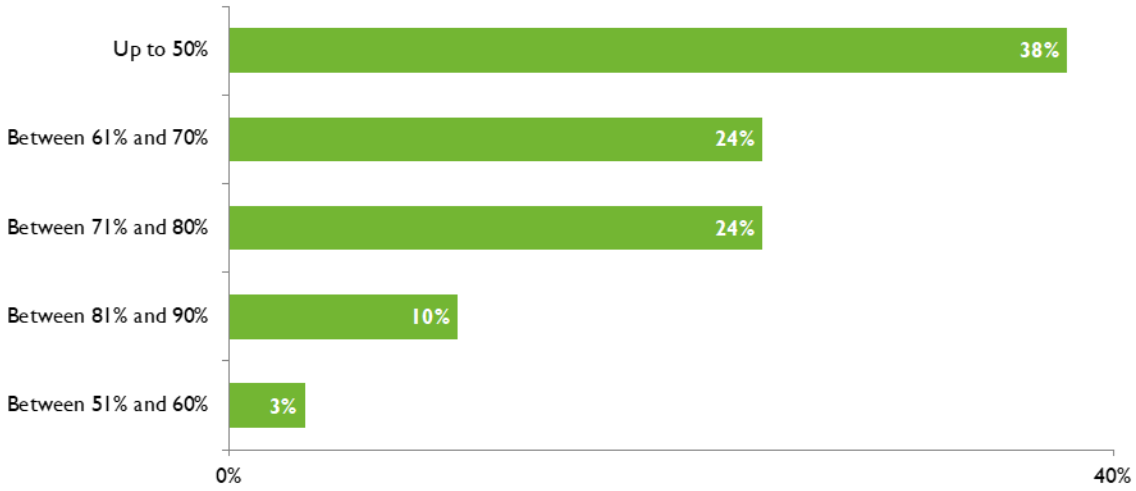

Figure 29: Reduction of lighting system from late-night setback for site lighting (n=29).

Appendix G: Multifamily Light and Health Topics

As part of developing the multifamily outdoor LPA measure, the Statewide CASE Team worked to understand how nighttime lighting impacts human health. As part of this, the Statewide CASE Team performed a literature review on the topic and solicited input from a subject matter expert to understand what the research supports when considering specific energy allowances for multifamily buildings.

Lighting at night has been associated with potential health problems such as disrupting human internal circadian rhythm. In a 2016 literature review, the American Medical Association found studies showing that "brighter residential nighttime lighting is associated with reduced sleep time, dissatisfaction of sleep quality, nighttime awakenings, excessive sleepiness, impaired daytime functioning and obesity" (American Medical Association 2016).

This may become more problematic with the increase in LED lighting. About 29 percent of 4000K LED light is emitted in the blue light spectrum (American Medical Association 2016) and melatonin suppression has the strongest response to short blue light wavelengths between 446 and 447 nm (West 2011). Although the effects of outdoor night lighting in a bedroom are not clear, it is important to take into consideration light levels that may affect melatonin levels and increased alertness.

Research Overview for Light and Health

The Statewide CASE Team focused on night lighting effects on melatonin suppression and increased alertness.

Literature shows that melatonin suppression is dependent on illuminance and irradiance levels but found suppression occurring at varying thresholds. A 1989 study tested melatonin suppression in thirteen subjects following one hour of light at midnight with intensities of 3,000, 1,000, 500, 350, and 200 lux (McIntyre 1989). Light was created using eight fluorescent tubes and melatonin levels were measured by taking blood samples. At all light levels except for 200 lux, the study observed a statistically significant decrease in melatonin levels after the study participants were exposed to the light. The study found the maximum percent suppression of melatonin to be 71, 67, 44, 38 and 16 percent at light intensity levels of 3,000, 1,000, 500, 350, and 200 lux respectively. A similar study in 2003 measured melatonin suppression after exposure to one hour of 509 nm monochromatic light at irradiance levels of 0.01, 0.3, 1.6, 5, and 13 $\mu W/cm^2$ and found the mean threshold irradiance for suppressing melatonin to be between 1.6 and 5 $\mu W/cm^2$ (Brainard 1988).

A 2000 study also tested melatonin suppression and circadian phase delay at a longer light exposure of 6.5 hours in twenty-three subjects (Zeitzer 2000). Light was

supplied from an overhead cool white fluorescent lamp filtered with a Lexan 9030 UV-restricting lens. The study tested light intensities ranging from three to 9,100 lux. Melatonin suppression and phase shift were observed to occur in a nearly stepped manner and were fit to a logistic model. The models indicated melatonin suppression saturating (90 percent of the asymptotic maximum response) at about 200 lux and phase-shifting responses saturating at about 550 lux.

On the other hand, literature shows varied results on the effects of nighttime lighting on alertness. In a 2009 study, effects of exposure to dim, narrowband blue light (460 nm, ~1 lux, 2 μW/cm^2), dim broad spectrum (white) ambient light (~0.2 lux, 0.5 μW/cm^2) and red light (640 nm, ~ 1lux, 0.7 μW/cm^2) were tested on eight participants (Phipps Nelson 2010). Different measurements of alertness were used such as subjective sleepiness using the Karolinska Sleepiness Scale (KSS), a two-hour simulated driving task (measuring lane and speed deviations), a psychomotor vigilance task (PVT) to measure reaction time, electroencephalographic (EEG) and electrooculographic (EOG) activity and salivary melatonin levels. Participants were exposed to one of the three light conditions from 23:30 until 05:30. Each participant tested the three light conditions on separate occasions with at least four weeks in between.

The study found PVT mean reaction times to be significantly faster in blue compared to ambient light, but no significant differences between red and ambient light conditions. EEG delta and theta activity and slow eye movement was also significantly reduced in blue than in ambient light. However, driving simulator lane and speed deviations and subjective sleepiness increased significantly across the night with no significant effect from light condition. Salivary melatonin levels also showed expected increase peaking at 23:00 with no significant effect from light condition.

Modeling Light Trespass Illuminance Values

Based on the literature review, the Statewide CASE Team found that at illuminance levels of about one lux, blue light had significant effects on alertness at night (Phipps Nelson 2010). The Statewide CASE Team used the lighting simulation software, AGi32, and modeled illuminance on the exterior of a window with two outdoor lighting arrangements in the case that interior vertical illuminance was one lux between five and six feet above finished floor and 10 feet into the room from the window wall. The first outdoor lighting arrangement used one LED luminaire, mounted 20 feet above grade, with Type V distribution, located 30 feet from the center of the window. The second lighting arrangement consisted of two LED luminaires, pole mounted at 20 feet above grade, with Type V distribution, spaced 60 feet apart centered on the window. For both arrangements, the lumen output of the of the luminaire was adjusted to achieve one lux at the interior calculation plane. These arrangements represent typical site lighting conditions that may occur on a multifamily property with pedestrian lighting to

characterize the amount of light on the façade that yields the target illuminance inside the window.

Modeling results indicated that the vertical illuminance at the exterior window was within two lux for both lighting arrangements, achieved with standard available lumen packages. Both lighting arrangements also achieved recommended horizontal illuminances for drives and parking.

The following room and window characteristics were used to model illuminance at the exterior of a window:

Table 49. Room and Window Modeling Properties

Location	Dimensions	Properties
Room	15ft by 15ft floor area, 8ft height	80% ceiling cavity reflectance 50% wall reflectance 20% floor cavity reflectance
Window	4ft height, 5ft length Windowsill at 3ft above finished floor	Transmission: 80%

Survey on Lighting and Health

The Statewide CASE Team surveyed subject matter experts in lighting about setting a threshold for outdoor lighting. Modeling of light trespass indicated that a one lux indoor threshold at eye level corresponded to a two-lux threshold at the exterior of the window. Given modeling results, the Statewide CASE Team asked the following questions:

1. Is it reasonable to consider an exterior light threshold limit at residential windows?
2. Given the variability of resident behavior within an interior space, is limiting exterior electric light on a window to two lux a benefit to residents?
3. It is known that nighttime setbacks for exterior lighting save energy. Do you think that establishing this type of threshold creates an opportunity to save more energy (than setback considerations, alone)?

Five subject matter experts responded to this survey. The following table shows answers from the respondents.

Table 50: Light and Health Survey Responses

Question Number	Response		
	Yes	No	Maybe/Don't Know
1	2	0	3
2	2	0	3
3	1	0	4

The “Maybe/Don’t Know” category includes respondents that did not answer the question and respondents that responded with a comment rather than a direct “Yes” or “No”. Some comments from the respondents included:

- “In any case, the illuminances that you are proposing certainly won’t have any circadian-related effects.”
- “Although I certainly understand that I am in a significant minority, I am not a fan of other-than-temporary light at night for exterior spaces. I do make exceptions for holiday and some monument/facade lighting. With the advent of small, low power, personal LED devices, I prefer to have folks carry a flashlight for illumination and wearable devices to be seen by others. If lighting large spaces is absolutely necessary or, more probably, desired, than I prefer motion-sensing or, better, addressable systems that are activated only when the space is occupied.”
- “I’m wondering if it makes sense to change the measurement point to the inside of the window rather that the outside, since many windows are not operable, and getting an illuminance meter up to a 6th story window is a challenge. That would knock off the vertical illuminance by 15-20 percent depending on the glass dirt and transmittance.”
- “This threshold is more likely to include a house-side shield, which saves no energy.”

Specific Impacts for Title 24 Multifamily Outdoor Lighting Sections

The Statewide CASE Team has collected this information with the intent to determine if “normal” parking lot and other lighting systems associated with multifamily housing are likely to be a source of light trespass into residents’ windows at night that approaches the level of concern for melatonin suppression or sleep retardation.

In lieu of definitive research results to support specific limits as part of a design criteria document, the safest approach for designers is to be aware of the issue and that the amount of light experienced inside the living spaces in a multifamily building should be kept to a minimum within reason. Minimizing this exposure involves both the amount of light at any given time, and the total light flux over a period of time, which can be considered a night’s worth of electric outdoor lighting.

This can be supported through Title 24, Part 6 in several ways:

- Promote lower light levels in situations where there is discretion and where the current practice is above that considered the minimum for safety and security. One way to do this is to eliminate LPAs for applications where the lighting application is inconsistent with residential land use or where the added value of the additional light levels is outweighed by the human health aspects of a residential environment. An example of this is the allowances in Table 140.7 -B Additional Lighting Power Allowance for Specific Applications. Some of these are clearly focused on retail applications and the argument can be made whether

they *should* be permitted. The energy code doesn't dictate whether they can be done on a multifamily housing project, but this proposed language would not provide additional LPA for these situations.

- Promote lower total light output by controlling the light better. This can be done be requiring a deeper reduction in light setback for after-hours conditions and encouraging even lower light levels when an outdoor space is not considered occupied. This is done by increasing the setback for after-hours light levels to match the 60 percent reduction in design criteria that the IES establishes in RP-20 and the Lighting Handbook, 10th Edition.

Lastly, the amount of high-angle light that emanates from the lighting equipment can be reduced to reduce light trespass, especially in the lower floors of multifamily housing projects. This is being addressed primarily through the CALGreen language that specifies the maximum G Rating by Lighting Zone that is permissible for specification in California. This section is not being changed by this code change proposal, but the method to ensure proper code compliance must be addressed to ensure that the limits are met. The current compliance documents do not have a direct comparison of the B, U, and G values and acceptable limits to ensure compliance.

Further Recommendations

Since the current IES documents and committees do not specifically address multifamily housing, the current approach in the California energy code is to apply nonresidential lighting design recommendations to this application (since the previous code versions has included multifamily housing over three floors in the nonresidential section of the code). This is similarly done in other design standards, including ASHRAE 90.1 and any codes based on the ASHRAE document.

The growing body of research pointing to risk factors associated with long term exposure to blue spectrum light at night is generating the needed support for IES to elevate this issue, so it can be addressed in the existing committee structures, Recommended Practice documents, and Handbook. Following is a list of potential actions that the IES can take to investigate this question.

- Update the IES-IDA MLO to address the problem that intra-site light trespass isn't suitably accounted for, specifically in the context of multifamily housing, but possibly for other applications that include sleeping quarters, including hospitals, assisted living facilities, dorms, barracks and other quasi-nonresidential building types.
- Create a subcommittee in the Roadway Lighting committee or similar appropriate location to investigate developing specific recommendations for lighting criteria and whether limits for light trespass or spill light should be considered for properties with residences within the same property as the source of the outdoor lighting. This committee should be incorporating the expertise of the Outdoor

Environmental Lighting committee, the Light and Human Health committee, and the Roadway Off-Roadway technical group.

- Introduce a subsection within the Lighting Handbook to specifically address internal property light trespass issues for multifamily housing and similarly for hotel/motel occupancy situations to increase sensitivity to these issues and present the results of the committee research. Since the handbook is a key source of design guidance for the industry, this step is crucial.
- Consider a review of all documents that may apply to multifamily outdoor lighting design to ensure that there are no other documents that may have coverage of this area and ensure that there is no conflicting guidance within the documentation.
- Collaborate with other international lighting standards-setting organizations and committees to evaluate what research has been done on this topic and what additional research needs exist to develop comprehensive and defensible guidance documents.

Appendix H: Multifamily Prototype Characterization

The Statewide CASE Team gathered nineteen plan sets from the California Multifamily New Homes Program, a utility incentive program, and classified them into the four prototypes based on the number of floors and site configuration for CASE analysis. While this is an above-code program, the Statewide CASE Team still thinks the sites are market representative since the information gathered from them for the purpose of this CASE measure is the shape of the site.

The Statewide CASE Team gathered information from the plan sets including number of floors, number of units, location, floor area, and whether the building has nonresidential spaces. The Statewide CASE Team then used a software program to calculate the building footprint, site, landscape, and hardscape area and perimeter for the purpose of being able to calculate lighting power allowances per Title 24, Part 6 Table 140.7-A General Hardscape Lighting Power Allowance. Three sites were removed from the data sample due to data quality issues including incomplete documentation or unreasonable results.

Table 60 and Table 61 at the end of this section show a summary of the data by site and by prototype.

To determine proposed LPA's for the 2022 multifamily code, the Statewide CASE Team performed the following steps for each site:

1. Calculate LPA based on existing 2019 Nonresidential requirements
2. Calculate 2019 equivalent allowance levels *without* linear allowance by adjusting initial and area allowances to create as nearly equivalent an allowance as is possible that excludes the linear allowance factor
3. Calculate LPA based on 2019 requirements without the linear allowance with the resultant initial and area allowances from step two
4. Calculate LPA based on the newly proposed 2022 Nonresidential allowances (to have a 2022 baseline for the comparison of the new MF proposed values)
5. Determine the average percent reduction in linear, area, and initial allowances between 2019 and 2022 nonresidential proposed requirements
6. Calculate proposed 2022 multifamily allowances by applying the average percentage reduction from step five to the allowances resulting from Step 3, (2019 equivalent allowances without linear allowance)

The Statewide CASE Team calculated the lighting power allowances for each site based on 2019 Title 24, Part 6 (Table 140.7-A) nonresidential allowances shown in Table 51 below with the takeoff data described above. For the case of LZ2 and LZ3 where there were both Asphalt and Concrete options, only the Asphalt option was

included because the proposed code reverts to the older Asphalt levels as the bases of design. The results are provided in Table 52.

Table 51: 2019 Nonresidential Lighting Power Allowance by Lighting Zone

Allowance	LZ1	LZ2A	LZ3A	LZ4
Area	0.018	0.023	0.025	0.03
Linear	0.15	0.17	0.25	0.35
Initial	180	250	350	400

Table 52: 2019 Calculated Lighting Power Allowance Wattage by Site Using 2019 NR Allowance Table

	LZ1	LZ2	LZ3	LZ4
Site 1	390	500	676	833
Site 2	901	1,109	1,472	1,890
Site 3	914	1,127	1,485	1,901
Site 4	949	1,176	1,525	1,938
Site 5	790	998	1,256	1,557
Site 6	1,033	1,278	1,652	2,103
Site 7	1,265	1,548	2,028	2,619
Site 8	1,143	1,412	1,818	2,319
Site 9	1,609	1,970	2,538	3,269
Site 10	1,743	2,130	2,748	3,550
Site 11	2,414	2,993	3,666	4,636
Site 12	2,446	3,042	3,695	4,651
Site 13	3,043	3,762	4,607	5,845
Site 14	5,696	6,912	8,756	11,380
Site 15	4,466	5,531	6,676	8,440
Site 16	8,581	10,393	13,157	17,134

The Statewide CASE Team then adjusted the 2019 initial and area allowances such that the resulting total LPA matches the total allowance per 2019 rules as closely as possible without resulting in a strong disadvantage to the allowances in the translation. These results are shown in Table 53 and Table 54 below.

Table 53: 2019 Equivalent Lighting Power Allowance without Linear Wattage Allowance

	LZ1	LZ2A	LZ3A	LZ4
Area	0.030	0.037	0.050	0.064
Linear	0	0	0	0
Initial	350	425	500	650

Table 54: 2019 Lighting Power Allowance Wattage by Site Using Alternate LPA Table Excluding Linear Wattage Allowance

	LZ1	LZ2A	LZ3A	LZ4
Site 1	491	599	735	951
Site 2	833	1,020	1,305	1,680
Site 3	879	1,077	1,381	1,778
Site 4	989	1,213	1,565	2,013
Site 5	1,013	1,243	1,605	2,064
Site 6	1,066	1,309	1,694	2,178
Site 7	1,132	1,390	1,804	2,319
Site 8	1,168	1,434	1,863	2,395
Site 9	1,513	1,859	2,438	3,131
Site 10	1,595	1,961	2,575	3,306
Site 11	2,790	3,435	4,567	5,856
Site 12	2,937	3,616	4,812	6,169
Site 13	3,438	4,234	5,647	7,238
Site 14	5,080	6,259	8,384	10,742
Site 15	5,248	6,466	8,664	11,099
Site 16	7,523	9,272	12,455	15,952

The Statewide CASE Team attempted to translate the allowances in this step as neutrally as possible so that it is neither more aggressive nor more lax when compared to the existing code. Due to the shape of the hardscape and area to perimeter ratios, this was not possible in all cases. For example, a site with many sidewalks will have a large hardscape perimeter and relatively small hardscape area leading to a low area to perimeter ratio (see Site 1 and Site 2 in Table 55 below) while a site with a large parking lot will have a larger perimeter area ratio due to the shape of the hardscape (see Site 8 in Table 55 below).

Essentially, the perimeter ratio reflects the “simplicity” of the site; the more complex (the greater the site deviates from an idealized square lot with a very simple square general hardscape area), the lower the ratio will become. Sites with large area to perimeter ratios are difficult to maintain overall comparable LPA values when removing the linear allowance without significantly increasing the LPA for sites with smaller area to perimeter ratios to ensure that the LPA formulas are neutral.

Table 55: Area to Perimeter Ratio by Site

Site ID	Area to Perimeter Ratio
Site 1	5.6
Site 2	5.6
Site 3	6.3
Site 4	8.3
Site 5	15.7
Site 6	8.5
Site 7	6.3
Site 8	40.3
Site 9	8.7
Site 10	7.9
Site 11	7.6
Site 12	15.9
Site 13	18.1
Site 14	15.3
Site 15	8.8
Site 16	18.2

The Statewide CASE Team remedied this issue with the use of the Excel Solver function where a user can select a value to minimize by altering the values in other cells. In this case, the cell to minimize was selected to be the *sum of the difference* in total LPA’s with and without linear allowances. The cells whose values were altered were the initial and area allowances values.

Table 56 below shows the percentage change in the total calculated effective LPA by site between existing 2019 allowances and the converted 2019 LPA formula without the linear allowance.

Table 56: Percent Change in Total Lighting Power Allowance by Site

	LZ1	LZ2A	LZ3A	LZ4
Site 1	26%	20%	9%	17%
Site 2	-8%	-8%	-11%	-14%
Site 3	-4%	-4%	-7%	-8%
Site 4	4%	3%	3%	5%
Site 5	28%	24%	28%	40%
Site 6	3%	2%	3%	5%
Site 7	-11%	-10%	-11%	-15%
Site 8	2%	2%	2%	4%
Site 9	-6%	-6%	-4%	-5%
Site 10	-9%	-8%	-6%	-9%
Site 11	16%	15%	25%	33%
Site 12	20%	19%	30%	41%
Site 13	13%	13%	23%	30%
Site 14	-11%	-9%	-4%	-7%
Site 15	18%	17%	30%	40%
Site 16	-12%	-11%	-5%	-9%

It is important to note that this process is not entirely automated, and attention was put on favoring the error to ensure that the MF LPA table for general hardscape does not penalize multifamily projects compared to the previous nonresidential LPA table. To do this, the Statewide CASE Team chose to favor over-allowance as opposed to under-allowance in the values that are set in the 2019 and 2022 proposed multifamily LPA tables. This means that if there is a difference in the allowance compared to the nonresidential cables, the project is likely to be given more LPA with the multifamily LPA table, not less, but it is not impossible to be allotted less. This is shown in Table 56 above when looking down a column of total allowed wattage differences, the error favors a positive error (resulting in greater positive error values and more sites with a positive error than a negative error).

The Statewide CASE Team also calculated the allowances for the 16 sites based on the proposed 2022 nonresidential lighting power allowances. Then, the Statewide CASE Team calculated the percentage reduction in allowances between 2019 and 2022 for LZ1-LZ4. These values are summarized in Table 57 and Table 58 below and were used to develop the proposed 2022 MF LPA values (which are based on the 2019 allowances without the linear allowance, calculated above, and reduced by the

respective average percentage for each lighting zone shown in Table 58). The proposed 2022 multifamily allowances are shown in Table 59.

Table 57: 2022 Proposed Nonresidential Lighting Power Allowance Values

	LZ1	LZ2A	LZ3A	LZ4
Area	0.015	0.018	0.021	0.24
Linear	0.13	0.15	0.2	0.29
Initial	150	200	250	320

Table 58: Percent Change in Lighting Power Allowance between 2019 and 2022 Nonresidential Lighting Power Allowance Values

	LZ1	LZ2A	LZ3A	LZ4
Area	-17%	-22%	-16%	-20%
Linear	-13%	-12%	-20%	-17%
Initial	-17%	-20%	-29%	-20%
Average	-15%	-18%	-20%	-19%

Table 59: 2022 Proposed Multifamily Allowance Values

	LZ1	LZ2A	LZ3A	LZ4
Area	0.026	0.030	0.038	0.055
Linear	0	0	0	0
Initial	300	350	400	450

Table 60 below provides the general summary of sites when grouped by the building prototype that each was assigned. These values represent the average characteristics for the sites when evaluated and compiled by prototype and do not represent any single site.

Table 60: Site Characteristics by Prototype

Prototype	Floor Area (ft2)	Unit Count	Building Footprint Area (ft2)	Site Area (ft2)	Landscape Area (ft2)	Hardscape Area (ft2)	Total Area (ft2)	Building Perimeter (ft)	Site Perimeter (ft)	Landscape Perimeter (ft)	Hardscape Perimeter (ft)
High-Rise	143,729	145	43,959	88,801	8,373	36,876	89,207	1,653	1,330	1,268	3,255
Mid-Rise	179,832	161	77,048	185,011	35,401	74,109	186,558	1,969	1,742	5,189	6,718
Low Rise - Garden	46,150	45	38,584	153,578	47,567	66,136	152,287	2,775	1,608	5,473	5,546
Low Rise - Corridor	40,521	70	32,608	92,979	36,122	24,087	92,816	1,502	1,284	3,192	2,759

Table 61 provides the general summary of sites when grouped by the building prototype that each was assigned. These values represent the average characteristics for the sites when evaluated and compiled by prototype and do not represent any single site.

Table 61: Evaluated Site Characteristics

Site	Prototype	Overall Prototype	Floor Area (total) (ft2)	Unit Count	Building Footprint Area (ft2)	Site Area (ft2)	Landscape Area (ft2)	Hardscape Area (ft2)	Total Area (ft2)	Building Perimeter (ft)	Site Perimeter (ft)	Landscape Perimeter (ft)	Hardscape Perimeter (ft)
Site 1	5 story mixed use	Mid Rise	43,649	24	55,507	60,731	-	4,705	60,212	989	1,033	-	835
Site 2	6 story mid-rise	High Rise	54,981	61	60,469	85,712	8,917	16,093	85,479	1,572	1,654	1,956	2,877
Site 3	Mid-rise	Mid Rise	350,774	249	41,817	64,954	5,059	17,621	64,497	1,401	1,188	1,374	2,777
Site 4	6 story mid-rise	High Rise	146,629	125	29,069	47,746	2,068	21,294	52,431	866	936	724	2,569
Site 5	3 story low rise	Low Rise - Corridor	28,305	49	18,263	51,084	10,112	22,101	50,476	901	940	1,833	1,412
Site 6	6 story mid-rise	High Rise	158,363	172	47,626	89,859	17,189	23,879	88,694	1,029	1,248	1,399	2,819
Site 7	3 story low rise	Low Rise - Corridor	52,737	90	46,952	134,873	62,131	26,072	135,155	2,103	1,628	4,551	4,107
Site 9	4 story low rise	Mid Rise	95,383	144	34,696	72,190	9,408	27,264	71,368	1,531	1,088	2,094	3,147
Site 10	Garden style	Low Rise - Garden	36,198	46	25,862	94,801	28,643	38,758	93,263	2,552	1,224	4,032	4,875
Site 11	2 story garden	Low Rise - Garden	21,366	36	17,862	94,097	34,451	41,504	93,817	2,146	1,241	4,840	5,443
Site 12	4 story LR + 10 townhomes	Low Rise - Garden	72,370	42	70,267	185,456	32,456	81,339	184,062	4,320	1,863	4,799	5,131
Site 13	6 story mixed use	High Rise	214,943	220	38,670	131,886	5,316	86,238	130,224	3,145	1,483	993	4,755
Site 14	Kind of garden style, 2 story	Low Rise - Garden	54,666	54	40,346	239,956	94,718	102,943	238,007	2,083	2,105	8,221	6,733
Site 15	5 story mid-rise	Mid Rise	175,864	174	183,581	389,824	68,124	157,683	409,388	3,502	2,569	13,058	17,855
Site 16	5 story mid-rise	Mid Rise	233,488	215	69,639	337,356	94,414	163,271	327,324	2,422	2,830	9,421	8,978

Appendix I: Multifamily Calculation Approach

The Statewide CASE Team used AGi32 lighting simulation software to calculate lighting layouts of various scenarios that are commonly found on multifamily projects: parking lot, plaza, and building entry lighting.

The Statewide CASE Team created a 3D model for each of the three scenarios and placed luminaires into the design scenarios in a manner consistent with good design practices and in keeping with the multifamily lighting survey results (to establish reasonable pole heights, wattages, and other variables that are commonly used in multifamily projects).

Based on product data gathered by as a sampling of the currently-available lighting products that may be suitable for specification, the Statewide CASE Team calculated the maximum vertical illuminance at various points on the façade of the building within the three prototypes to determine the maximum illumination that each floor of the building may receive.

Multifamily Calculation Methodology

The Statewide CASE Team set up a calculation matrix to analyze what effect the variables of interest have on light levels and light trespass into residential units. The intention was to determine optimal lighting design to ensure the maximum amount of light reaches the parking lot or building entry area while minimizing the amount of light that reaches the building façade. The Statewide CASE Team analyzed pole location, mounting height, different luminaire manufacturers, distribution type, and wattages for each of the scenarios described above.

The Statewide CASE Team varied the pole height and location while using real product data for the specifications. For example, in one simulation the Statewide CASE Team modelled 25-foot dual head poles located in the middle of a 120-foot-wide parking lot with an adjacent 6-foot strip of grass and sidewalk with a luminaire product with a Glare rating of G2, distribution Type III, and a total wattage of 70. AGi32 reports maximum illuminance levels at window height of each of the floors in each prototype.

Parking Lot Calculations

Parking space calculations were performed using AGI32 photometric modeling software. A representative model of the parking space, sidewalk, and building was built to the dimensions shown in Table 62 and Figure 30.

Table 62: Parking Lot Geometry Assumptions

Model Dimensions	Value
Curb-to-curb width	60 ft and 120 ft
Sidewalk width	5 ft
Grass width	6 ft
Building floor height	9.5 ft
Building floors	6

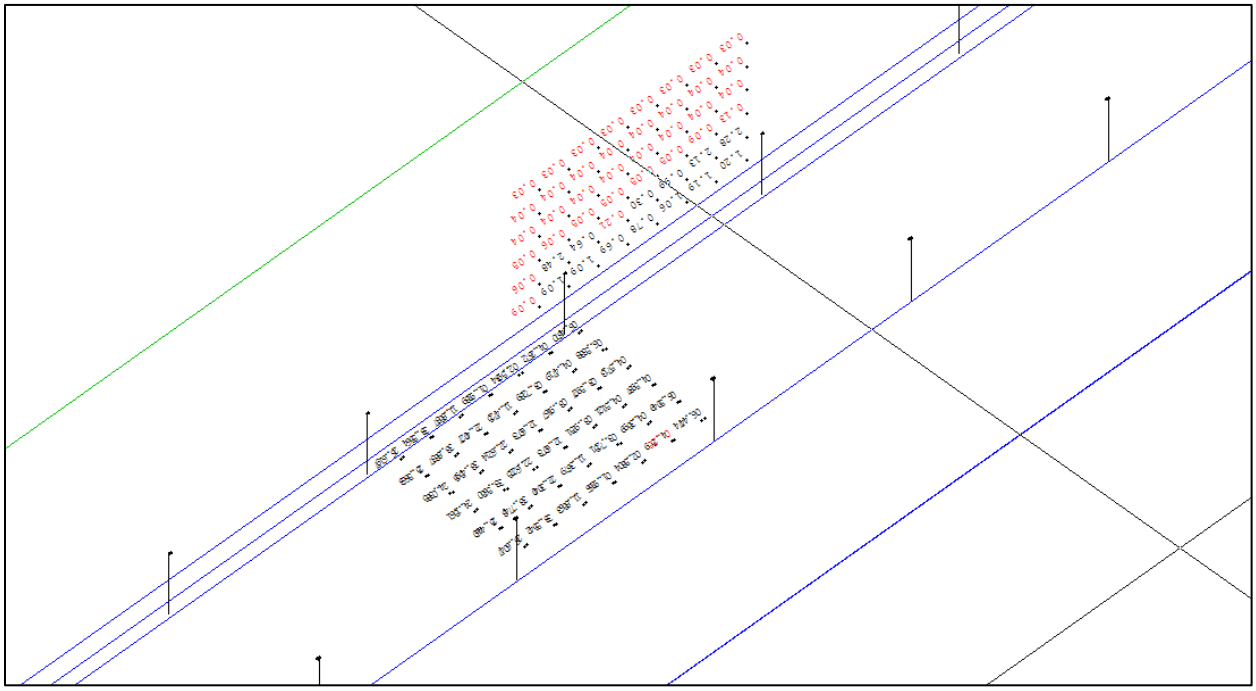

Figure 30: Parking space calculation model.

Five columns of pole fixtures were placed in the parking lot. The fixtures were placed using IES photometric files from a variety of manufacturers. The following fixture information was recorded:

- BUG G-Rating
- Luminaire manufacturer (using anonymized coding)
- Distribution Type
- Wattage
- Total Light Loss Factor (LLF), the product of two variables:
    - Lamp Lumen Depreciation (LLD)
    - Luminaire Dirt Depreciation (LDD)

The following lighting fixture characteristics were modified to create 184 unique cases:

- Fixture model
- Pole position

    - Center of the parking lot
    - Two rows: Center of the parking lot, and edge of the parking lot
- Fixture head configuration
    - One head
    - Two heads, back to back
- Pole height
    - 20 feet
    - 25 feet
    - 30 feet
    - 35 feet

Two calculation grids were placed in the model. One grid was placed on the parking lot, and one grid was placed on the adjacent building. The calculation grids were built using the following dimensions in Table 63 and Table 64.

Table 63: Parking Lot Calculation Grid Values

Parking Lot Grid Dimensions	Value
Left-to-right point spacing	5 ft
Top-to-bottom point spacing	4 ft
Left-to-right length	150 ft
Top-to-bottom width	12 ft

Table 64: Parking Lot Building Calculation Grid Values

Building Grid Dimensions	Value
Left-to-right point spacing	12 ft
Top-to-bottom point spacing	9.5 ft
Left-to-right length	84 ft
Top-to-bottom height	52 ft
Number of rows	6

Criteria for minimum allowable brightness and uniformity in the parking lot were established based on the IES recommended practices as detailed in the 10th Edition Handbook and the parking lot's calculation grid was used to determine when the criteria were met. The grid targeted the criteria as shown in Table 65.

Table 65: Parking Lot Calculation Design Criteria

Parking Lot Measurements	Criteria
Horizontal minimum illuminance	Minimum 0.5 fc
Vertical minimum illuminance	Minimum 0.25 fc
Horizontal maximum to minimum illuminance ratio	Maximum 15:1
Horizontal average to minimum illuminance ratio	Maximum 4:1

Once each unique case was built, pole-to-pole spacing was modified to find the maximum possible distance between poles while meeting the parking lot calculation grid's criteria. If the criteria could not be met with one row at the parking lot's edge at a minimum pole spacing of 50 feet, a second row would be added at the parking lot's center. If the criteria could not be met with two rows, the case would be considered not applicable.

Once the pole-to-pole spacing was found for each case, the building grid was used to measure lighting trespass into the adjacent building. Maximum vertical illuminance was measured and recoded for each floor of the building, represented by a row in the building's calculation grid.

Pedestrian Space Calculations

Pedestrian space calculations were performed using the same methodology as the parking lot calculations, with modified dimensions and criteria as shown in Table 66 and Figure 31

Table 66: Pedestrian Space Calculation Geometry Assumptions

Model Dimensions	Value
Curb-to-curb width	30 ft
Grass width	6 ft
Building floor height	9.5 ft
Building floors	6

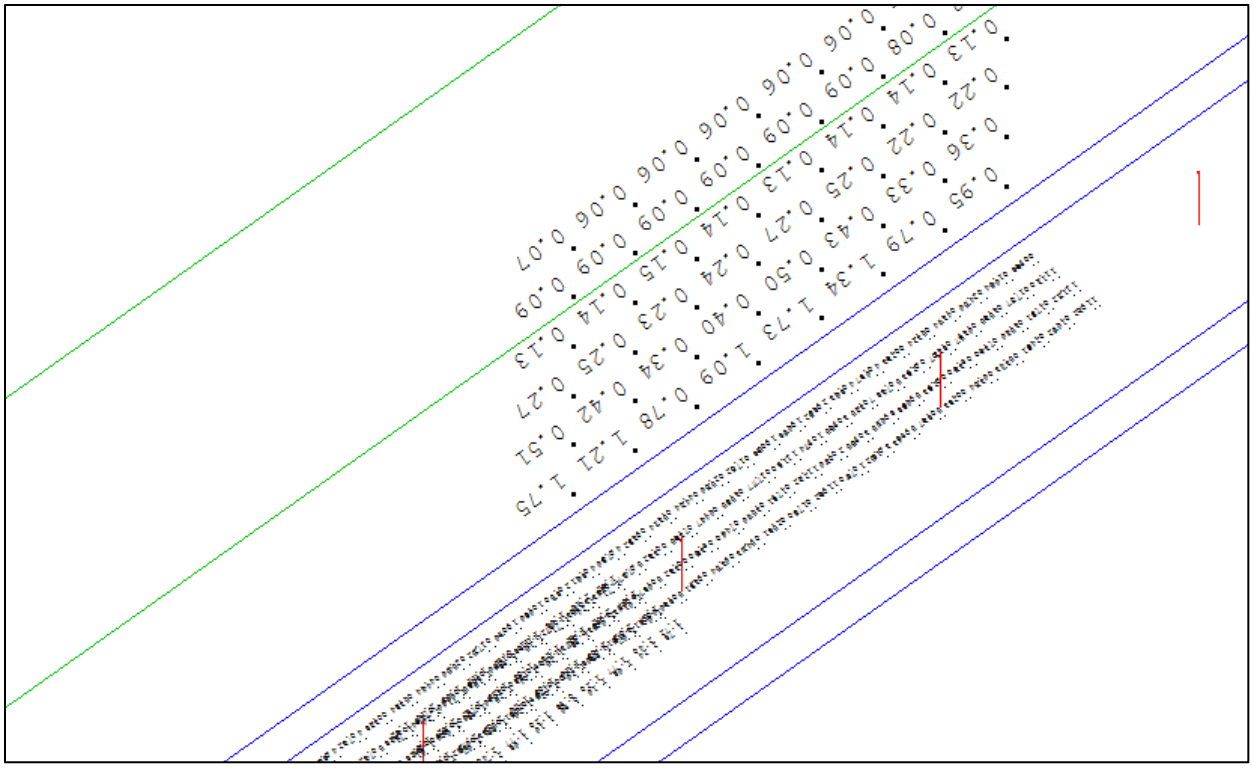

Figure 31: Pedestrian space calculation model.

The following lighting fixture characteristics were modified to create 123 unique cases:

- Fixture model
- Pole position
  - Center of the parking lot
  - Five feet inside the parking lot
- Fixture head configuration
  - One head
  - Two heads, back-to-back
- Pole height
  - 10 feet
  - 14 feet
  - 18 feet

Two calculation grids were placed in the model. One grid was placed on the parking lot, and one grid was placed on the adjacent building. The calculation grids were built using the following dimensions in Table 67 and Table 68.

Table 67: Pedestrian Space Calculation Grid Values

Plaza Grid Dimensions	Value
Left-to-right point spacing	5 ft
Top-to-bottom point spacing	4 ft
Left-to-right length	150 ft
Top-to-bottom width	12 ft

Table 68: Pedestrian Space Building Calculation Grid Values

Building Grid Dimensions	Value
Left-to-right point spacing	12 ft
Top-to-bottom point spacing	9.5 ft
Left-to-right length	84 ft
Top-to-bottom height	52 ft
Number of rows	6

Multifamily Calculation Goals

The final goal of this Final CASE Report was to create limits for outdoor lighting that are appropriate for circumstances and conditions associated with the residential nature of multifamily buildings. These calculations support the goal of the Final CASE Report by informing development of new general hardscape and entry LPA calculations in the existing Nonresidential Table 140.7-A and B of Title 24, Part 6. Based on the illumination levels at the windows of residential units generated by various mounting height and real luminaire specifications, the Statewide CASE Team will revise Table 140.7-A and B with new general hardscape and building entry LPAs.

Light and Health and Calculations Connection

One of the benefits of lower LPAs other than energy savings is the lower impact it has on human health. Recent research outlined in Appendix G explains the impact outdoor lighting at night can have on sleep. Light can have a significant impact on melatonin suppression and circadian rhythms which diminishes sleep quality, subjective sleepiness, and increases alertness. This issue is exacerbated by the increased use of LED lighting in outdoor lighting applications which has a higher proportion of emission in the blue light spectrum than traditional CFL or incandescent luminaires.

Researchers have proposed acceptable levels of illuminance in residential units to minimize the impact of light on circadian rhythms (McIntyre 1989), (Brainard 1988), (Zeitzer 2000), and (Phipps Nelson 2010). The intent of the calculations is to target these levels of illuminance while also ensuring adequate lighting is provided to exterior

spaces such as parking lots and building entry areas. The calculations will inform what realistic configurations achieve both goals in a cost-effective manner.

Multifamily Calculation Results

Based on the calculation procedures as detailed in this appendix, the following tables of calculation results present the overall lighting power density calculated through the scenarios that were set up to test the performance of modern outdoor LED luminaires.

Figure 32 below shows the trends of the parking lot and pedestrian zone calculations for effective lighting power density and luminaire wattage. There are clear differences in the trendlines for these two categories. The current infrastructure of the outdoor lighting LPA tables effectively relies on the more stringent (higher lighting power density) condition for both of these categories because they are both considered general hardscape. As a check against the proposed LPA values in the code, these graphs provide some good context, but not specifically for the Lighting Zones, which ultimately control what is permissible in the state.

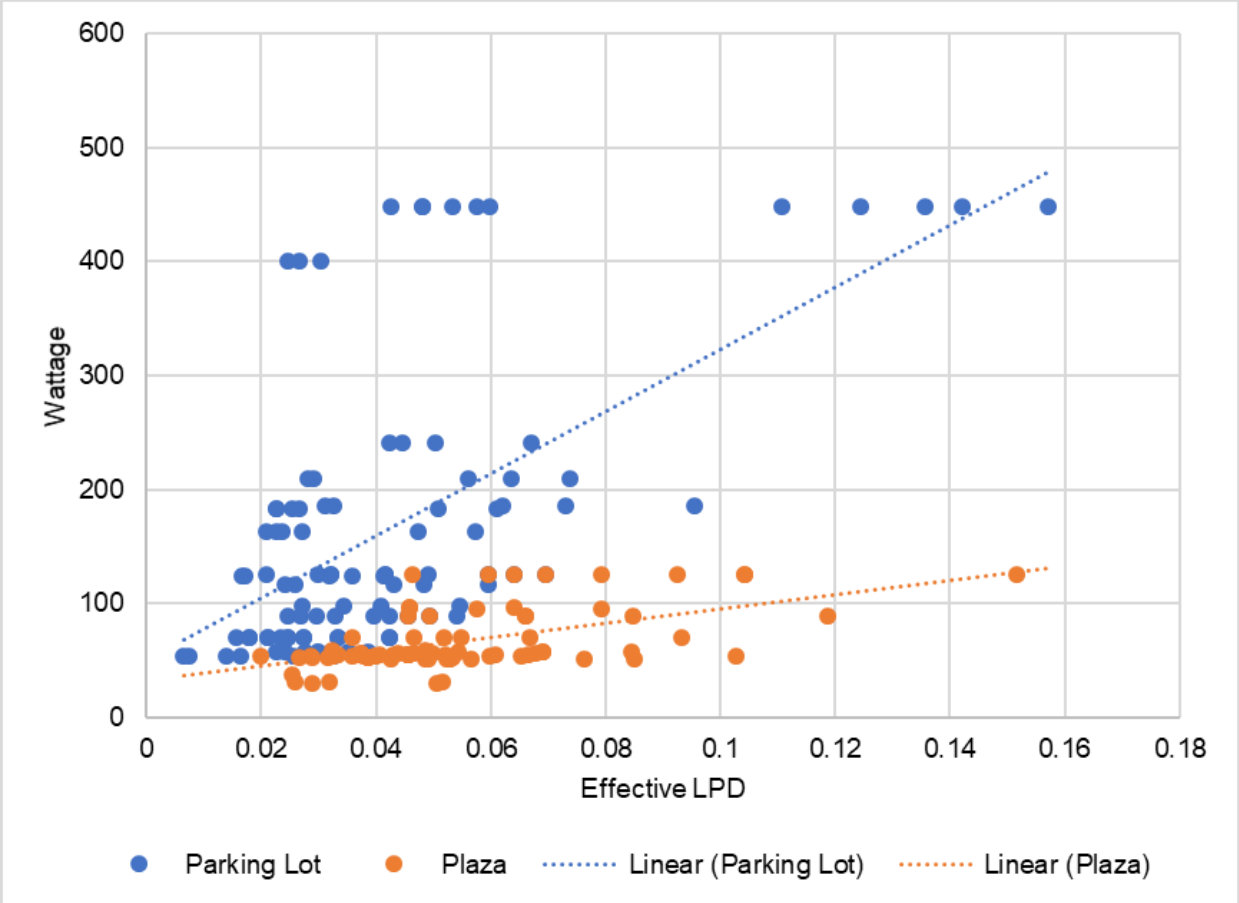

Figure 32: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios.

Figure 33 below provides the same information with color coding for the Lighting Zone Uplight and Glare (UG) rating that each luminaire meets. Note that these results do not imply that these products can be applied on any location on the property (there are additional restrictions for Backlight when near the property boundary), but the lighting products should be applicable for much of the site without restriction.

The results indicate that there is a wide range of eLPD that the lighting systems may produce for any given circumstance, but clearly, some of these are not optimized and are not necessarily given the same weighting as the cluster of lighting products that are capable of efficiently meeting the lighting criteria as detailed by the Illumination Engineering Society.

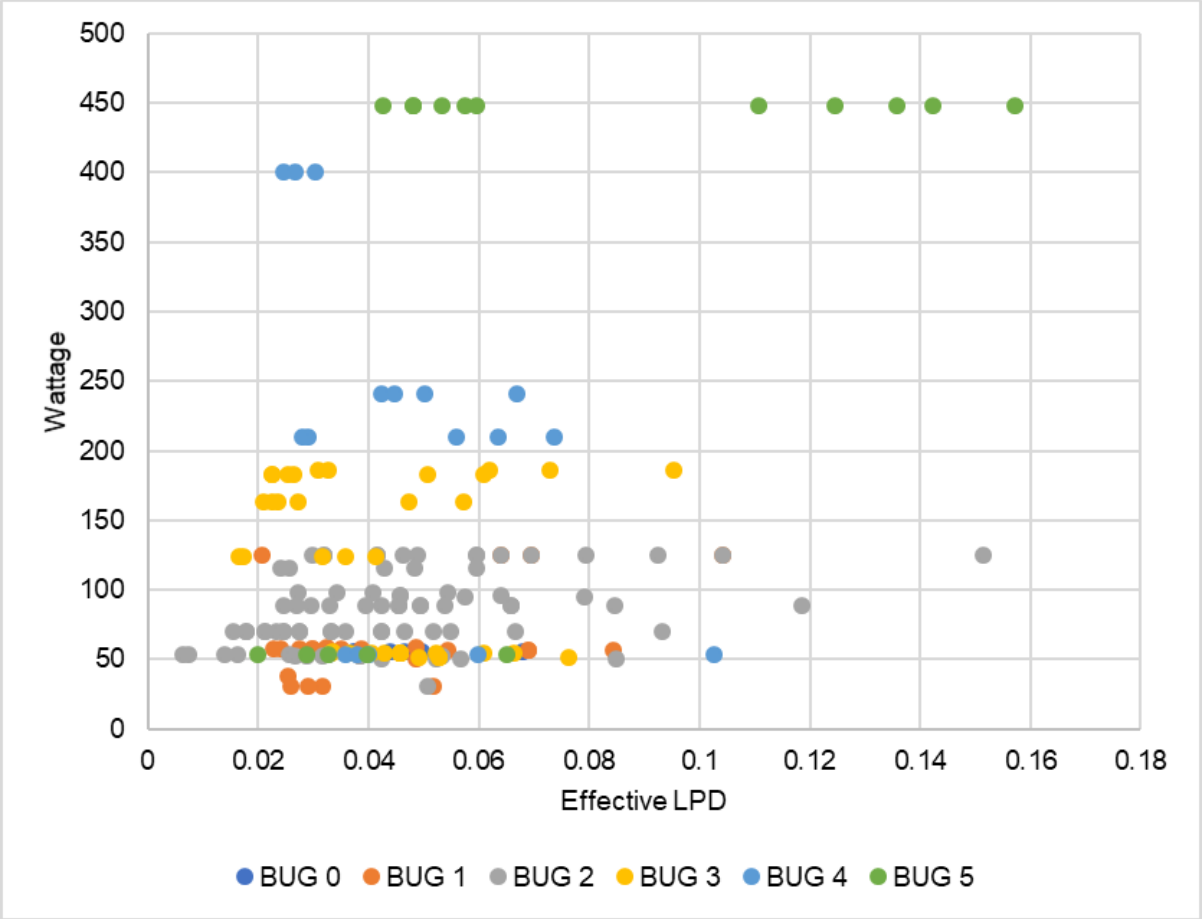

Figure 33: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios with lighting zone differentiation.

Similarly, Figure 34 below provides the same information with color coding for the mounting height of the luminaires as part of the calculations. The results also indicate that there is a range of eLPD that the lighting systems may produce based on mounting height. Again, some of these are not optimized and are not necessarily given the same

weighting as the cluster of lighting products that are capable of efficiently meeting the lighting criteria as detailed by the Illumination Engineering Society.

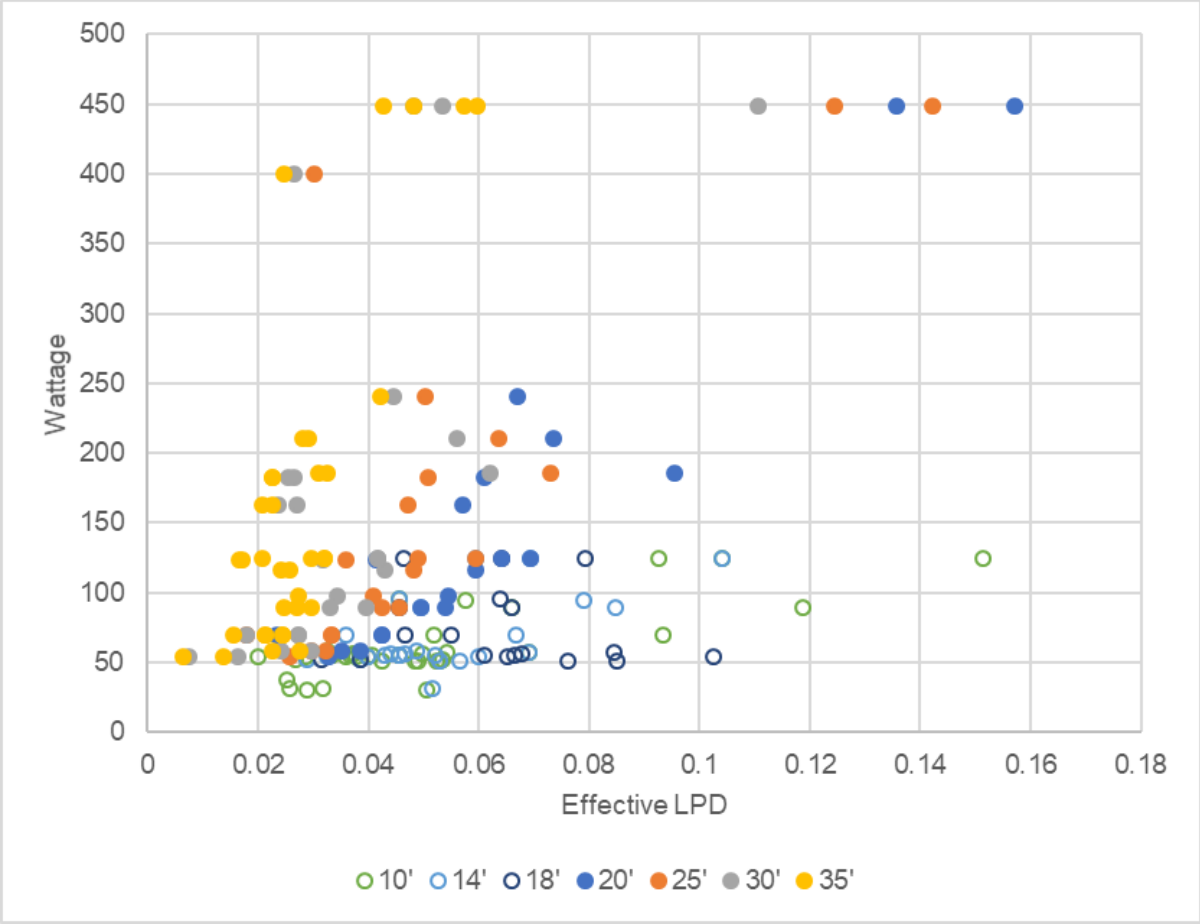

Figure 34: Calculation results graph: wattage vs. eLPD for parking lot and plaza scenarios with mounting height differentiation

The following group of tables provide the calculation results for each individual scenario that produce the results graphs above. Table 69 through Table 74 shows the results for the Parking Lot calculations. Table 75 through Table 78 shows the results for the Plaza calculations.

These tables show all the permutations of parking lot or plaza pole spacing scenarios for a given luminaire and not all of these are possible to achieve the desired design criteria. In some examples, the results FAIL to achieve criteria and for a variety of reasons. Those reasons are detailed in the “Notes” column just to the right of the center, and in these circumstances, no results are shown in the yellow criteria columns to the right.

In the circumstances where the luminaire (wattage, pole mounting height, and head configuration, etc.) is able to meet criteria, the results columns will show the results for

each particular criterion and the one highlighted in yellow will be the criterion that failed first, so it represents the “controlling criterion”.

If there is a design that is fairly well optimized for the space geometry and design criteria, more than one criterion will likely be on the verge of failing, so there may be sites where more than one column of criterion is shown in yellow. That is an indication that the luminaire was well suited for the circumstances of the site geometry to meet the design criteria efficiently without over-lighting.

Note, the following calculation tables are also available via excel spreadsheet, please send a request to info@title24stakeholders.com.

Table 69: Calculation Results – Parking Lot, Pt. 1

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total LL	Watt.	Q'tv	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
125	Parking Lot, 60' wide	20'	Opposite side poles	2	A	V	0.756	95	1	N/A - Min Vert of 0.1 @ 50' Pole-Pole		120							
126	Parking Lot, 60' wide	25'	Opposite side poles	2	A	V	0.756	95	1	N/A - Min Vert of 0.13 @ 50' Pole-Pole		120							
127	Parking Lot, 60' wide	30'	Opposite side poles	2	A	V	0.756	95	1	N/A - Min Vert of 0.15 @ 50' Pole-Pole		120							
128	Parking Lot, 60' wide	35'	Opposite side poles	2	A	V	0.756	95	1	N/A - Min Vert of 0.15 @ 50' Pole-Pole		120							
289	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	70	1		50	60	2.09	0.38		1.70	0.02	0.92	1.12
290	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	70	1		65	60	1.77	0.25		1.55	0.02	0.71	0.87
291	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	70	1		65	60	1.50	0.34		1.71	0.02	0.87	1.06
292	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	70	1		75	60	1.28	0.30		1.66	0.02	0.88	1.07
293	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	70	2	N/A - Min Vert of 0.02 @ 50' Pole-Pole		120							
294	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	70	2	N/A - Min Vert of 0.06 @ 50' Pole-Pole		120							
295	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	70	2	N/A - Min Vert of 0.18 @ 50' Pole-Pole		120							
296	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	70	2		55	120	0.68	0.27		2.62	0.02	0.75	0.92
297	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.801	116	2		65	60	2.45	0.46		2.16	0.06	1.61	2.01
298	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.801	116	2		80	60	1.26	0.25		2.95	0.05	2.48	3.10
299	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.801	116	2		90	60	1.31	0.31		2.29	0.04	2.15	2.68
300	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.801	116	1		75	60	0.67	0.28		2.70	0.03	2.26	2.82
301	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.801	116	2	N/A - Horiz Avg:Min >4		120							
302	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.801	116	2	N/A - Horiz Avg:Min >4		120							
303	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.801	116	2	N/A - Horiz. Avg:Min of 5.39 from 50'-		120							
304	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.801	116	2		80	120	0.70	0.28		3.31	0.02	0.89	1.11
313	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.862	54	2		55	60	1.40	0.30		2.24	0.03	0.70	0.81
314	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.862	54	2		70	60	1.56	0.25		1.57	0.03	0.58	0.67
315	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.862	54	1		55	60	0.57	0.28		2.25	0.02	0.32	0.37
316	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.862	54	1		65	60	0.66	0.27		1.52	0.01	0.31	0.36
317	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.862	54	1	N/A - Min Vert of 0.14 @ 50' Pole-Pole		120							
318	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.862	54	1	N/A - Min Vert of 0.22 @ 50' Pole-Pole		120							
319	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.862	54	1		60	120	0.58	0.27		2.21	0.01	0.71	0.82
320	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.862	54	1		70	120	0.69	0.25		1.46	0.01	0.84	0.97
333	Parking Lot, 60' wide	20'	Opposite side poles	2	D	V	0.862	74	1	N/A - Min Vert = 0.1 @ 50' Pole-Pole		120							
334	Parking Lot, 60' wide	25'	Opposite side poles	2	D	V	0.862	74	1	N/A - Min Vert = 0.15 @ 50' Pole-Pole		120							
335	Parking Lot, 60' wide	30'	Opposite side poles	2	D	V	0.862	74	1	N/A - Min Vert = 0.22 @ 50' Pole-Pole		120							
336	Parking Lot, 60' wide	35'	Opposite side poles	2	D	V	0.862	74	1	N/A - Min Vert = 0.23 @ 50' Pole-Pole		120							

Table 70: Calculation Results – Parking Lot, Pt. 2

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total Lu	Watt.	Q'ty	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
337	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	70	2		55	60	1.40	0.30		2.24	0.04	0.70	0.85
338	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	70	2		70	60	1.56	0.25		1.57	0.03	0.58	0.71
339	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	70	2		85	60	1.32	0.27		1.42	0.03	0.50	0.61
340	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	70	2		95	60	1.06	0.26		1.48	0.02	0.50	0.61
341	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
342	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
343	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
344	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	70	2		55	120	0.68	0.27		2.62	0.02	0.75	0.92
369	Parking Lot, 60' wide	20'	Near-side poles	1	D	III	0.819	58	2		55	60	1.07	0.26		2.30	0.04	0.58	0.71
370	Parking Lot, 60' wide	25'	Near-side poles	1	D	III	0.819	58	2		65	60	1.36	0.33		1.51	0.03	0.56	0.68
371	Parking Lot, 60' wide	30'	Near-side poles	1	D	III	0.819	58	2		80	60	1.07	0.25		1.45	0.02	0.52	0.63
372	Parking Lot, 60' wide	35'	Near-side poles	1	D	III	0.819	58	2		85	60	0.95	0.29		1.46	0.02	0.55	0.67
373	Parking Lot, 60' wide	20'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
374	Parking Lot, 60' wide	25'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
375	Parking Lot, 60' wide	30'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
376	Parking Lot, 60' wide	35'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
377	Parking Lot, 60' wide	20'	Near-side poles	1	D	III	0.819	58	2		50	60	1.60	0.29		1.70	0.04	0.70	0.85
378	Parking Lot, 60' wide	25'	Near-side poles	1	D	III	0.819	58	2		60	60	1.55	0.26		1.45	0.03	0.59	0.72
379	Parking Lot, 60' wide	30'	Near-side poles	1	D	III	0.819	58	2		65	60	1.15	0.26		1.71	0.03	0.66	0.81
380	Parking Lot, 60' wide	35'	Near-side poles	1	D	III	0.819	58	2		70	60	1.05	0.27		1.65	0.03	0.72	0.88
381	Parking Lot, 60' wide	20'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
382	Parking Lot, 60' wide	25'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
383	Parking Lot, 60' wide	30'	Opposite side poles	1	D	III	0.819	58	2	N/A - Horiz. Avg:Min >4, Min Vert <0.2		120							
384	Parking Lot, 60' wide	35'	Opposite side poles	1	D	III	0.819	58	2	N/A - Min Vert = 0.24 @ 50' Pole-Pole		120							
401	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	70	2		55	60	1.40	0.30		2.24	0.04	0.70	0.85
402	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	70	2		70	60	1.56	0.25		1.57	0.03	0.58	0.71
403	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	70	2		85	60	1.32	0.27		1.42	0.03	0.50	0.61
404	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	70	2		95	60	1.06	0.26		1.48	0.02	0.50	0.61
405	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz Avg:Min >4 and Min Vert <		120							
406	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz Avg:Min >4 and Min Vert <		120							
407	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz Avg:Min >4 and Min Vert <		120							
408	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	70	2	N/A - Horiz. Avg:Min of 4.16 and Min V		120							

Table 71: Calculation Results – Parking Lot, Pt. 3

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total LL	Watt.	Q'ty	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
409	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	89	2		60	60	1.50	0.26		2.37	0.05	0.77	0.94
410	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	89	2		70	60	1.92	0.30		1.56	0.04	0.71	0.87
411	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	89	2		90	60	1.45	0.28		1.46	0.03	0.62	0.76
412	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	89	2		100	60	1.22	0.27		1.49	0.03	0.58	0.71
413	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	89	2	N/A - Horiz. Avg:Min >4		120							
414	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	89	2	N/A - Horiz. Avg:Min >4		120							
415	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	89	2	N/A - Horiz. Avg:Min >4		120							
416	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	89	2	N/A - Horiz. Avg:Min of 4.02 @ 60'		120							
417	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	89	2		55	60	2.39	0.44		1.82	0.05	1.22	1.49
418	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	89	2		65	60	2.12	0.31		1.59	0.05	0.88	1.07
419	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	89	2		75	60	1.65	0.27		1.67	0.04	1.09	1.33
420	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	89	1		55	60	0.78	0.29		2.24	0.03	0.88	1.07
421	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	89	2	N/A - Vert Min of 0.03 @ 50' Pole-Pole		120							
422	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	89	2	N/A - Vert Min of 0.08 @ 50' Pole-Pole		120							
423	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	89	2	N/A - Vert Min of 0.21 @ 50' Pole-Pole		120							
424	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	89	2		60	120	0.76	0.26		2.67	0.02	0.84	1.03
433	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	98	2		60	60	1.68	0.28		2.49	0.05	0.93	1.14
434	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	98	2		80	60	1.67	0.26		1.80	0.04	0.70	0.85
435	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	98	2		95	60	1.53	0.27		1.52	0.03	0.71	0.87
436	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	98	1		60	60	0.51	0.26		3.69	0.03	0.84	1.03
437	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	98	2	N/A - Horiz. Avg:Min >4		120							
438	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	98	2	N/A - Horiz. Avg:Min >4		120							
439	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	98	2	N/A - Horiz. Avg:Min >4		120							
440	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	98	2	N/A - Horiz. Avg:Min of 4.33 from 50'-7		120							
441	Parking Lot, 60' wide	20'	Near-side poles	5	D	III	0.819	570	2		65	60	7.62	0.61		3.09	0.29	15.03	18.35
442	Parking Lot, 60' wide	25'	Near-side poles	5	D	III	0.819	570	2		90	60	3.62	0.34		3.90	0.21	11.28	13.77
443	Parking Lot, 60' wide	30'	Near-side poles	5	D	III	0.819	570	2		110	60	3.22	0.34		3.38	0.17	9.82	11.99
444	Parking Lot, 60' wide	35'	Near-side poles	5	D	III	0.819	570	1		110	60	1.75	0.27		3.08	0.09	10.53	12.86
445	Parking Lot, 60' wide	20'	Opposite side poles	5	D	III	0.819	570	2	N/A - Horiz. Avg:Min >4		120							
446	Parking Lot, 60' wide	25'	Opposite side poles	5	D	III	0.819	570	2	N/A - Horiz. Avg:Min >4		120							
447	Parking Lot, 60' wide	30'	Opposite side poles	5	D	III	0.819	570	2	N/A - Horiz. Avg:Min >4		120							
448	Parking Lot, 60' wide	35'	Opposite side poles	5	D	III	0.819	570	2		120	120	1.83	0.28		3.49	0.08	2.11	2.58

Table 72: Calculation Results – Parking Lot, Pt. 4

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total LL	Watt.	Q'ty	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
449	Parking Lot, 60' wide	20'	Near-side poles	5	C	III	0.81	448	2		110	60	2.39	0.32		3.59	0.14	2.79	3.44
450	Parking Lot, 60' wide	25'	Near-side poles	5	C	III	0.81	448	2		120	60	2.60	0.26		2.77	0.12	2.76	3.41
451	Parking Lot, 60' wide	30'	Near-side poles	5	C	III	0.81	448	2		135	60	3.21	0.25		2.00	0.11	2.84	3.51
452	Parking Lot, 60' wide	35'	Near-side poles	5	C	III	0.81	448	1		125	60	1.13	0.30		2.99	0.06	2.47	3.05
453	Parking Lot, 60' wide	20'	Opposite side poles	5	C	III	0.81	448	2	N/A - Horiz. Avg:Min >4		120							
454	Parking Lot, 60' wide	25'	Opposite side poles	5	C	III	0.81	448	2	N/A - Horiz. Avg:Min >4		120							
455	Parking Lot, 60' wide	30'	Opposite side poles	5	C	III	0.81	448	2	N/A - Horiz. Avg:Min >4		120							
456	Parking Lot, 60' wide	35'	Opposite side poles	5	C	III	0.81	448	2		130	120	1.30	0.27		2.88	0.06	1.92	2.37
457	Parking Lot, 60' wide	20'	Near-side poles	5	V	III	0.815	448	2		95	60	1.40	0.25		3.14	0.16	5.91	7.25
458	Parking Lot, 60' wide	25'	Near-side poles	5	V	III	0.815	448	2		105	60	1.99	0.28		2.00	0.14	3.50	4.29
459	Parking Lot, 60' wide	30'	Near-side poles	5	V	III	0.815	448	1		140	60	0.94	0.25		3.32	0.05	8.14	9.98
460	Parking Lot, 60' wide	35'	Near-side poles	5	V	III	0.815	448	1		155	60	2.32	0.27		2.32	0.05	3.40	4.17
461	Parking Lot, 60' wide	20'	Opposite side poles	5	V	III	0.815	448	2	N/A - Horiz. Avg:Min >4		120							
462	Parking Lot, 60' wide	25'	Opposite side poles	5	V	III	0.815	448	2	N/A - Horiz. Avg:Min >4		120							
463	Parking Lot, 60' wide	30'	Opposite side poles	5	V	III	0.815	448	2		155	120	0.94	0.28		3.81	0.05	1.33	1.63
464	Parking Lot, 60' wide	35'	Opposite side poles	5	V	III	0.815	448	2		175	120	1.16	0.26		2.71	0.04	1.81	2.22
469	Parking Lot, 60' wide	20'	Opposite side poles	4	D	V	0.819	400	1	N/A - Horiz. Avg:Min >4		120							
470	Parking Lot, 60' wide	25'	Opposite side poles	4	D	V	0.819	400	1		110	120	0.84	0.26		3.01	0.03	1.61	1.97
471	Parking Lot, 60' wide	30'	Opposite side poles	4	D	V	0.819	400	1		125	120	0.95	0.26		2.19	0.03	1.83	2.23
472	Parking Lot, 60' wide	35'	Opposite side poles	4	D	V	0.819	400	1		135	120	0.94	0.27		1.90	0.02	1.84	2.25
477	Parking Lot, 60' wide	20'	Opposite side poles	4	V	III	0.815	241	2	N/A - Horiz. Avg:Min >4	60	120					0.07		
478	Parking Lot, 60' wide	25'	Opposite side poles	4	V	III	0.815	241	2		80	120	1.09	0.26		3.48	0.05	1.94	2.38
479	Parking Lot, 60' wide	30'	Opposite side poles	4	V	III	0.815	241	2		90	120	1.52	0.26		2.01	0.04	2.77	3.40
480	Parking Lot, 60' wide	35'	Opposite side poles	4	V	III	0.815	241	2		95	120	1.63	0.27		1.65	0.04	2.90	3.56
481	Parking Lot, 60' wide	20'	Near-side poles	4	C	III	0.81	210	2		95	60	2.45	0.28		2.93	0.07	2.52	3.11
482	Parking Lot, 60' wide	25'	Near-side poles	4	C	III	0.81	210	2		110	60	3.20	0.26		1.94	0.06	2.14	2.64
483	Parking Lot, 60' wide	30'	Near-side poles	4	C	III	0.81	210	2		125	60	3.25	0.29		1.66	0.06	2.21	2.73
484	Parking Lot, 60' wide	35'	Near-side poles	4	C	III	0.81	210	1		120	60	0.91	0.28		3.00	0.03	1.92	2.37
485	Parking Lot, 60' wide	20'	Opposite side poles	4	C	III	0.81	210	2	N/A - Horiz. Avg:Min >4		120							
486	Parking Lot, 60' wide	25'	Opposite side poles	4	C	III	0.81	210	2	N/A - Horiz. Avg:Min >4		120							
487	Parking Lot, 60' wide	30'	Opposite side poles	4	C	III	0.81	210	2	N/A - Horiz. Avg:Min >4		120							
488	Parking Lot, 60' wide	35'	Opposite side poles	4	C	III	0.81	210	2		125	120	1.03	0.26		2.94	0.03	1.56	1.93

Table 73: Calculation Results – Parking Lot, Pt. 5

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total Ll	Watt.	Q'ty	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
489	Parking Lot, 60' wide	20'	Near-side poles	3	D	III	0.801	186	2		65	60	1.72	0.25		2.83	0.10	1.00	1.25
490	Parking Lot, 60' wide	25'	Near-side poles	3	D	III	0.801	186	2		85	60	1.80	0.27		1.79	0.07	0.79	0.99
491	Parking Lot, 60' wide	30'	Near-side poles	3	D	III	0.801	186	2		100	60	1.67	0.27		1.57	0.06	0.98	1.22
492	Parking Lot, 60' wide	35'	Near-side poles	3	D	III	0.801	186	1		95	60	0.86	0.26		2.64	0.03	3.77	4.71
493	Parking Lot, 60' wide	20'	Opposite side poles	3	D	III	0.801	186	2	N/A - Horiz. Avg:Min >4		120							
494	Parking Lot, 60' wide	25'	Opposite side poles	3	D	III	0.801	186	2	N/A - Horiz. Avg:Min >4		120							
495	Parking Lot, 60' wide	30'	Opposite side poles	3	D	III	0.801	186	2	N/A - Horiz. Avg:Min >4		120							
496	Parking Lot, 60' wide	35'	Opposite side poles	3	D	III	0.801	186	2		100	120	0.94	0.27		3.00	0.03	1.18	1.47
497	Parking Lot, 60' wide	20'	Near-side poles	3	W	III	0.792	183	2		100	60	1.54	0.27		2.32	0.06	1.00	1.26
498	Parking Lot, 60' wide	25'	Near-side poles	3	W	III	0.792	183	2		120	60	1.32	0.27		2.29	0.05	0.99	1.25
499	Parking Lot, 60' wide	30'	Near-side poles	3	W	III	0.792	183	1		115	60	0.60	0.28		2.52	0.03	0.97	1.22
500	Parking Lot, 60' wide	35'	Near-side poles	3	W	III	0.792	183	1		135	60	0.74	0.26		1.65	0.02	0.87	1.10
501	Parking Lot, 60' wide	20'	Opposite side poles	3	W	III	0.792	183	2	N/A - Horiz. Avg:Min >4		120							
502	Parking Lot, 60' wide	25'	Opposite side poles	3	W	III	0.792	183	2	N/A - Horiz. Avg:Min >4		120							
503	Parking Lot, 60' wide	30'	Opposite side poles	3	W	III	0.792	183	2		120	120	0.68	0.25		2.60	0.03	0.68	0.86
504	Parking Lot, 60' wide	35'	Opposite side poles	3	W	III	0.792	183	2		135	120	0.82	0.27		1.84	0.02	1.14	1.44
505	Parking Lot, 60' wide	20'	Near-side poles	3	V	III	0.815	163	2		95	60	1.70	0.28		2.09	0.06	3.55	4.35
506	Parking Lot, 60' wide	25'	Near-side poles	3	V	III	0.815	163	2		115	60	1.49	0.26		1.97	0.05	1.09	1.34
507	Parking Lot, 60' wide	30'	Near-side poles	3	V	III	0.815	163	1		100	60	0.52	0.28		3.25	0.03	3.16	3.88
508	Parking Lot, 60' wide	35'	Near-side poles	3	V	III	0.815	163	1		120	60	0.69	0.27		1.91	0.02	1.32	1.62
509	Parking Lot, 60' wide	20'	Opposite side poles	3	V	III	0.815	163	2	N/A - Horiz. Avg:Min >4		120							
510	Parking Lot, 60' wide	25'	Opposite side poles	3	V	III	0.815	163	2	N/A - Horiz. Avg:Min >4		120							
511	Parking Lot, 60' wide	30'	Opposite side poles	3	V	III	0.815	163	2		115	120	0.61	0.27		2.90	0.02	0.73	0.90
512	Parking Lot, 60' wide	35'	Opposite side poles	3	V	III	0.815	163	2		130	120	0.76	0.28		1.97	0.02	0.96	1.18
513	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	125	2		65	60	1.72	0.25		2.83	0.06	1.00	1.22
514	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	125	2		85	60	1.80	0.27		1.79	0.05	0.79	0.96
515	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	125	2		100	60	1.67	0.27		1.57	0.04	0.98	1.20
516	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	125	1		65	60	0.56	0.29		3.66	0.03	0.93	1.14
517	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
518	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
519	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
520	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							

Table 74: Calculation Results – Parking Lot, Pt. 6

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lum. Man	Dist. Typ	Total LL	Watt.	Q'ty	Notes	Pole-Pole Spacin	Curb-Curb Spacin	.5	.25	15:1	4:1	Eff. LP	MAX Ve	Initial MAX Ve
521	Parking Lot, 60' wide	20'	Near-side poles	2	D	III	0.819	125	2		60	60	2.46	0.34		2.26	0.07	1.02	1.25
522	Parking Lot, 60' wide	25'	Near-side poles	2	D	III	0.819	125	2		70	60	2.25	0.25		1.95	0.06	1.28	1.56
523	Parking Lot, 60' wide	30'	Near-side poles	2	D	III	0.819	125	1		50	60	0.77	0.29		3.69	0.04	1.38	1.68
524	Parking Lot, 60' wide	35'	Near-side poles	2	D	III	0.819	125	1		65	60	0.93	0.28		2.24	0.03	1.20	1.47
525	Parking Lot, 60' wide	20'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
526	Parking Lot, 60' wide	25'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
527	Parking Lot, 60' wide	30'	Opposite side poles	2	D	III	0.819	125	2	N/A - Horiz. Avg:Min >4		120							
528	Parking Lot, 60' wide	35'	Opposite side poles	2	D	III	0.819	125	2		70	120	0.93	0.25		2.56	0.03	1.06	1.29
529	Parking Lot, 60' wide	20'	Opposite side poles	1	V	V	0.815	125	1	N/A - Horiz. Avg:Min >4		120							
530	Parking Lot, 60' wide	25'	Opposite side poles	1	V	V	0.815	125	1	N/A - Horiz. Avg:Min >4		120							
531	Parking Lot, 60' wide	30'	Opposite side poles	1	V	V	0.815	125	1	N/A - Horiz. Avg:Min >4		120							
532	Parking Lot, 60' wide	35'	Opposite side poles	1	V	V	0.815	125	1		50	120	0.59	0.26		3.15	0.02	0.38	0.47
533	Parking Lot, 60' wide	20'	Near-side poles	3	C	III	0.855	124	2		100	60	1.34	0.28		2.99	0.04	0.83	0.97
534	Parking Lot, 60' wide	25'	Near-side poles	3	C	III	0.855	124	2		115	60	1.60	0.28		2.20	0.04	0.57	0.67
535	Parking Lot, 60' wide	30'	Near-side poles	3	C	III	0.855	124	2		130	60	1.94	0.28		1.78	0.03	0.72	0.84
536	Parking Lot, 60' wide	35'	Near-side poles	3	C	III	0.855	124	1		120	60	0.06	0.29		2.69	0.02	0.38	0.44
537	Parking Lot, 60' wide	20'	Opposite side poles	3	C	III	0.855	124	2	N/A - Horiz. Avg:Min >4		120							
538	Parking Lot, 60' wide	25'	Opposite side poles	3	C	III	0.855	124	2	N/A - Horiz. Avg:Min >4		120							
539	Parking Lot, 60' wide	30'	Opposite side poles	3	C	III	0.855	124	2	N/A - Horiz. Avg:Min >4		120							
540	Parking Lot, 60' wide	35'	Opposite side poles	3	C	III	0.855	124	2		125	120	0.65	0.29		2.78	0.02	0.56	0.65
473	Parking Lot, 60' wide	20'	Near-side poles	4	V	III	0.815	241	2		65	60	1.58	0.30		3.78	0.12	44.86	55.02
474	Parking Lot, 60' wide	25'	Near-side poles	4	V	III	0.815	241	2		80	60	1.75	0.29		2.46	0.10	13.76	16.88
475	Parking Lot, 60' wide	30'	Near-side poles	4	V	III	0.815	241	1		75	60	0.67	0.28		3.16	0.05	34.90	42.80
476	Parking Lot, 60' wide	35'	Near-side poles	4	V	III	0.815	241	1		85	60	0.69	0.30		2.36	0.05	19.72	24.18

Table 75: Calculation Results – Plaza, Pt. 1

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lumina ire Man	Distrib ution Typ	Total LL	Watt a	Q'ty	Notes	Pole-Pole Spacin	Plaza widtl	0.6	2	4:1	5:1	Eff. LP	MAX Ve	Initial MAX Ve
912	Plaza, 30' wide	10'	Single row, middle	2	A	V	0.756	95	1		55	30	2.56	2.19	2.53	1.74	0.06	2.28	3.02
913	Plaza, 30' wide	14'	Single row, middle	2	A	V	0.756	95	1		40	30	2.62	2.51	1.91	1.24	0.08	3.09	4.09
914	Plaza, 30' wide	18'	Single row, middle	2	A	V	0.756	95	1	Vert average <2		30							
954	Plaza, 30' wide	10'	Single row, middle	1	A	V	0.756	51	1		35	30	2.48	2.49	1.33	1.22	0.05	1.52	2.01
955	Plaza, 30' wide	14'	Single row, middle	1	A	V	0.756	51	1	Vert average <2		30							
956	Plaza, 30' wide	18'	Single row, middle	1	A	V	0.756	51	1	Vert average <2		30							
957	Plaza, 30' wide	10'	wo heads, middle (type II	2	A	III	0.756	51	2		65	30	2.57	2.98	3.67	2.09	0.05	2.23	2.95
958	Plaza, 30' wide	14'	wo heads, middle (type II	2	A	III	0.756	51	2		60	30	2.08	2.08	1.84	1.84	0.06	2.67	3.53
959	Plaza, 30' wide	18'	wo heads, middle (type II	2	A	III	0.756	51	2		40	30	2.52	2.04	1.70	1.37	0.09	2.98	3.94
960	Plaza, 30' wide	10'	ow, five feet from edge (t	2	A	III	0.756	51	1		40	30	2.40	2.01	1.90	1.58	0.04	1.73	2.29
961	Plaza, 30' wide	14'	ow, five feet from edge (t	2	A	III	0.756	51	1	Vert average <2		30							
962	Plaza, 30' wide	18'	ow, five feet from edge (t	2	A	III	0.756	51	1	Vert average <2		30							
966	Plaza, 30' wide	10'	Single row, middle	1	A	V	0.756	31	1		40	30	2.23	2.43	1.78	1.57	0.03	0.49	0.65
967	Plaza, 30' wide	14'	Single row, middle	1	A	V	0.756	31	1	Vert average <2		30							
968	Plaza, 30' wide	18'	Single row, middle	1	A	V	0.756	31	1	Vert average <2		30							
969	Plaza, 30' wide	10'	wo heads, middle (type II	1	A	III	0.756	31	2		65	30	1.57	2.08	3.65	2.09	0.03	1.36	1.80
970	Plaza, 30' wide	14'	wo heads, middle (type II	1	A	III	0.756	31	2	Vert average <2	40	30					0.05		
971	Plaza, 30' wide	18'	wo heads, middle (type II	1	A	III	0.756	31	2	Vert average <2		30							
972	Plaza, 30' wide	10'	ow, five feet from edge (t	1	A	III	0.756	31	1	Vert average <2		30							
973	Plaza, 30' wide	14'	ow, five feet from edge (t	1	A	III	0.756	31	1	Vert average <2		30							
974	Plaza, 30' wide	18'	ow, five feet from edge (t	1	A	III	0.756	31	1	Vert average <2		30							
927	Plaza, 30' wide	10'	Single row, middle	1	B	V	0.85	58	1		60	30	1.64	2.47	3.71	1.91	0.03	1.84	2.17
928	Plaza, 30' wide	14'	Single row, middle	1	B	V	0.85	58	1		40	30	2.02	2.12	1.16	2.20	0.05	2.81	3.31
929	Plaza, 30' wide	18'	Single row, middle	1	B	V	0.85	58	1	Vert average <2		30							
930	Plaza, 30' wide	10'	wo heads, middle (type II	1	B	III	0.81	57	2		55	30	3.15	3.40	2.86	1.97	0.07	0.68	0.84
931	Plaza, 30' wide	14'	wo heads, middle (type II	1	B	III	0.81	57	2		55	30	2.08	2.13	1.39	1.29	0.07	2.75	3.40
932	Plaza, 30' wide	18'	wo heads, middle (type II	1	B	III	0.81	57	2		45	30	2.56	2.07	1.98	1.34	0.08	3.30	4.07
933	Plaza, 30' wide	10'	ow, five feet from edge (t	1	B	III	0.81	57	1	Vert average <2		30							
934	Plaza, 30' wide	14'	ow, five feet from edge (t	1	B	III	0.81	57	1	Vert average <2		30							
935	Plaza, 30' wide	18'	ow, five feet from edge (t	1	B	III	0.81	57	1	Vert average <2		30							
936	Plaza, 30' wide	10'	Single row, middle	1	B	V	0.81	57	1		35	30	1.60	2.09	1.70	1.41	0.05	0.82	1.01
937	Plaza, 30' wide	14'	Single row, middle	1	B	V	0.81	57	1	Vert average <2		30							

Table 76: Calculation Results – Plaza, Pt. 2

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Luminaire Man	Distribution Typ	Total LL	Watta	Q'ty	Notes	Pole-Pole Spacin	Plaza widtl	0.6	2	4:1	5:1	Eff. LP	MAX Ve	Initial MAX Ve
938	Plaza, 30' wide	18'	Single row, middle	1	B	V	0.81	57	1	Vert average <2		30							
939	Plaza, 30' wide	10'	wo heads, middle (type I	0	BE	III	0.81	56	2		75	30	2.23	3.32	3.33	2.94	0.05	2.48	3.06
940	Plaza, 30' wide	14'	wo heads, middle (type I	0	BE	III	0.81	56	2		85	30	1.63	2.06	2.26	2.15	0.04	2.80	3.46
941	Plaza, 30' wide	18'	wo heads, middle (type I	0	BE	III	0.81	56	2		55	30	2.34	2.17	2.07	1.36	0.07	2.64	3.26
942	Plaza, 30' wide	10'	ow, five feet from edge (	0	BE	III	0.81	56	1		50	30	2.26	2.03	2.40	1.71	0.04	1.50	1.85
943	Plaza, 30' wide	14'	ow, five feet from edge (	0	BE	III	0.81	56	1		40	30	2.16	2.04	2.77	1.38	0.05	1.41	1.74
944	Plaza, 30' wide	18'	ow, five feet from edge (	0	BE	III	0.81	56	1	Vert average <2		30							
945	Plaza, 30' wide	10'	Single row, middle	0	BE	V	0.81	56	1		50	30	1.81	2.19	1.87	1.82	0.04	1.79	2.21
946	Plaza, 30' wide	14'	Single row, middle	0	BE	V	0.81	56	1	Vert average <2		30							
947	Plaza, 30' wide	18'	Single row, middle	0	BE	V	0.81	56	1	Vert average <2		30							
948	Plaza, 30' wide	10'	wo heads, middle (type I	2	C	III	0.864	52	2		65	30	4.90	5.68	3.36	2.16	0.05	1.03	1.19
949	Plaza, 30' wide	14'	wo heads, middle (type I	2	C	III	0.864	52	2		90	30	2.64	2.42	3.47	2.16	0.04	2.05	2.37
950	Plaza, 30' wide	18'	wo heads, middle (type I	2	C	III	0.864	52	2		90	30	2.48	2.07	1.69	1.41	0.04	1.86	2.15
951	Plaza, 30' wide	10'	ow, five feet from edge (	2	C	III	0.864	52	1		65	30	2.70	2.61	2.69	2.03	0.03	0.50	0.58
952	Plaza, 30' wide	14'	ow, five feet from edge (	2	C	III	0.864	52	1		60	30	2.27	2.21	1.39	1.19	0.03	0.26	0.30
953	Plaza, 30' wide	18'	ow, five feet from edge (	2	C	III	0.864	52	1		55	30	2.51	2.20	1.28	1.16	0.03	0.51	0.59
903	Plaza, 30' wide	10'	wo heads, middle (type I	2	D	III	0.819	125	2		55	30	14.37	10.83	3.03	2.62	0.15	2.63	3.21
904	Plaza, 30' wide	14'	wo heads, middle (type I	2	D	III	0.819	125	2		80	30	7.56	5.90	3.53	2.60	0.10	4.81	5.87
905	Plaza, 30' wide	18'	wo heads, middle (type I	2	D	III	0.819	125	2		105	30	4.82	2.89	3.80	2.55	0.08	4.68	5.71
906	Plaza, 30' wide	10'	ow, five feet from edge (	2	D	III	0.819	125	1		45	30	8.83	4.81	3.08	2.80	0.09	1.00	1.22
907	Plaza, 30' wide	14'	ow, five feet from edge (	2	D	III	0.819	125	1		70	30	5.03	3.29	3.33	2.61	0.06	0.89	1.09
908	Plaza, 30' wide	18'	ow, five feet from edge (	2	D	III	0.819	125	1		90	30	3.44	2.19	3.07	2.37	0.05	0.84	1.03
915	Plaza, 30' wide	10'	wo heads, middle (type I	2	D	III	0.819	89	2		50	30	9.36	7.50	3.64	1.64	0.12	3.32	4.05
916	Plaza, 30' wide	14'	wo heads, middle (type I	2	D	III	0.819	89	2		70	30	5.09	3.88	3.69	1.58	0.08	6.87	8.39
917	Plaza, 30' wide	18'	wo heads, middle (type I	2	D	III	0.819	89	2		90	30	3.20	2.30	3.68	1.56	0.07	7.43	9.07
918	Plaza, 30' wide	10'	ow, five feet from edge (	2	D	III	0.819	89	1		45	30	6.78	3.49	3.85	2.33	0.07	0.39	0.48
919	Plaza, 30' wide	14'	ow, five feet from edge (	2	D	III	0.819	89	1		60	30	2.80	2.92	3.05	1.92	0.05	0.77	0.94
920	Plaza, 30' wide	18'	ow, five feet from edge (	2	D	III	0.819	89	1		65	30	3.12	2.01	1.88	1.56	0.05	0.88	1.07
921	Plaza, 30' wide	10'	wo heads, middle (type I	2	D	III	0.819	70	2		50	30	7.68	6.14	3.63	1.64	0.09	2.72	3.32
922	Plaza, 30' wide	14'	wo heads, middle (type I	2	D	III	0.819	70	2		70	30	4.16	3.17	3.68	1.58	0.07	5.62	6.86
923	Plaza, 30' wide	18'	wo heads, middle (type I	2	D	III	0.819	70	2		85	30	2.78	2.08	3.02	1.47	0.05	6.08	7.42
924	Plaza, 30' wide	10'	ow, five feet from edge (	2	D	III	0.819	70	1		45	30	5.51	2.90	3.42	2.19	0.05	0.35	0.43

Table 77: Calculation Results – Plaza, Pt. 3

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Luminaire Man	Distribution Typ	Total LL	Watta	Q'ty	Notes	Pole-Pole Spacin	Plaza widtl	0.6	2	4:1	5:1	Eff. LP	MAX Ve	Initial MAX Ve
925	Plaza, 30' wide	14'	ow, five feet from edge (t	2	D	III	0.819	70	1		65	30	3.14	2.18	3.45	2.00	0.04	0.64	0.78
926	Plaza, 30' wide	18'	ow, five feet from edge (t	2	D	III	0.819	70	1		50	30	3.31	3.23	1.47	1.32	0.05	0.86	1.05
963	Plaza, 30' wide	10'	Single row, middle	1	E	V	0.801	38	1		50	30	2.00	2.01	2.51	1.71	0.03	1.47	1.84
964	Plaza, 30' wide	14'	Single row, middle	1	E	V	0.801	38	1	Avg/Min > 4		30							
965	Plaza, 30' wide	18'	Single row, middle	1	E	V	0.801	38	1	Avg/Min > 4		30							
900	Plaza, 30' wide	10'	Single row, middle	1	V	V	0.815	125	1	Avg/Min > 4	40	30					0.10		
901	Plaza, 30' wide	14'	Single row, middle	1	V	V	0.815	125	1		60	30	3.93	3.23	3.57	2.42	0.07		
902	Plaza, 30' wide	18'	Single row, middle	1	V	V	0.815	125	1		65	30	3.12	2.05	1.70	1.93	0.06	4.11	5.04
909	Plaza, 30' wide	10'	Single row, middle	2	W	V	0.801	96	1		70	30	2.19	2.72	3.98	2.71	0.05	2.88	3.60
910	Plaza, 30' wide	14'	Single row, middle	2	W	V	0.801	96	1		70	30	1.83	2.06	1.91	1.72	0.05	3.70	4.62
911	Plaza, 30' wide	18'	Single row, middle	2	W	V	0.801	96	1		50	30	3.41	3.40	1.88	1.33	0.06	3.62	4.52
975	Plaza, 30' wide	10'	Single row, middle	1	W	V	0.801	30	1		35	30	1.97	2.06	1.19	1.25	0.03	1.15	1.44
976	Plaza, 30' wide	14'	Single row, middle	1	W	V	0.801	30	1	Vert Average < 2		30							
977	Plaza, 30' wide	18'	Single row, middle	1	W	V	0.801	30	1	Vert Average < 2		30							
978	Plaza, 30' wide	10'	wo heads, middle (type II	2	W	IV	0.801	30	2		40	30	1.89	2.24	10.50	1.58	0.05	0.43	0.54
979	Plaza, 30' wide	14'	wo heads, middle (type II	2	W	IV	0.801	30	2	Vert Average < 2		30							
980	Plaza, 30' wide	18'	wo heads, middle (type II	2	W	IV	0.801	30	2	Vert Average < 2		30							
981	Plaza, 30' wide	10'	ow, five feet from edge (t	2	W	IV	0.801	30	1	Vert Average < 2		30							
982	Plaza, 30' wide	14'	ow, five feet from edge (t	2	W	IV	0.801	30	1	Vert Average < 2		30							
983	Plaza, 30' wide	18'	ow, five feet from edge (t	2	W	IV	0.801	30	1	Vert Average < 2		30							
984	Plaza, 30' wide	10'	wo heads, middle (type II	3	BE	V	0.765	52	2		65	30	2.38	3.70	3.84	3.45	0.05	2.92	3.82
985	Plaza, 30' wide	14'	wo heads, middle (type II	3	BE	V	0.765	52	2		65	30	2.00	2.15	2.30	2.22	0.05	3.06	4.00
986	Plaza, 30' wide	18'	wo heads, middle (type II	3	BE	V	0.765	52	2		45	30	2.62	2.11	2.57	1.26	0.08	2.92	3.82
987	Plaza, 30' wide	10'	ow, five feet from edge (t	3	BE	V	0.765	52	1		35	30	2.69	2.07	1.92	1.64	0.05	2.78	3.63
988	Plaza, 30' wide	14'	ow, five feet from edge (t	3	BE	V	0.765	52	1	Vert Average < 2		30							
989	Plaza, 30' wide	18'	ow, five feet from edge (t	3	BE	V	0.765	52	1	Vert Average < 2		30							
990	Plaza, 30' wide	10'	wo heads, middle (type II	4	BE	V	0.765	54	2		95	30	1.07	2.07	1.95	1.74	0.04	4.15	5.42
991	Plaza, 30' wide	14'	wo heads, middle (type II	4	BE	V	0.765	54	2		60	30	1.36	2.04	1.14	1.18	0.06	2.66	3.48
992	Plaza, 30' wide	18'	wo heads, middle (type II	4	BE	V	0.765	54	2		35	30	1.70	2.04	1.39	1.21	0.10	7.66	10.01
993	Plaza, 30' wide	10'	ow, five feet from edge (t	4	BE	V	0.765	54	1		45	30	1.10	2.08	1.26	1.17	0.04	3.35	4.38
994	Plaza, 30' wide	14'	ow, five feet from edge (t	4	BE	V	0.765	54	1	Vert Average < 2		30							
995	Plaza, 30' wide	18'	ow, five feet from edge (t	4	BE	V	0.765	54	1	Vert Average < 2		30							

Table 78: Calculation Results – Plaza, Pt. 4

											Results		Horiz. Min.	Vert. Min.	Horiz. Max: Min	Horiz. Avg: Min			
Sim C	Condition	Poles	Other	BUG G-rati	Lumina ire Man	Distrib ution Typ	Total LL	Watt a	Q'ty	Notes	Pole-Pole Spacin	Plaza widtl	0.6	2	4:1	5:1	Eff. LP	MAX Ve	Initial MAX Ve
996	Plaza, 30' wide	10'	Single row, middle	4	BE	V	0.765	54	1		50	30	1.04	2.11	1.14	1.17	0.04	3.33	4.35
997	Plaza, 30' wide	14'	Single row, middle	4	BE	V	0.765	54	1	Vert Average < 2		30							
998	Plaza, 30' wide	18'	Single row, middle	4	BE	V	0.765	54	1	Vert Average < 2		30							
1002	Plaza, 30' wide	10'	wo heads, middle (type II	5	BE	IV	0.765	54	2		125	30	1.29	2.05	3.00	2.25	0.03	2.77	3.62
1003	Plaza, 30' wide	14'	wo heads, middle (type II	5	BE	IV	0.765	54	2		90	30	1.18	2.04	1.55	1.85	0.04	2.44	3.19
1004	Plaza, 30' wide	18'	wo heads, middle (type II	5	BE	IV	0.765	54	2		55	30	1.52	2.11	1.24	1.21	0.07	3.61	4.72
1005	Plaza, 30' wide	10'	ow, five feet from edge (t	5	BE	IV	0.765	54	1		90	30	1.02	2.06	2.49	2.36	0.02	0.66	0.86
1006	Plaza, 30' wide	14'	ow, five feet from edge (t	5	BE	IV	0.765	54	1		55	30	1.38	2.05	1.57	1.49	0.03	1.02	1.33
1007	Plaza, 30' wide	18'	ow, five feet from edge (t	5	BE	IV	0.765	54	1	Vert Average < 2		30							
1008	Plaza, 30' wide	10'	Single row, middle	3	BE	V	0.765	55	1		50	30	1.71	2.07	1.80	1.60	0.04	1.75	2.29
1009	Plaza, 30' wide	14'	Single row, middle	3	BE	V	0.765	55	1	Vert Average < 2		30							
1010	Plaza, 30' wide	18'	Single row, middle	3	BE	V	0.765	55	1	Vert Average < 2		30							
1014	Plaza, 30' wide	10'	wo heads, middle (type II	3	BE	IV	0.765	55	2		80	30	2.19	3.41	3.71	2.67	0.05	2.89	3.78
1015	Plaza, 30' wide	14'	wo heads, middle (type II	3	BE	IV	0.765	55	2		85	30	1.66	2.17	2.08	1.98	0.04	3.04	3.97
1016	Plaza, 30' wide	18'	wo heads, middle (type II	3	BE	IV	0.765	55	2		60	30	2.23	2.02	1.77	1.24	0.06	2.69	3.52
1017	Plaza, 30' wide	10'	ow, five feet from edge (t	3	BE	IV	0.765	55	1		55	30	2.03	2.07	2.48	1.96	0.03	1.75	2.29
1018	Plaza, 30' wide	14'	ow, five feet from edge (t	3	BE	IV	0.765	55	1		40	30	2.21	2.16	2.23	1.33	0.05	1.56	2.04
1019	Plaza, 30' wide	18'	ow, five feet from edge (t	3	BE	IV	0.765	55	1	Vert Average < 2		30							
1020	Plaza, 30' wide	10'	Single row, middle	3	BE	V	0.765	55	1		55	30	1.66	2.13	2.02	1.82	0.03	1.95	2.55
1021	Plaza, 30' wide	14'	Single row, middle	3	BE	V	0.765	55	1	Vert Average < 2		30							
1022	Plaza, 30' wide	18'	Single row, middle	3	BE	V	0.765	55	1	Vert Average < 2		30							
1026	Plaza, 30' wide	10'	wo heads, middle (type II	3	BE	IV	0.765	55	2		80	30	2.01	3.10	3.65	2.74	0.05	2.60	3.40
1027	Plaza, 30' wide	14'	wo heads, middle (type II	3	BE	IV	0.765	55	2		80	30	1.61	2.05	1.89	1.91	0.05	2.68	3.50
1028	Plaza, 30' wide	18'	wo heads, middle (type II	3	BE	IV	0.765	55	2		55	30	2.17	2.06	1.61	1.29	0.07	2.58	3.37
1029	Plaza, 30' wide	10'	ow, five feet from edge (t	3	BE	IV	0.765	55	1		45	30	2.30	2.15	1.83	1.47	0.04	1.70	2.22
1030	Plaza, 30' wide	14'	ow, five feet from edge (t	3	BE	IV	0.765	55	1		35	30	2.25	2.02	1.88	1.40	0.05	1.63	2.13
1031	Plaza, 30' wide	18'	ow, five feet from edge (t	3	BE	IV	0.765	55	1	Vert Average < 2		30							

Appendix J: Lighting Zone Calculations

The tables below list the weighting and cost per watt determined for each special application. The special application calculations were developed used 119 different products from 58 manufacturers, listed by the luminaire manufacturer letter and luminaire product number. Each of the luminaires studied are commercially available and represent typical LED luminaire offered in 2019.

Table 79: Building Entrances and Exits Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Area Light																	
B	002	$ 1,381	25	0.93	1,170	1	2	1	0.091	0.063	0.063	0.063	$ 55	$ 5.02	$ 3.45	$ 3.45	$ 3.45
B	002	$ 1,381	25	0.93	1,216	1	1	1	0.091	0.063	0.063	0.063	$ 55	$ 5.02	$ 3.45	$ 3.45	$ 3.45
B	002	$ 1,381	25	0.93	1,735	1	0	1	0.091	0.063	0.063	0.063	$ 55	$ 5.02	$ 3.45	$ 3.45	$ 3.45
A	002	$ 1,553	21	0.83	2,051	1	0	1	0.091	0.063	0.063	0.063	$ 74	$ 6.72	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	21	0.83	2,189	1	0	1	0.091	0.063	0.063	0.063	$ 74	$ 6.72	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	21	0.83	2,114	1	0	1	0.091	0.063	0.063	0.063	$ 74	$ 6.72	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	30	0.83	2,760	1	0	1	0.091	0.063	0.063	0.063	$ 52	$ 4.71	$ 3.24	$ 3.24	$ 3.24
B	002	$ 1,381	25	0.93	1,830	1	0	1	0.091	0.063	0.063	0.063	$ 55	$ 5.02	$ 3.45	$ 3.45	$ 3.45
W	002	$ 1,970	22	0.84	2,117	1	0	1	0.091	0.063	0.063	0.063	$ 90	$ 8.14	$ 5.60	$ 5.60	$ 5.60
BD	001	$ 1,434	36	0.92	2,221	1	0	1		0.063	0.063	0.063	$ 40	$ -	$ 2.49	$ 2.49	$ 2.49
W	003	$ 1,071	30	0.84	3,126	1	0	1	0.091	0.063	0.063	0.063	$ 36	$ 3.24	$ 2.23	$ 2.23	$ 2.23
BD	001	$ 1,434	52	0.92	3,178	1	0	1		0.063	0.063	0.063	$ 28	$ -	$ 1.72	$ 1.72	$ 1.72
AF	003	$ 1,776	48	0.70	4,247	1	0	1		0.063	0.063	0.063	$ 37	$ -	$ 2.31	$ 2.31	$ 2.31
A	001	$ 1,379	22	0.84	1,888	1	0	1	0.091	0.063	0.063	0.063	$ 63	$ 5.70	$ 3.92	$ 3.92	$ 3.92
A	001	$ 1,379	51	0.84	4,431	2	0	2		0.063	0.063	0.063	$ 27	$ -	$ 1.69	$ 1.69	$ 1.69
A	001	$ 1,379	51	0.84	4,348	1	0	1		0.063	0.063	0.063	$ 27	$ -	$ 1.69	$ 1.69	$ 1.69
A	001	$ 1,450	95	0.84	7,312	2	0	2					$ 15	$ -	$ -	$ -	$ -
W	004	$ 1,063	96	0.89	10,231	3	0	2					$ 11	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00	$867.4	$ 62.06	$ 52.57	$ 52.57	$ 52.57
Cylindrical - Wall Mounted, Up/Down																	
C	003	$ 619	10	0.87	838	2	5	0	0.200	0.125	0.125	0.125	$ 62	$ 12.38	$ 7.74	$ 7.74	$ 7.74
M	001	$ 950	8	0.70	900	1	1	0	0.200	0.125	0.125	0.125	$ 119	$ 23.74	$ 14.84	$ 14.84	$ 14.84
AO	001	$ 349	13	0.70	931	1	1	0	0.200	0.125	0.125	0.125	$ 27	$ 5.37	$ 3.36	$ 3.36	$ 3.36
H	003	$ 434	21	0.81	1,047	1	4	0	0.200	0.125	0.125	0.125	$ 21	$ 4.14	$ 2.58	$ 2.58	$ 2.58
F	001	$ 1,056	34	0.70	2,212	2	5	0		0.125	0.125	0.125	$ 31	$ -	$ 3.88	$ 3.88	$ 3.88
C	003	$ 862	29	0.70	2,319	2	5	0	0.200	0.125	0.125	0.125	$ 30	$ 6.05	$ 3.78	$ 3.78	$ 3.78
F	001	$ 1,067	42	0.70	3,288	3	5	0		0.125	0.125	0.125	$ 25	$ -	$ 3.18	$ 3.18	$ 3.18
F	001	$ 1,352	57	0.70	4,607	3	5	0		0.125	0.125	0.125	$ 24	$ -	$ 2.97	$ 2.97	$ 2.97
AF	004	$ 1,214	76	0.70	4,884	1	5	1					$ 16	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00	$354.6	$ 51.68	$ 42.32	$ 42.32	$ 42.32
Downlight																	
J	001	$ 561	10	0.70	647	1	0	0	0.040	0.040	0.040	0.040	$ 56	$ 2.25	$ 2.25	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.040	0.040	0.040	0.040	$ 17	$ 0.68	$ 0.68	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.040	0.040	0.040	0.040	$ 40	$ 1.60	$ 1.60	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.040	0.040	0.040	0.040	$ 15	$ 0.60	$ 0.60	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.040	0.040	0.040	0.040	$ 13	$ 0.52	$ 0.52	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.040	0.040	0.040	0.040	$ 12	$ 0.49	$ 0.49	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.040	0.040	0.040	0.040	$ 13	$ 0.51	$ 0.51	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.040	0.040	0.040	0.040	$ 10	$ 0.41	$ 0.41	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.040	0.040	0.040	0.040	$ 7	$ 0.26	$ 0.26	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.040	0.040	0.040	0.040	$ 4	$ 0.18	$ 0.18	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.040	0.040	0.040	0.040	$ 7	$ 0.27	$ 0.27	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.040	0.040	0.040	0.040	$ 4	$ 0.16	$ 0.16	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.040	0.040	0.040	0.040	$ 9	$ 0.34	$ 0.34	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.040	0.040	0.040	0.040	$ 6	$ 0.25	$ 0.25	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.040	0.040	0.040	0.040	$ 7	$ 0.29	$ 0.29	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.040	0.040	0.040	0.040	$ 6	$ 0.26	$ 0.26	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.040	0.040	0.040	0.040	$ 6	$ 0.23	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.040	0.040	0.040	0.040	$ 3	$ 0.11	$ 0.11	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.040	0.040	0.040	0.040	$ 6	$ 0.25	$ 0.25	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.040	0.040	0.040	0.040	$ 7	$ 0.26	$ 0.26	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.040	0.040	0.040	0.040	$ 7	$ 0.27	$ 0.27	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.040	0.040	0.040	0.040	$ 6	$ 0.23	$ 0.23	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.040	0.040	0.040	0.040	$ 10	$ 0.41	$ 0.41	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0	0.040	0.040	0.040	0.040	$ 2	$ 0.06	$ 0.06	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0	0.040	0.040	0.040	0.040	$ 5	$ 0.18	$ 0.18	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00	277	$ 11.07	$ 11.07	$ 11.07	$ 11.07

Table 80: Building Entrances and Exits Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Recessed Linear																	
AB	002	$ 424	18	0.70	1,371	1	0	1	0.045	0.037	0.032	0.032	$ 24	$ 1.07	$ 0.87	$ 0.76	$ 0.76
AB	002	$ 424	38	0.70	2,560	1	0	1	0.045	0.037	0.032	0.032	$ 11	$ 0.51	$ 0.41	$ 0.36	$ 0.36
AV	001	$ 549	30	0.95	2,068	1	0	1	0.045	0.037	0.032	0.032	$ 19	$ 0.84	$ 0.69	$ 0.60	$ 0.60
AV	001	$ 549	39	0.95	2,756	1	0	1	0.045	0.037	0.032	0.032	$ 14	$ 0.64	$ 0.52	$ 0.45	$ 0.45
AV	001	$ 549	24	0.95	3,444	1	0	1	0.045	0.037	0.032	0.032	$ 23	$ 1.02	$ 0.83	$ 0.73	$ 0.73
AW	001	$ 610	22	0.70	2,000	1	0	1	0.045	0.037	0.032	0.032	$ 28	$ 1.26	$ 1.03	$ 0.89	$ 0.89
AW	001	$ 610	33	0.70	3,000	1	0	1	0.045	0.037	0.032	0.032	$ 18	$ 0.84	$ 0.68	$ 0.59	$ 0.59
AW	001	$ 610	44	0.70	4,000	2	0	1	0.045	0.037	0.032	0.032	$ 14	$ 0.62	$ 0.51	$ 0.44	$ 0.44
Y	001	$ 631	14	0.70	1,056	1	0	1	0.045	0.037	0.032	0.032	$ 44	$ 1.99	$ 1.62	$ 1.41	$ 1.41
Y	001	$ 631	18	0.70	1,328	1	0	1	0.045	0.037	0.032	0.032	$ 34	$ 1.56	$ 1.27	$ 1.11	$ 1.11
Y	001	$ 631	28	0.70	2,004	1	0	1	0.045	0.037	0.032	0.032	$ 22	$ 1.01	$ 0.82	$ 0.72	$ 0.72
Y	001	$ 631	37	0.70	2,580	1	0	1	0.045	0.037	0.032	0.032	$ 17	$ 0.78	$ 0.64	$ 0.55	$ 0.55
AA	001	$ 440	42	0.70	2,050	1	1	0	0.045	0.037	0.032	0.032	$ 11	$ 0.48	$ 0.39	$ 0.34	$ 0.34
AZ	001	$ 329	12	0.70	580	0	1	0	0.045	0.037	0.032	0.032	$ 27	$ 1.21	$ 0.98	$ 0.86	$ 0.86
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.045	0.037	0.032	0.032	$ 12	$ 0.56	$ 0.46	$ 0.40	$ 0.40
Z	002	$ 574	23	0.70	2,000	1	0	1	0.045	0.037	0.032	0.032	$ 25	$ 1.13	$ 0.92	$ 0.81	$ 0.81
Z	002	$ 574	36	0.70	3,000	1	0	1	0.045	0.037	0.032	0.032	$ 16	$ 0.73	$ 0.60	$ 0.52	$ 0.52
Z	002	$ 574	49	0.70	4,000	2	0	1	0.045	0.037	0.032	0.032	$ 12	$ 0.53	$ 0.43	$ 0.38	$ 0.38
Z	001	$ 599	31	0.70	2,914	1	0	1	0.045	0.037	0.032	0.032	$ 19	$ 0.88	$ 0.72	$ 0.63	$ 0.63
BE	001	$ 160	10	0.70	1,236	0	1	0	0.045	0.037	0.032	0.032	$ 17	$ 0.76	$ 0.62	$ 0.54	$ 0.54
BE	001	$ 245	18	0.70	1,696	0	1	0	0.045	0.037	0.032	0.032	$ 14	$ 0.63	$ 0.51	$ 0.45	$ 0.45
BE	001	$ 329	26	0.70	2,308	0	1	0	0.045	0.037	0.032	0.032	$ 12	$ 0.57	$ 0.46	$ 0.40	$ 0.40
AX	001	$ 589	19	0.70	1,008	1	2	1		0.037	0.032	0.032	$ 31	$ -	$ 1.16	$ 1.01	$ 1.01
AX	001	$ 589	35	0.70	1,876	1	2	1		0.037	0.032	0.032	$ 17	$ -	$ 0.63	$ 0.55	$ 0.55
AY	001	$ 574	8	0.70	1,400	1	2	1		0.037	0.032	0.032	$ 72	$ -	$ 2.66	$ 2.31	$ 2.31
AY	001	$ 574	12	0.70	2,200	1	2	1		0.037	0.032	0.032	$ 49	$ -	$ 1.83	$ 1.60	$ 1.60
AY	001	$ 574	19	0.70	3,200	1	3	1			0.032	0.032	$ 30	$ -	$ -	$ 0.96	$ 0.96
AY	001	$ 574	24	0.70	4,000	1	3	1			0.032	0.032	$ 24	$ -	$ -	$ 0.77	$ 0.77
AY	001	$ 574	30	0.70	4,800	2	3	1			0.032	0.032	$ 19	$ -	$ -	$ 0.62	$ 0.62
AY	001	$ 574	65	0.70	8,800	2	3	1			0.032	0.032	$ 9	$ -	$ -	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1		0.037	0.032	0.032	$ 14	$ -	$ 0.53	$ 0.46	$ 0.46
								SUM	1.00	1.00	1.00	1.00	$ 697	$ 19.63	$ 22.80	$ 22.49	$ 22.49
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.250	0.167	0.111	0.111	$ 5	$ 1.22	$ 0.82	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.250	0.167	0.111	0.111	$ 42	$ 10.43	$ 6.95	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.250	0.167	0.111	0.111	$ 5	$ 1.13	$ 0.75	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2			0.111	0.111	$ 11	$ -	$ -	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.250	0.167	0.111	0.111	$ 13	$ 3.24	$ 2.16	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1		0.167	0.111	0.111	$ 15	$ -	$ 2.45	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2			0.111	0.111	$ 8	$ -	$ -	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2		0.167	0.111	0.111	$ 9	$ -	$ 1.47	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2			0.111	0.111	$ 9	$ -	$ -	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00	$ 115	$ 16.03	$ 14.61	$ 12.79	$ 12.79

Table 81: Building Entrances and Exits Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.040	0.034	0.030	0.030	$ 29	$ 1.16	$ 1.00	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.040	0.034	0.030	0.030	$ 14	$ 0.55	$ 0.48	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.040	0.034	0.030	0.030	$ 24	$ 0.97	$ 0.83	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.040	0.034	0.030	0.030	$ 19	$ 0.74	$ 0.64	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.040	0.034	0.030	0.030	$ 14	$ 0.56	$ 0.48	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.040	0.034	0.030	0.030	$ 24	$ 0.95	$ 0.82	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.040	0.034	0.030	0.030	$ 29	$ 1.16	$ 1.00	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.040	0.034	0.030	0.030	$ 19	$ 0.77	$ 0.66	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.040	0.034	0.030	0.030	$ 14	$ 0.58	$ 0.50	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.040	0.034	0.030	0.030	$ 33	$ 1.31	$ 1.13	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.040	0.034	0.030	0.030	$ 16	$ 0.66	$ 0.56	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.040	0.034	0.030	0.030	$ 13	$ 0.51	$ 0.44	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.040	0.034	0.030	0.030	$ 40	$ 1.58	$ 1.36	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.040	0.034	0.030	0.030	$ 31	$ 1.24	$ 1.07	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.040	0.034	0.030	0.030	$ 20	$ 0.80	$ 0.69	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.040	0.034	0.030	0.030	$ 15	$ 0.62	$ 0.53	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.040	0.034	0.030	0.030	$ 34	$ 1.35	$ 1.16	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.040	0.034	0.030	0.030	$ 15	$ 0.62	$ 0.53	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.040	0.034	0.030	0.030	$ 17	$ 0.70	$ 0.60	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.040	0.034	0.030	0.030	$ 38	$ 1.51	$ 1.30	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.040	0.034	0.030	0.030	$ 24	$ 0.98	$ 0.84	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.040	0.034	0.030	0.030	$ 18	$ 0.71	$ 0.61	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.040	0.034	0.030	0.030	$ 17	$ 0.67	$ 0.57	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.040	0.034	0.030	0.030	$ 14	$ 0.56	$ 0.48	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.040	0.034	0.030	0.030	$ 12	$ 0.50	$ 0.43	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1		0.034	0.030	0.030	$ 31	$ -	$ 1.08	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1		0.034	0.030	0.030	$ 17	$ -	$ 0.58	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1		0.034	0.030	0.030	$ 66	$ -	$ 2.26	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1		0.034	0.030	0.030	$ 45	$ -	$ 1.56	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1			0.030	0.030	$ 27	$ -	$ -	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1			0.030	0.030	$ 22	$ -	$ -	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1			0.030	0.030	$ 17	$ -	$ -	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.030	0.030	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00	$ 777	$ 21.74	$ 24.22	$ 23.55	$ 23.55
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0				0.056	$ 26	$ -	$ -	$ -	$ 1.47
H	002	$ 639	14	0.70	846	0	4	0				0.056	$ 46	$ -	$ -	$ -	$ 2.54
S	001	$ 147	26	0.70	823	1	0	0	0.083	0.083	0.071	0.056	$ 6	$ 0.47	$ 0.47	$ 0.40	$ 0.31
AH	001	$ 815	24	0.70	950	1	3	1			0.071	0.056	$ 34	$ -	$ -	$ 2.42	$ 1.89
C	001	$ 409	16	0.95	1,084	0	4	0				0.056	$ 26	$ -	$ -	$ -	$ 1.47
S	002	$ 162	18	0.70	1,189	1	1	0	0.083	0.083	0.071	0.056	$ 9	$ 0.75	$ 0.75	$ 0.64	$ 0.50
C	001	$ 409	16	0.95	1,214	0	4	0				0.056	$ 26	$ -	$ -	$ -	$ 1.47
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.083	0.083	0.071	0.056	$ 66	$ 5.52	$ 5.52	$ 4.73	$ 3.68
AF	001	$ 809	40	0.70	1,290	1	1	1	0.083	0.083	0.071	0.056	$ 20	$ 1.67	$ 1.67	$ 1.43	$ 1.11
V	005	$ 381	13	0.91	1,415	0	0	1	0.083	0.083	0.071	0.056	$ 29	$ 2.44	$ 2.44	$ 2.09	$ 1.63
V	004	$ 408	12	0.90	1,494	0	0	0	0.083	0.083	0.071	0.056	$ 34	$ 2.84	$ 2.84	$ 2.43	$ 1.89
B	004	$ 1,719	88	0.70	3,003	1	3	0			0.071	0.056	$ 20	$ -	$ -	$ 1.40	$ 1.09
V	005	$ 381	19	0.91	1,957	1	0	1	0.083	0.083	0.071	0.056	$ 20	$ 1.67	$ 1.67	$ 1.43	$ 1.11
V	005	$ 381	19	0.91	2,031	1	0	1	0.083	0.083	0.071	0.056	$ 20	$ 1.67	$ 1.67	$ 1.43	$ 1.11
AE	001	$ 163	27	0.70	2,075	1	1	0	0.083	0.083	0.071	0.056	$ 6	$ 0.50	$ 0.50	$ 0.43	$ 0.34
AF	002	$ 368	20	0.70	2,054	1	1	1	0.083	0.083	0.071	0.056	$ 19	$ 1.56	$ 1.56	$ 1.34	$ 1.04
V	004	$ 449	25	0.90	3,163	1	0	1	0.083	0.083	0.071	0.056	$ 18	$ 1.50	$ 1.50	$ 1.28	$ 1.00
V	004	$ 490	50	0.90	6,025	1	0	1	0.083	0.083	0.071	0.056	$ 10	$ 0.82	$ 0.82	$ 0.70	$ 0.54
								SUM	1.00	1.00	1.00	1.00	$ 435	$ 21.41	$ 21.41	$ 22.18	$ 24.18
									1.00	1.00	1.00	1.00		$ 29.09	$ 27.00	$ 26.71	$ 27.00

Table 82: Primary Entrances Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Area Light																	
B	002	$ 1,381	25	0.93	1,170	1	2	1	0.063	0.063	0.063	0.063	$ 55	$ 3.45	$ 3.45	$ 3.45	$ 3.45
B	002	$ 1,381	25	0.93	1,216	1	1	1	0.063	0.063	0.063	0.063	$ 55	$ 3.45	$ 3.45	$ 3.45	$ 3.45
B	002	$ 1,381	25	0.93	1,735	1	0	1	0.063	0.063	0.063	0.063	$ 55	$ 3.45	$ 3.45	$ 3.45	$ 3.45
A	002	$ 1,553	21	0.83	2,051	1	0	1	0.063	0.063	0.063	0.063	$ 74	$ 4.62	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	21	0.83	2,189	1	0	1	0.063	0.063	0.063	0.063	$ 74	$ 4.62	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	21	0.83	2,114	1	0	1	0.063	0.063	0.063	0.063	$ 74	$ 4.62	$ 4.62	$ 4.62	$ 4.62
A	002	$ 1,553	30	0.83	2,760	1	0	1	0.063	0.063	0.063	0.063	$ 52	$ 3.24	$ 3.24	$ 3.24	$ 3.24
B	002	$ 1,381	25	0.93	1,830	1	0	1	0.063	0.063	0.063	0.063	$ 55	$ 3.45	$ 3.45	$ 3.45	$ 3.45
W	002	$ 1,970	22	0.84	2,117	1	0	1	0.063	0.063	0.063	0.063	$ 90	$ 5.60	$ 5.60	$ 5.60	$ 5.60
BD	001	$ 1,434	36	0.92	2,221	1	0	1	0.063	0.063	0.063	0.063	$ 40	$ 2.49	$ 2.49	$ 2.49	$ 2.49
W	003	$ 1,071	30	0.84	3,126	1	0	1	0.063	0.063	0.063	0.063	$ 36	$ 2.23	$ 2.23	$ 2.23	$ 2.23
BD	001	$ 1,434	52	0.92	3,178	1	0	1	0.063	0.063	0.063	0.063	$ 28	$ 1.72	$ 1.72	$ 1.72	$ 1.72
AF	003	$ 1,776	48	0.70	4,247	1	0	1	0.063	0.063	0.063	0.063	$ 37	$ 2.31	$ 2.31	$ 2.31	$ 2.31
A	001	$ 1,379	22	0.84	1,888	1	0	1	0.063	0.063	0.063	0.063	$ 63	$ 3.92	$ 3.92	$ 3.92	$ 3.92
A	001	$ 1,379	51	0.84	4,431	2	0	2	0.063	0.063	0.063	0.063	$ 27	$ 1.69	$ 1.69	$ 1.69	$ 1.69
A	001	$ 1,379	51	0.84	4,348	1	0	1	0.063	0.063	0.063	0.063	$ 27	$ 1.69	$ 1.69	$ 1.69	$ 1.69
A	001	$ 1,450	95	0.84	7,312	2	0	2					$ 15	$ -	$ -	$ -	$ -
W	004	$ 1,063	96	0.89	10,231	3	0	2					$ 11	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00	$ 867	$52.57	$52.57	$52.57	$52.57

Cylindrical - Wall Mounted up/down																	
2019 LED									Weighting					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
C	003	$ 619	10	0.87	838	2	5	0	0.111	0.111	0.111	0.111	$ 62	$ 6.88	$ 6.88	$ 6.88	$ 6.88
M	001	$ 950	8	0.70	900	1	1	0	0.111	0.111	0.111	0.111	$ 119	$ 13.19	$ 13.19	$ 13.19	$ 13.19
AO	001	$ 349	13	0.70	931	1	1	0	0.111	0.111	0.111	0.111	$ 27	$ 2.99	$ 2.99	$ 2.99	$ 2.99
H	003	$ 434	21	0.81	1,047	1	4	0	0.111	0.111	0.111	0.111	$ 21	$ 2.30	$ 2.30	$ 2.30	$ 2.30
F	001	$ 1,056	34	0.70	2,212	2	5	0	0.111	0.111	0.111	0.111	$ 31	$ 3.45	$ 3.45	$ 3.45	$ 3.45
C	003	$ 862	29	0.70	2,319	2	5	0	0.111	0.111	0.111	0.111	$ 30	$ 3.36	$ 3.36	$ 3.36	$ 3.36
F	001	$ 1,067	42	0.70	3,288	3	5	0	0.111	0.111	0.111	0.111	$ 25	$ 2.82	$ 2.82	$ 2.82	$ 2.82
F	001	$ 1,352	57	0.70	4,607	3	5	0	0.111	0.111	0.111	0.111	$ 24	$ 2.64	$ 2.64	$ 2.64	$ 2.64
AF	004	$ 1,214	76	0.70	4,884	1	5	1	0.111	0.111	0.111	0.111	$ 16	$ 1.78	$ 1.78	$ 1.78	$ 1.78
								SUM	0.89	0.89	0.89	0.89		$39.41	$39.41	$39.41	$39.41

Downlight																	
2019 LED									Weighting					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
J	001	$ 561	10	0.70	647	1	0	0	0.043	0.040	0.040	0.040	$ 56	$ 2.44	$ 2.25	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.043	0.040	0.040	0.040	$ 17	$ 0.74	$ 0.68	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.043	0.040	0.040	0.040	$ 40	$ 1.74	$ 1.60	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.043	0.040	0.040	0.040	$ 15	$ 0.65	$ 0.60	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.043	0.040	0.040	0.040	$ 13	$ 0.57	$ 0.52	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.043	0.040	0.040	0.040	$ 12	$ 0.54	$ 0.49	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.043	0.040	0.040	0.040	$ 13	$ 0.56	$ 0.51	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.043	0.040	0.040	0.040	$ 10	$ 0.44	$ 0.41	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.043	0.040	0.040	0.040	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.043	0.040	0.040	0.040	$ 4	$ 0.19	$ 0.18	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.043	0.040	0.040	0.040	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.043	0.040	0.040	0.040	$ 4	$ 0.18	$ 0.16	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.043	0.040	0.040	0.040	$ 9	$ 0.37	$ 0.34	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.043	0.040	0.040	0.040	$ 6	$ 0.28	$ 0.25	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.043	0.040	0.040	0.040	$ 7	$ 0.32	$ 0.29	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.043	0.040	0.040	0.040	$ 6	$ 0.28	$ 0.26	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.043	0.040	0.040	0.040	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.043	0.040	0.040	0.040	$ 3	$ 0.12	$ 0.11	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.043	0.040	0.040	0.040	$ 6	$ 0.27	$ 0.25	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.043	0.040	0.040	0.040	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.043	0.040	0.040	0.040	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.043	0.040	0.040	0.040	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.043	0.040	0.040	0.040	$ 10	$ 0.45	$ 0.41	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0		0.040	0.040	0.040	$ 2	$ -	$ 0.06	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0		0.040	0.040	0.040	$ 5	$ -	$ 0.18	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00		$11.77	$11.07	$11.07	$11.07

Table 83: Primary Entrances Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Recessed Linear																	
AB	002	$ 424	18	0.70	1,371	1	0	1	0.032	0.032	0.031	0.031	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.032	0.032	0.031	0.031	$ 11	$ 0.36	$ 0.36	$ 0.35	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.032	0.032	0.031	0.031	$ 4	$ 0.13	$ 0.13	$ 0.12	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.032	0.032	0.031	0.031	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.032	0.032	0.031	0.031	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.032	0.032	0.031	0.031	$ 23	$ 0.73	$ 0.73	$ 0.70	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.032	0.032	0.031	0.031	$ 28	$ 0.89	$ 0.89	$ 0.87	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.032	0.032	0.031	0.031	$ 18	$ 0.59	$ 0.59	$ 0.57	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.032	0.032	0.031	0.031	$ 14	$ 0.44	$ 0.44	$ 0.43	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.032	0.032	0.031	0.031	$ 44	$ 1.41	$ 1.41	$ 1.37	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.032	0.032	0.031	0.031	$ 34	$ 1.11	$ 1.11	$ 1.07	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.032	0.032	0.031	0.031	$ 22	$ 0.72	$ 0.72	$ 0.69	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.032	0.032	0.031	0.031	$ 17	$ 0.55	$ 0.55	$ 0.54	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.032	0.032	0.031	0.031	$ 11	$ 0.34	$ 0.34	$ 0.33	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.032	0.032	0.031	0.031	$ 27	$ 0.86	$ 0.86	$ 0.83	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.032	0.032	0.031	0.031	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.032	0.032	0.031	0.031	$ 25	$ 0.81	$ 0.81	$ 0.78	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.032	0.032	0.031	0.031	$ 16	$ 0.52	$ 0.52	$ 0.51	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.032	0.032	0.031	0.031	$ 12	$ 0.38	$ 0.38	$ 0.37	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.032	0.032	0.031	0.031	$ 19	$ 0.63	$ 0.63	$ 0.61	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.032	0.032	0.031	0.031	$ 17	$ 0.54	$ 0.54	$ 0.52	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.032	0.032	0.031	0.031	$ 14	$ 0.45	$ 0.45	$ 0.43	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.032	0.032	0.031	0.031	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.032	0.032	0.031	0.031	$ 31	$ 1.01	$ 1.01	$ 0.98	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.032	0.032	0.031	0.031	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.032	0.032	0.031	0.031	$ 72	$ 2.31	$ 2.31	$ 2.24	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.032	0.032	0.031	0.031	$ 49	$ 1.60	$ 1.60	$ 1.55	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.032	0.032	0.031	0.031	$ 30	$ 0.96	$ 0.96	$ 0.93	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.032	0.032	0.031	0.031	$ 24	$ 0.77	$ 0.77	$ 0.75	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.032	0.032	0.031	0.031	$ 19	$ 0.62	$ 0.62	$ 0.60	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1			0.031	0.031	$ 9	$ -	$ -	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.032	0.032	0.031	0.031	$ 14	$ 0.46	$ 0.46	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.34	$22.34	$21.91	$21.91
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.031	0.031	0.030	0.030	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.031	0.031	0.030	0.030	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.031	0.031	0.030	0.030	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.031	0.031	0.030	0.030	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.031	0.031	0.030	0.030	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.031	0.031	0.030	0.030	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.031	0.031	0.030	0.030	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.031	0.031	0.030	0.030	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.031	0.031	0.030	0.030	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.031	0.031	0.030	0.030	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.031	0.031	0.030	0.030	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.031	0.031	0.030	0.030	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.031	0.031	0.030	0.030	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.031	0.031	0.030	0.030	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.031	0.031	0.030	0.030	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.031	0.031	0.030	0.030	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.031	0.031	0.030	0.030	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.031	0.031	0.030	0.030	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.031	0.031	0.030	0.030	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.031	0.031	0.030	0.030	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.031	0.031	0.030	0.030	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.031	0.031	0.030	0.030	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.031	0.031	0.030	0.030	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.031	0.031	0.030	0.030	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.031	0.031	0.030	0.030	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.031	0.031	0.030	0.030	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.031	0.031	0.030	0.030	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.031	0.031	0.030	0.030	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.031	0.031	0.030	0.030	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.031	0.031	0.030	0.030	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.031	0.031	0.030	0.030	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.031	0.031	0.030	0.030	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.030	0.030	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$24.03	$24.03	$23.55	$23.55

Table 84: Primary Entrances Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	Total $/W	LZ1	LZ2	LZ3	LZ4
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.125	0.125	0.111	0.111	$ 5	$ 0.61	$ 0.61	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.125	0.125	0.111	0.111	$ 42	$ 5.22	$ 5.22	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.125	0.125	0.111	0.111	$ 5	$ 0.57	$ 0.57	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2	0.125	0.125	0.111	0.111	$ 11	$ 1.40	$ 1.40	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.125	0.125	0.111	0.111	$ 13	$ 1.62	$ 1.62	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1	0.125	0.125	0.111	0.111	$ 15	$ 1.84	$ 1.84	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2	0.125	0.125	0.111	0.111	$ 8	$ 0.97	$ 0.97	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2	0.125	0.125	0.111	0.111	$ 9	$ 1.11	$ 1.11	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2			0.111	0.111	$ 9	$ -	$ -	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00		$13.33	$13.33	$12.79	$12.79
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.045	0.042	0.040	0.040	$ 26	$ 1.20	$ 1.10	$ 1.06	$ 1.06
H	002	$ 639	14	0.70	846	0	4	0	0.045	0.042	0.040	0.040	$ 46	$ 2.07	$ 1.90	$ 1.83	$ 1.83
S	001	$ 147	26	0.70	823	1	0	0	0.045	0.042	0.040	0.040	$ 6	$ 0.25	$ 0.23	$ 0.22	$ 0.22
AH	001	$ 815	24	0.70	950	1	3	1	0.045	0.042	0.040	0.040	$ 34	$ 1.54	$ 1.41	$ 1.36	$ 1.36
C	001	$ 409	16	0.95	1,084	0	4	0	0.045	0.042	0.040	0.040	$ 26	$ 1.20	$ 1.10	$ 1.06	$ 1.06
S	002	$ 162	18	0.70	1,189	1	1	0	0.045	0.042	0.040	0.040	$ 9	$ 0.41	$ 0.38	$ 0.36	$ 0.36
C	001	$ 409	16	0.95	1,214	0	4	0	0.045	0.042	0.040	0.040	$ 26	$ 1.20	$ 1.10	$ 1.06	$ 1.06
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.045	0.042	0.040	0.040	$ 66	$ 3.01	$ 2.76	$ 2.65	$ 2.65
AF	001	$ 809	40	0.70	1,290	1	1	1	0.045	0.042	0.040	0.040	$ 20	$ 0.91	$ 0.83	$ 0.80	$ 0.80
V	005	$ 381	13	0.91	1,415	0	0	1	0.045	0.042	0.040	0.040	$ 29	$ 1.33	$ 1.22	$ 1.17	$ 1.17
V	004	$ 408	12	0.90	1,494	0	0	0	0.045	0.042	0.040	0.040	$ 34	$ 1.55	$ 1.42	$ 1.36	$ 1.36
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.045	0.042	0.040	0.040	$ 20	$ 0.89	$ 0.82	$ 0.79	$ 0.79
V	005	$ 381	19	0.91	1,957	1	0	1	0.045	0.042	0.040	0.040	$ 20	$ 0.91	$ 0.84	$ 0.80	$ 0.80
V	005	$ 381	19	0.91	2,031	1	0	1	0.045	0.042	0.040	0.040	$ 20	$ 0.91	$ 0.84	$ 0.80	$ 0.80
AE	001	$ 163	27	0.70	2,075	1	1	0	0.045	0.042	0.040	0.040	$ 6	$ 0.27	$ 0.25	$ 0.24	$ 0.24
AF	002	$ 368	20	0.70	2,054	1	1	1	0.045	0.042	0.040	0.040	$ 19	$ 0.85	$ 0.78	$ 0.75	$ 0.75
V	005	$ 381	26	0.91	2,623	1	0	1	0.045	0.042	0.040	0.040	$ 15	$ 0.67	$ 0.61	$ 0.59	$ 0.59
AG	001	$ 518	36	0.70	2,603	1	0	1	0.045	0.042	0.040	0.040	$ 14	$ 0.65	$ 0.60	$ 0.58	$ 0.58
V	004	$ 449	25	0.90	3,163	1	0	1	0.045	0.042	0.040	0.040	$ 18	$ 0.82	$ 0.75	$ 0.72	$ 0.72
V	005	$ 506	35	0.91	3,912	1	0	2	0.05	0.042	0.040	0.040	$ 14	$ 0.66	$ 0.60	$ 0.58	$ 0.58
V	004	$ 490	50	0.90	6,025	1	0	1	0.045	0.042	0.040	0.040	$ 10	$ 0.45	$ 0.41	$ 0.39	$ 0.39
B	004	$ 707	52	0.70	4,390	1	0	0	0.045	0.042	0.040	0.040	$ 14	$ 0.62	$ 0.57	$ 0.54	$ 0.54
V	005	$ 506	73	0.91	6,865	1	0	2		0.042	0.040	0.040	$ 7	$ -	$ 0.29	$ 0.28	$ 0.28
W	004	$ 1,027	76	0.70	8,051	3	0	3			0.040	0.040	$ 14	$ -	$ -	$ 0.54	$ 0.54
W	004	$ 1,107	101	0.70	12,064	2	0	2		0.042	0.040	0.040	$ 11	$ -	$ 0.46	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.38	$21.26	$20.95	$20.95
									1.0	1.0	1.0	1.0		$26.55	$26.29	$26.04	$26.04

Table 85: Drive-Up Window Cost per Watt

2019 LED									Weighted					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Cylindrical - Wall Mounted up/down																	
C	003	$ 619	10	0.87	838	2	5	0	0.09	0.09	0.09	0.09		$ 62	$ 5.63	$ 5.63	$ 5.63	$ 5.63
M	001	$ 950	8	0.70	900	1	1	0	0.09	0.09	0.09	0.09		$ 119	$10.79	$10.79	$10.79	$10.79
AO	001	$ 349	13	0.70	931	1	1	0	0.09	0.09	0.09	0.09		$ 27	$ 2.44	$ 2.44	$ 2.44	$ 2.44
H	003	$ 434	21	0.81	1,047	1	4	0	0.09	0.09	0.09	0.09		$ 21	$ 1.88	$ 1.88	$ 1.88	$ 1.88
AN	001	$ -	24	0.70	1,333	1	3	2	0.09	0.09	0.09	0.09		$ -	$ -	$ -	$ -	$ -
F	001	$ 1,056	34	0.70	2,212	2	5	0	0.09	0.09	0.09	0.09		$ 31	$ 2.82	$ 2.82	$ 2.82	$ 2.82
C	003	$ 862	29	0.70	2,319	2	5	0	0.09	0.09	0.09	0.09		$ 30	$ 2.75	$ 2.75	$ 2.75	$ 2.75
F	001	$ 1,067	42	0.70	3,288	3	5	0	0.09	0.09	0.09	0.09		$ 25	$ 2.31	$ 2.31	$ 2.31	$ 2.31
BA	001	$ -	34	0.70	3,800	3	5	0	0.09	0.09	0.09	0.09		$ -	$ -	$ -	$ -	$ -
F	001	$ 1,352	57	0.70	4,607	3	5	0	0.09	0.09	0.09	0.09		$ 24	$ 2.16	$ 2.16	$ 2.16	$ 2.16
AF	004	$ 1,214	76	0.70	4,884	1	5	1	0.09	0.09	0.09	0.09		$ 16	$ 1.46	$ 1.46	$ 1.46	$ 1.46
								SUM	1.00	1.00	1.00	1.00			$32.24	$32.24	$32.24	$32.24
Downlight																	
J	001	$ 561	10	0.70	647	1	0	0	0.03	0.03	0.03	0.03		$ 56	$ 1.94	$ 1.94	$ 1.94	$ 1.94
K	001	$ 220	13	0.70	780	1	1	0	0.03	0.03	0.03	0.03		$ 17	$ 0.58	$ 0.58	$ 0.58	$ 0.58
J	001	$ 561	14	0.70	884	1	0	0	0.03	0.03	0.03	0.03		$ 40	$ 1.38	$ 1.38	$ 1.38	$ 1.38
P	001	$ 208	14	0.89	1,066	1	1	0	0.03	0.03	0.03	0.03		$ 15	$ 0.51	$ 0.51	$ 0.51	$ 0.51
K	001	$ 286	22	0.70	1,170	2	1	0	0.03	0.03	0.03	0.03		$ 13	$ 0.45	$ 0.45	$ 0.45	$ 0.45
K	001	$ 272	22	0.70	1,426	2	1	0	0.03	0.03	0.03	0.03		$ 12	$ 0.43	$ 0.43	$ 0.43	$ 0.43
K	002	$ 236	19	0.70	1,461	2	0	0	0.03	0.03	0.03	0.03		$ 13	$ 0.44	$ 0.44	$ 0.44	$ 0.44
K	002	$ 236	23	0.70	1,860	2	0	0	0.03	0.03	0.03	0.03		$ 10	$ 0.35	$ 0.35	$ 0.35	$ 0.35
P	001	$ 237	36	0.89	1,995	2	1	0	0.03	0.03	0.03	0.03		$ 7	$ 0.23	$ 0.23	$ 0.23	$ 0.23
C	005	$ 94	21	0.70	1,914	2	0	0	0.03	0.03	0.03	0.03		$ 4	$ 0.15	$ 0.15	$ 0.15	$ 0.15
P	001	$ 237	35	0.89	2,130	2	1	0	0.03	0.03	0.03	0.03		$ 7	$ 0.23	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	28	0.70	2,203	2	0	0	0.03	0.03	0.03	0.03		$ 4	$ 0.14	$ 0.14	$ 0.14	$ 0.14
K	002	$ 251	30	0.70	2,521	2	0	0	0.03	0.03	0.03	0.03		$ 9	$ 0.29	$ 0.29	$ 0.29	$ 0.29
P	001	$ 257	41	0.89	2,621	3	1	0	0.03	0.03	0.03	0.03		$ 6	$ 0.22	$ 0.22	$ 0.22	$ 0.22
Q	001	$ -	29	0.90	2,754	2	0	0	0.03	0.03	0.03	0.03		$ -	$ -	$ -	$ -	$ -
K	002	$ 266	37	0.70	2,917	3	0	0	0.03	0.03	0.03	0.03		$ 7	$ 0.25	$ 0.25	$ 0.25	$ 0.25
Q	001	$ -	29	0.90	2,944	2	0	0	0.03	0.03	0.03	0.03		$ -	$ -	$ -	$ -	$ -
K	002	$ 310	48	0.70	3,029	3	0	0	0.03	0.03	0.03	0.03		$ 6	$ 0.22	$ 0.22	$ 0.22	$ 0.22
P	001	$ 256	44	0.89	3,184	3	1	0	0.03	0.03	0.03	0.03		$ 6	$ 0.20	$ 0.20	$ 0.20	$ 0.20
C	005	$ 112	42	0.70	3,300	3	0	0	0.03	0.03	0.03	0.03		$ 3	$ 0.09	$ 0.09	$ 0.09	$ 0.09
K	002	$ 295	48	0.70	3,839	3	0	0	0.03	0.03	0.03	0.03		$ 6	$ 0.21	$ 0.21	$ 0.21	$ 0.21
K	002	$ 310	47	0.70	4,234	3	0	0	0.03	0.03	0.03	0.03		$ 7	$ 0.23	$ 0.23	$ 0.23	$ 0.23
Q	001	$ -	41	0.90	4,327	3	0	0	0.03	0.03	0.03	0.03		$ -	$ -	$ -	$ -	$ -
K	002	$ 324	49	0.70	4,982	3	0	0	0.03	0.03	0.03	0.03		$ 7	$ 0.23	$ 0.23	$ 0.23	$ 0.23
Q	001	$ -	58	0.80	6,305	4	0	0	0.03	0.03	0.03	0.03		$ -	$ -	$ -	$ -	$ -
K	002	$ 427	75	0.70	6,168	3	0	0	0.03	0.03	0.03	0.03		$ 6	$ 0.20	$ 0.20	$ 0.20	$ 0.20
AR	002	$ 585	57	0.70	5,716	3	1	1	0.03	0.03	0.03	0.03		$ 10	$ 0.35	$ 0.35	$ 0.35	$ 0.35
C	005	$ 175	115	0.70	7,816	4	0	0	0.03	0.03	0.03	0.03		$ 2	$ 0.05	$ 0.05	$ 0.05	$ 0.05
K	002	$ 530	115	0.70	11,296	3	0	0	0.03	0.03	0.03	0.03		$ 5	$ 0.16	$ 0.16	$ 0.16	$ 0.16
								SUM	1	1	1	1			$ 9.54	$ 9.54	$ 9.54	$ 9.54
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.11	0.11	0.10	0.10		$ 5	$ 0.54	$ 0.54	$ 0.49	$ 0.49
BB	001	$ 793	19	0.70	1,509	1	0	0	0.11	0.11	0.10	0.10		$ 42	$ 4.64	$ 4.64	$ 4.17	$ 4.17
Q	002	$ 61	14	0.70	1,081	1	1	0	0.11	0.11	0.10	0.10		$ 5	$ 0.50	$ 0.50	$ 0.45	$ 0.45
T	001	$ 272	24	0.70	3,055	2	3	2	0.11	0.11	0.10	0.10		$ 11	$ 1.24	$ 1.24	$ 1.12	$ 1.12
C	006	$ 363	28	0.70	3,293	1	0	1	0.11	0.11	0.10	0.10		$ 13	$ 1.44	$ 1.44	$ 1.30	$ 1.30
BB	002	$ -	35	0.70	3,147	1	0	1	0.11	0.11	0.10	0.10		$ -	$ -	$ -	$ -	$ -
AL	002	$ 455	31	0.70	4,210	2	2	1	0.11	0.11	0.10	0.10		$ 15	$ 1.63	$ 1.63	$ 1.47	$ 1.47
T	001	$ 296	38	0.70	4,443	2	3	2	0.11	0.11	0.10	0.10		$ 8	$ 0.86	$ 0.86	$ 0.78	$ 0.78
C	006	$ 398	45	0.70	4,949	3	0	2	0.11	0.11	0.10	0.10		$ 9	$ 0.98	$ 0.98	$ 0.88	$ 0.88
T	001	$ 465	55	0.70	6,959	2	3	2			0.10	0.10		$ 9	$ -	$ -	$ 0.85	$ 0.85
								SUM	1.00	1.00	1.00	1.00		$ 115	$11.84	$11.84	$11.51	$11.51

Table 86: Drive-Up Window Cost per Watt, continued

2019 LED									Weighted					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Recessed Linear																	
AB	002	$ 424	18	0.70	1,371	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.74	$ 0.74	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.03	0.03	0.03	0.03	$ 11	$ 0.36	$ 0.35	$ 0.35	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.03	0.03	0.03	0.03	$ 4	$ 0.13	$ 0.12	$ 0.12	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.58	$ 0.58	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.44	$ 0.44	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 23	$ 0.73	$ 0.70	$ 0.70	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 28	$ 0.89	$ 0.87	$ 0.87	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.59	$ 0.57	$ 0.57	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.43	$ 0.43	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 44	$ 1.41	$ 1.37	$ 1.37	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 34	$ 1.11	$ 1.07	$ 1.07	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 22	$ 0.72	$ 0.69	$ 0.69	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.54	$ 0.54	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.03	0.03	0.03	0.03	$ 11	$ 0.34	$ 0.33	$ 0.33	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.03	0.03	0.03	0.03	$ 27	$ 0.86	$ 0.83	$ 0.83	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.39	$ 0.39	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 25	$ 0.81	$ 0.78	$ 0.78	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.52	$ 0.51	$ 0.51	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 12	$ 0.38	$ 0.37	$ 0.37	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.63	$ 0.61	$ 0.61	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.52	$ 0.52	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.43	$ 0.43	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.39	$ 0.39	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.03	0.03	0.03	0.03	$ 31	$ 1.01	$ 0.98	$ 0.98	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.53	$ 0.53	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 72	$ 2.31	$ 2.24	$ 2.24	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 49	$ 1.60	$ 1.55	$ 1.55	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 30	$ 0.96	$ 0.93	$ 0.93	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 24	$ 0.77	$ 0.75	$ 0.75	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 19	$ 0.62	$ 0.60	$ 0.60	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1		0.03	0.03	0.03	$ 9	$ -	$ 0.28	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.03	0.03	0.03	0.03	$ 14	$ 0.46	$ 0.44	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.34	$21.91	$21.91	$21.91
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00	$ 777	$24.03	$24.03	$23.55	$23.55

Table 87: Drive-Up Window Cost per Watt, continued

2019 LED									Weighted					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.05	0.05	0.05	0.05		$ 26	$ 1.20	$ 1.20	$ 1.20	$ 1.20
H	002	$ 639	14	0.70	846	0	4	0	0.05	0.05	0.05	0.05		$ 46	$ 2.07	$ 2.07	$ 2.07	$ 2.07
S	001	$ 147	26	0.70	823	1	0	0	0.05	0.05	0.05	0.05		$ 6	$ 0.25	$ 0.25	$ 0.25	$ 0.25
AH	001	$ 815	24	0.70	950	1	3	1	0.05	0.05	0.05	0.05		$ 34	$ 1.54	$ 1.54	$ 1.54	$ 1.54
C	001	$ 409	16	0.95	1,084	0	4	0	0.05	0.05	0.05	0.05		$ 26	$ 1.20	$ 1.20	$ 1.20	$ 1.20
S	002	$ 162	18	0.70	1,189	1	1	0	0.05	0.05	0.05	0.05		$ 9	$ 0.41	$ 0.41	$ 0.41	$ 0.41
C	001	$ 409	16	0.95	1,214	0	4	0	0.05	0.05	0.05	0.05		$ 26	$ 1.20	$ 1.20	$ 1.20	$ 1.20
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.05	0.05	0.05	0.05		$ 66	$ 3.01	$ 3.01	$ 3.01	$ 3.01
AF	001	$ 809	40	0.70	1,290	1	1	1	0.05	0.05	0.05	0.05		$ 20	$ 0.91	$ 0.91	$ 0.91	$ 0.91
V	005	$ 381	13	0.91	1,415	0	0	1	0.05	0.05	0.05	0.05		$ 29	$ 1.33	$ 1.33	$ 1.33	$ 1.33
V	004	$ 408	12	0.90	1,494	0	0	0	0.05	0.05	0.05	0.05		$ 34	$ 1.55	$ 1.55	$ 1.55	$ 1.55
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.05	0.05	0.05	0.05		$ 20	$ 0.89	$ 0.89	$ 0.89	$ 0.89
V	005	$ 381	19	0.91	1,957	1	0	1	0.05	0.05	0.05	0.05		$ 20	$ 0.91	$ 0.91	$ 0.91	$ 0.91
V	005	$ 381	19	0.91	2,031	1	0	1	0.05	0.05	0.05	0.05		$ 20	$ 0.91	$ 0.91	$ 0.91	$ 0.91
AE	001	$ 163	27	0.70	2,075	1	1	0	0.05	0.05	0.05	0.05		$ 6	$ 0.27	$ 0.27	$ 0.27	$ 0.27
AF	002	$ 368	20	0.70	2,054	1	1	1	0.05	0.05	0.05	0.05		$ 19	$ 0.85	$ 0.85	$ 0.85	$ 0.85
V	005	$ 381	26	0.91	2,623	1	0	1	0.05	0.05	0.05	0.05		$ 15	$ 0.67	$ 0.67	$ 0.67	$ 0.67
AG	001	$ 518	36	0.70	2,603	1	0	1	0.05	0.05	0.05	0.05		$ 14	$ 0.65	$ 0.65	$ 0.65	$ 0.65
V	004	$ 449	25	0.90	3,163	1	0	1	0.05	0.05	0.05	0.05		$ 18	$ 0.82	$ 0.82	$ 0.82	$ 0.82
V	005	$ 506	35	0.91	3,912	1	0	2	0.05	0.05	0.05	0.05		$ 14	$ 0.66	$ 0.66	$ 0.66	$ 0.66
V	004	$ 490	50	0.90	6,025	1	0	1	0.05	0.05	0.05	0.05		$ 10	$ 0.45	$ 0.45	$ 0.45	$ 0.45
B	004	$ 707	52	0.70	4,390	1	0	0	0.05	0.05	0.05	0.05		$ 14	$ 0.62	$ 0.62	$ 0.62	$ 0.62
								SUM	1.00	1.00	1.00	1.00		$ 492	$22.38	$22.38	$22.38	$22.38
									1	1	1	1			$20.40	$20.33	$20.19	$20.19

Table 88: Uncovered Fuel Dispenser Cost per Watt

2019 LED									Weighting					Weighted Cost			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.50	0.20	0.11	0.09	$ 21	$10.40	$ 4.16	$ 2.31	$ 1.89
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.20	0.11	0.09	$ 11	$ -	$ 2.21	$ 1.23	$ 1.01
C	009	$ 863	124	0.95	14,200	2	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.77	$ 0.63
V	002	$ 1,074	125	0.91	13,999	3	0	1	0.50	0.20	0.11	0.09	$ 9	$ 4.29	$ 1.72	$ 0.95	$ 0.78
C	008	$ 1,544	149	0.96	18,132	3	0	3			0.11	0.09	$ 10	$ -	$ -	$ 1.15	$ 0.94
W	005	$ 960	183	0.88	18,162	3	0	3			0.11	0.09	$ 5	$ -	$ -	$ 0.58	$ 0.48
V	002	$ 1,081	163	0.91	17,683	3	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.74	$ 0.60
C	009	$ 1,114	210	0.90	23,769	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.48
V	002	$ 1,159	241	0.91	24,870	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.44
C	009	$ 1,384	448	0.90	45,673	3	0	5					$ 3	$ -	$ -	$ -	$ -
V	003	$ 1,603	448	0.91	45,686	4	0	5					$ 4	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00		$14.69	$14.20	$11.13	$10.03
Flood																	
AT	001	$ 571	70	0.93	7,389				0.33	0.25	0.17	0.13	$ 8	$ 2.72	$ 2.04	$ 1.36	$ 1.02
AL	001	$ 256	64	0.87	9,275				0.33	0.25	0.17	0.13	$ 4	$ 1.33	$ 1.00	$ 0.67	$ 0.50
AT	002	$ 953	90	0.92	10,699					0.25	0.17	0.13	$ 11	$ -	$ 2.65	$ 1.77	$ 1.32
C	007	$ 1,305	99	0.70	11,100				0.33	0.25	0.17	0.13	$ 13	$ 4.40	$ 3.30	$ 2.20	$ 1.65
AT	002	$ 1,017	135	0.92	13,709						0.17	0.13	$ 8	$ -	$ -	$ 1.26	$ 0.94
AT	002	$ 1,079	175	0.92	17,615						0.17	0.13	$ 6	$ -	$ -	$ 1.03	$ 0.77
W	001	$ 1,039	213	0.96	20,138							0.13	$ 5	$ -	$ -	$ -	$ 0.61
V	001	$ 690	244	0.96	28,237							0.13	$ 3	$ -	$ -	$ -	$ 0.35
								SUM	1.00	1.00	1.00	1.00		$ 8.45	$ 8.98	$ 8.27	$ 7.17
Wall Mounted																	
V	005	$ 506	35	0.91	3,912	1	0	2	0.25	0.17	0.14	0.14	$ 14	$ 3.61	$ 2.41	$ 2.06	$ 2.06
V	004	$ 490	50	0.90	6,025	1	0	1	0.25	0.17	0.14	0.14	$ 10	$ 2.45	$ 1.63	$ 1.40	$ 1.40
W	007	$ -	52	0.99	6,076	1	0	2	0.25	0.17	0.14	0.14	$-	$ -	$ -	$ -	$ -
V	004	$ 490	50	0.90	6,025	1	0	1	0.25	0.17	0.14	0.14	$ 10	$ 2.45	$ 1.63	$ 1.40	$ 1.40
V	005	$ 506	73	0.91	6,865	1	0	2		0.17	0.14	0.14	$ 7	$ -	$ 1.15	$ 0.99	$ 0.99
W	004	$ 1,027	76	0.70	8,051	3	0	3			0.14	0.14	$ 14	$ -	$ -	$ 1.93	$ 1.93
W	004	$ 1,107	101	0.70	12,064	2	0	2		0.17	0.14	0.14	$ 11	$ -	$ 1.83	$ 1.57	$ 1.57
								SUM	1.00	1.00	1.00	1.00		$ 8.51	$ 8.66	$ 9.35	$ 9.35
									1.00	1.00	1.00	1.00		$10.55	$10.61	$ 9.59	$ 8.85

Table 89: ATM Machine Lighting Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
Cylindrical - Wall Mounted up/down																
C	003	$ 619	10	0.87	838	2	5	0	0.09	0.09	0.09	0.09	$ 62	$ 5.63	$ 5.63	$ 5.63
M	001	$ 950	8	0.70	900	1	1	0	0.09	0.09	0.09	0.09	$ 119	$ 10.79	$ 10.79	$ 10.79
AO	001	$ 349	13	0.70	931	1	1	0	0.09	0.09	0.09	0.09	$ 27	$ 2.44	$ 2.44	$ 2.44
H	003	$ 434	21	0.81	1,047	1	4	0	0.09	0.09	0.09	0.09	$ 21	$ 1.88	$ 1.88	$ 1.88
AN	001	$ -	24	0.70	1,333	1	3	2	0.09	0.09	0.09	0.09	$ -	$ -	$ -	$ -
F	001	$ 1,056	34	0.70	2,212	2	5	0	0.09	0.09	0.09	0.09	$ 31	$ 2.82	$ 2.82	$ 2.82
C	003	$ 862	29	0.70	2,319	2	5	0	0.09	0.09	0.09	0.09	$ 30	$ 2.75	$ 2.75	$ 2.75
F	001	$ 1,067	42	0.70	3,288	3	5	0	0.09	0.09	0.09	0.09	$ 25	$ 2.31	$ 2.31	$ 2.31
BA	001	$ -	34	0.70	3,800				0.09	0.09	0.09	0.09	$ -	$ -	$ -	$ -
F	001	$ 1,352	57	0.70	4,607	3	5	0	0.09	0.09	0.09	0.09	$ 24	$ 2.16	$ 2.16	$ 2.16
AF	004	$ 1,214	76	0.70	4,884	1	5	1	0.09	0.09	0.09	0.09	$ 16	$ 1.46	$ 1.46	$ 1.46
								SUM	1.00	1.00	1.00	1.00	$ 355	$ 32.24	$ 32.24	$ 32.24
Downlight																
J	001	$ 561	10	0.70	647	1	0	0	0.04	0.04	0.04	0.04	$ 56	$ 2.44	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.04	0.04	0.04	0.04	$ 17	$ 0.74	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.04	0.04	0.04	0.04	$ 40	$ 1.74	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.04	0.04	0.04	0.04	$ 15	$ 0.65	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.04	0.04	0.04	0.04	$ 13	$ 0.57	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.04	0.04	0.04	0.04	$ 12	$ 0.54	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.04	0.04	0.04	0.04	$ 13	$ 0.56	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.04	0.04	0.04	0.04	$ 10	$ 0.44	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.19	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.18	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.04	0.04	0.04	0.04	$ 9	$ 0.37	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.32	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.04	0.04	0.04	0.04	$ 3	$ 0.12	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.27	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.04	0.04	0.04	0.04	$ 10	$ 0.45	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0		0.04	0.04	0.04	$ 2	$ -	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0		0.04	0.04	0.04	$ 5	$ -	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00	$ 277	$ 11.77	$ 11.07	$ 11.07
Recessed Linear																
AB	002	$ 424	18	0.70	1,371	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.03	0.03	0.03	0.03	$ 11	$ 0.36	$ 0.36	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.03	0.03	0.03	0.03	$ 4	$ 0.13	$ 0.13	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 23	$ 0.73	$ 0.73	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 28	$ 0.89	$ 0.89	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.59	$ 0.59	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 44	$ 1.41	$ 1.41	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 34	$ 1.11	$ 1.11	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 22	$ 0.72	$ 0.72	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.03	0.03	0.03	0.03	$ 11	$ 0.34	$ 0.34	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.03	0.03	0.03	0.03	$ 27	$ 0.86	$ 0.86	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 25	$ 0.81	$ 0.81	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.52	$ 0.52	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 12	$ 0.38	$ 0.38	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.63	$ 0.63	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.03	0.03	0.03	0.03	$ 31	$ 1.01	$ 1.01	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 72	$ 2.31	$ 2.31	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 49	$ 1.60	$ 1.60	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 30	$ 0.96	$ 0.96	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 24	$ 0.77	$ 0.77	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 19	$ 0.62	$ 0.62	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1			0.03	0.03	$ 9	$ -	$ -	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.03	0.03	0.03	0.03	$ 14	$ 0.46	$ 0.46	$ 0.44
								SUM	1.00	1.00	1.00	1.00	$ 701	$ 22.34	$ 22.34	$ 21.91

Table 90: ATM Machine Lighting Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.13	0.13	0.11	0.11		$ 5	$ 0.61	$ 0.61	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.13	0.13	0.11	0.11		$ 42	$ 5.22	$ 5.22	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.13	0.13	0.11	0.11		$ 5	$ 0.57	$ 0.57	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2	0.13	0.13	0.11	0.11		$ 11	$ 1.40	$ 1.40	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.13	0.13	0.11	0.11		$ 13	$ 1.62	$ 1.62	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1	0.13	0.13	0.11	0.11		$ 15	$ 1.84	$ 1.84	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2	0.13	0.13	0.11	0.11		$ 8	$ 0.97	$ 0.97	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2	0.13	0.13	0.11	0.11		$ 9	$ 1.11	$ 1.11	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2			0.11	0.11		$ 9	$ -	$ -	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00		$ 115	$ 13.33	$ 13.33	$ 12.79	$ 12.79
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03		$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03		$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03		$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03		$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03		$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03		$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03		$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03		$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03		$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03		$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03		$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03		$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03		$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03		$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03		$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03		$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03		$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03		$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03		$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03		$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03		$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03		$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03		$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03		$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03		$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03		$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03		$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03		$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03		$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03		$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03		$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03		$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03		$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$ 777	$ 24.03	$ 24.03	$ 23.55	$ 23.55
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.04	0.04	0.04	0.04		$ 26	$ 1.15	$ 1.15	$ 1.15	$ 1.15
H	002	$ 639	14	0.70	846	0	4	0	0.04	0.04	0.04	0.04		$ 46	$ 1.98	$ 1.98	$ 1.98	$ 1.98
S	001	$ 147	26	0.70	823	1	0	0	0.04	0.04	0.04	0.04		$ 6	$ 0.24	$ 0.24	$ 0.24	$ 0.24
AH	001	$ 815	24	0.70	950	1	3	1	0.04	0.04	0.04	0.04		$ 34	$ 1.48	$ 1.48	$ 1.48	$ 1.48
C	001	$ 409	16	0.95	1,084	0	4	0	0.04	0.04	0.04	0.04		$ 26	$ 1.15	$ 1.15	$ 1.15	$ 1.15
S	002	$ 162	18	0.70	1,189	1	1	0	0.04	0.04	0.04	0.04		$ 9	$ 0.39	$ 0.39	$ 0.39	$ 0.39
C	001	$ 409	16	0.95	1,214	0	4	0	0.04	0.04	0.04	0.04		$ 26	$ 1.15	$ 1.15	$ 1.15	$ 1.15
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.04	0.04	0.04	0.04		$ 66	$ 2.88	$ 2.88	$ 2.88	$ 2.88
AF	001	$ 809	40	0.70	1,290	1	1	1	0.04	0.04	0.04	0.04		$ 20	$ 0.87	$ 0.87	$ 0.87	$ 0.87
V	005	$ 381	13	0.91	1,415	0	0	1	0.04	0.04	0.04	0.04		$ 29	$ 1.28	$ 1.28	$ 1.28	$ 1.28
V	004	$ 408	12	0.90	1,494	0	0	0	0.04	0.04	0.04	0.04		$ 34	$ 1.48	$ 1.48	$ 1.48	$ 1.48
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.04	0.04	0.04	0.04		$ 20	$ 0.85	$ 0.85	$ 0.85	$ 0.85
V	005	$ 381	19	0.91	1,957	1	0	1	0.04	0.04	0.04	0.04		$ 20	$ 0.87	$ 0.87	$ 0.87	$ 0.87
V	005	$ 381	19	0.91	2,031	1	0	1	0.04	0.04	0.04	0.04		$ 20	$ 0.87	$ 0.87	$ 0.87	$ 0.87
AE	001	$ 163	27	0.70	2,075	1	1	0	0.04	0.04	0.04	0.04		$ 6	$ 0.26	$ 0.26	$ 0.26	$ 0.26
AF	002	$ 368	20	0.70	2,054	1	1	1	0.04	0.04	0.04	0.04		$ 19	$ 0.82	$ 0.82	$ 0.82	$ 0.82
V	005	$ 381	26	0.91	2,623	1	0	1	0.04	0.04	0.04	0.04		$ 15	$ 0.64	$ 0.64	$ 0.64	$ 0.64
AG	001	$ 518	36	0.70	2,603	1	0	1	0.04	0.04	0.04	0.04		$ 14	$ 0.63	$ 0.63	$ 0.63	$ 0.63
V	004	$ 449	25	0.90	3,163	1	0	1	0.04	0.04	0.04	0.04		$ 18	$ 0.78	$ 0.78	$ 0.78	$ 0.78
V	005	$ 506	35	0.91	3,912	1	0	2	0.04	0.04	0.04	0.04		$ 14	$ 0.63	$ 0.63	$ 0.63	$ 0.63
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04		$ 10	$ 0.43	$ 0.43	$ 0.43	$ 0.43
B	004	$ 707	52	0.70	4,390	1	0	0	0.04	0.04	0.04	0.04		$ 14	$ 0.59	$ 0.59	$ 0.59	$ 0.59
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04		$ 10	$ 0.43	$ 0.43	$ 0.43	$ 0.43
								SUM	1.00	1.00	1.00	1.00		$ 502	$ 21.84	$ 21.84	$ 21.84	$ 21.84
									1	1	1	1		$ 20.92	$ 20.81	$ 20.57	$ 20.57

Table 91: Outdoor Sales Frontage Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt				
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.50	0.20	0.11	0.09	$ 21	$10.40	$ 4.16	$ 2.31	$ 1.89
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.20	0.11	0.09	$ 11	$ -	$ 2.21	$ 1.23	$ 1.01
C	009	$ 863	124	0.95	14,200	2	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.77	$ 0.63
V	002	$ 1,074	125	0.91	13,999	3	0	1	0.50	0.20	0.11	0.09	$ 9	$ 4.29	$ 1.72	$ 0.95	$ 0.78
C	008	$ 1,544	149	0.96	18,132	3	0	3			0.11	0.09	$ 10	$ -	$ -	$ 1.15	$ 0.94
W	005	$ 960	183	0.88	18,162	3	0	3			0.11	0.09	$ 5	$ -	$ -	$ 0.58	$ 0.48
V	002	$ 1,081	163	0.91	17,683	3	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.74	$ 0.60
C	009	$ 1,114	210	0.90	23,769	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.48
V	002	$ 1,159	241	0.91	24,870	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.44
C	009	$ 1,384	448	0.90	45,673	3	0	5					$ 3	$ -	$ -	$ -	$ -
V	003	$ 1,603	448	0.91	45,686	4	0	5					$ 4	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00		$14.69	$14.20	$11.13	$10.03
Flood																	
AT	001	$ 571	70	0.93	7,389	-	-	-		1.00	0.25	0.13	$ 8	$ -	$ 8.16	$ 2.04	$ 1.02
AL	001	$ 256	64	0.87	9,275	-	-	-			0.25	0.13	$ 4	$ -	$ -	$ 1.00	$ 0.50
AT	002	$ 953	90	0.92	10,699	-	-	-			0.25	0.13	$ 11	$ -	$ -	$ 2.65	$ 1.32
C	007	$ 1,305	99	0.70	11,100	-	-	-			0.25	0.13	$ 13	$ -	$ -	$ 3.30	$ 1.65
AT	002	$ 1,017	135	0.92	13,709	-	-	-				0.13	$ 8	$ -	$ -	$ -	$ 0.94
AT	002	$ 1,079	175	0.92	17,615	-	-	-				0.13	$ 6	$ -	$ -	$ -	$ 0.77
W	001	$ 1,039	213	0.96	20,138	-	-	-				0.13	$ 5	$ -	$ -	$ -	$ 0.61
V	001	$ 690	244	0.96	28,237	-	-	-				0.13	$ 3	$ -	$ -	$ -	$ 0.35
								SUM	0.00	1.00	1.00	1.00		$ -	$ 8.16	$ 8.98	$ 7.17
									0.50	1.00	1.00	1.00		$ 7.35	$11.18	$10.06	$ 8.60

Table 92: Hardscape Ornamental Lighting Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt				
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
N	001	$ 22	1	0.70	90	0	1	0	0.05	0.04	0.04	0.04	$ 23	$ 1.09	$ 0.96	$ 0.96	$ 0.96
R	001	$ 45	1	0.70	42	0	3	1	0.05	0.04	0.04	0.04	$ 45	$ 2.14	$ 1.87	$ 1.87	$ 1.87
R	001	$ 45	3	0.70	256	0	3	1	0.05	0.04	0.04	0.04	$ 15	$ 0.71	$ 0.62	$ 0.62	$ 0.62
O	001	$ 806	13	0.70	925	1	0	0	0.05	0.04	0.04	0.04	$ 61	$ 2.89	$ 2.52	$ 2.52	$ 2.52
B	002	$ 1,381	25	0.93	1,170	1	2	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.30	$ 2.30	$ 2.30
B	002	$ 1,381	25	0.93	1,216	1	1	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.30	$ 2.30	$ 2.30
B	002	$ 1,381	25	0.93	1,735	1	0	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.30	$ 2.30	$ 2.30
A	002	$ 1,553	21	0.83	2,051	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.08	$ 3.08	$ 3.08
A	002	$ 1,553	21	0.83	2,189	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.08	$ 3.08	$ 3.08
A	002	$ 1,553	21	0.83	2,114	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.08	$ 3.08	$ 3.08
A	002	$ 1,553	30	0.83	2,760	1	0	1	0.05	0.04	0.04	0.04	$ 52	$ 2.47	$ 2.16	$ 2.16	$ 2.16
B	002	$ 1,381	25	0.93	1,830	1	0	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.30	$ 2.30	$ 2.30
W	002	$ 1,970	22	0.84	2,117	1	0	1	0.05	0.04	0.04	0.04	$ 90	$ 4.26	$ 3.73	$ 3.73	$ 3.73
BD	001	$ 1,434	36	0.92	2,221	1	0	1	0.05	0.04	0.04	0.04	$ 40	$ 1.90	$ 1.66	$ 1.66	$ 1.66
W	003	$ 1,071	30	0.84	3,126	1	0	1	0.05	0.04	0.04	0.04	$ 36	$ 1.70	$ 1.49	$ 1.49	$ 1.49
BD	001	$ 1,434	52	0.92	3,178	1	0	1	0.05	0.04	0.04	0.04	$ 28	$ 1.31	$ 1.15	$ 1.15	$ 1.15
AF	003	$ 1,776	48	0.70	4,247	1	0	1	0.05	0.04	0.04	0.04	$ 37	$ 1.76	$ 1.54	$ 1.54	$ 1.54
A	001	$ 1,379	22	0.84	1,888	1	0	1	0.05	0.04	0.04	0.04	$ 63	$ 2.98	$ 2.61	$ 2.61	$ 2.61
A	001	$ 1,379	51	0.84	4,431	2	0	2	0.05	0.04	0.04	0.04	$ 27	$ 1.29	$ 1.13	$ 1.13	$ 1.13
A	001	$ 1,379	51	0.84	4,348	1	0	1	0.05	0.04	0.04	0.04	$ 27	$ 1.29	$ 1.13	$ 1.13	$ 1.13
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.05	0.04	0.04	0.04	$ 21	$ 0.99	$ 0.87	$ 0.87	$ 0.87
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.04	0.04	0.04	$ 15	$ -	$ 0.64	$ 0.64	$ 0.64
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.04	0.04	0.04	$ 15	$ -	$ 0.64	$ 0.64	$ 0.64
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.04	0.04	0.04	$ 11	$ -	$ 0.46	$ 0.46	$ 0.46
								SUM	1.00	1.00	1.00	1.00		$47.87	$43.62	$43.62	$43.62
									1.00	1.00	1.00	1.00		$47.87	$43.62	$43.62	$43.62

Table 93: Building Facades Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Cylindrical - Wall Mounted up/down																	
C	003	$ 619	10	0.87	838	2	5	0	0.10	0.10	0.10	0.10	$ 62	$ 6.19	$ 6.19	$ 6.19	$ 6.19
M	001	$ 950	8	0.70	900	1	1	0	0.10	0.10	0.10	0.10	$ 119	$11.87	$11.87	$11.87	$11.87
AO	001	$ 349	13	0.70	931	1	1	0	0.10	0.10	0.10	0.10	$ 27	$ 2.69	$ 2.69	$ 2.69	$ 2.69
H	003	$ 434	21	0.81	1,047	1	4	0	0.10	0.10	0.10	0.10	$ 21	$ 2.07	$ 2.07	$ 2.07	$ 2.07
AN	001	$ -	24	0.70	1,333	1	3	2	0.10	0.10	0.10	0.10	$ -	$ -	$ -	$ -	$ -
F	001	$ 1,056	34	0.70	2,212	2	5	0	0.10	0.10	0.10	0.10	$ 31	$ 3.10	$ 3.10	$ 3.10	$ 3.10
C	003	$ 862	29	0.70	2,319	2	5	0	0.10	0.10	0.10	0.10	$ 30	$ 3.02	$ 3.02	$ 3.02	$ 3.02
F	001	$ 1,067	42	0.70	3,288	3	5	0	0.10	0.10	0.10	0.10	$ 25	$ 2.54	$ 2.54	$ 2.54	$ 2.54
BA	001	$ -	34	0.70	3,800	na	na	na	0.10	0.10	0.10	0.10	$ -	$ -	$ -	$ -	$ -
F	001	$ 1,352	57	0.70	4,607	3	5	0	0.10	0.10	0.10	0.10	$ 24	$ 2.37	$ 2.37	$ 2.37	$ 2.37
AF	004	$ 1,214	76	0.70	4,884	1	5	1	0.10	0.10	0.10	0.10	$ 16	$ 1.61	$ 1.61	$ 1.61	$ 1.61
								SUM	1.00	1.00	1.00	1.00		$33.86	$33.86	$33.86	$33.86
Ground Mounted Floodlight																	
U	001	$ 3,053	104	0.70	5,833	-	-	-	0.50	0.33	0.25	0.17	$ 29	$14.68	$ 9.79	$ 7.34	$ 4.89
AS	001	$ 2,302	60	0.70	4,088	-	-	-	0.50	0.33	0.25	0.17	$ 38	$19.18	$12.79	$ 9.59	$ 6.39
U	001	$ 2,760	156	0.70	10,602	-	-	-			0.25	0.17	$ 18	$ -	$ -	$ 4.42	$ 2.95
AM	001	$ 2,307	150	0.70	8,899	-	-	-		0.33	0.25	0.17	$ 15	$ -	$ 5.13	$ 3.85	$ 2.56
AD	001	$ 3,917	200	0.70	12,163	-	-	-				0.17	$ 20	$ -	$ -	$ -	$ 3.26
AU	001	$ 4,198	122	0.70	14,040	-	-	-				0.17	$ 34	$ -	$ -	$ -	$ 5.74
								SUM	1.00	1.00	1.00	1.00		$33.86	$27.70	$25.20	$25.79
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.10	$ 1.10	$ 1.10
H	002	$ 639	14	0.70	846	0	4	0	0.04	0.04	0.04	0.04	$ 46	$ 1.98	$ 1.90	$ 1.90	$ 1.90
S	001	$ 147	26	0.70	823	1	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.24	$ 0.23	$ 0.23	$ 0.23
AH	001	$ 815	24	0.70	950	1	3	1	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.41	$ 1.41	$ 1.41
C	001	$ 409	16	0.95	1,084	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.10	$ 1.10	$ 1.10
S	002	$ 162	18	0.70	1,189	1	1	0	0.04	0.04	0.04	0.04	$ 9	$ 0.39	$ 0.38	$ 0.38	$ 0.38
C	001	$ 409	16	0.95	1,214	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.10	$ 1.10	$ 1.10
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.04	0.04	0.04	0.04	$ 66	$ 2.88	$ 2.76	$ 2.76	$ 2.76
AF	001	$ 809	40	0.70	1,290	1	1	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.83	$ 0.83	$ 0.83
V	005	$ 381	13	0.91	1,415	0	0	1	0.04	0.04	0.04	0.04	$ 29	$ 1.28	$ 1.22	$ 1.22	$ 1.22
V	004	$ 408	12	0.90	1,494	0	0	0	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.42	$ 1.42	$ 1.42
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.04	0.04	0.04	0.04	$ 20	$ 0.85	$ 0.82	$ 0.82	$ 0.82
V	005	$ 381	19	0.91	1,957	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.84	$ 0.84	$ 0.84
V	005	$ 381	19	0.91	2,031	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.84	$ 0.84	$ 0.84
AE	001	$ 163	27	0.70	2,075	1	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.26	$ 0.25	$ 0.25	$ 0.25
AF	002	$ 368	20	0.70	2,054	1	1	1	0.04	0.04	0.04	0.04	$ 19	$ 0.82	$ 0.78	$ 0.78	$ 0.78
V	005	$ 381	26	0.91	2,623	1	0	1	0.04	0.04	0.04	0.04	$ 15	$ 0.64	$ 0.61	$ 0.61	$ 0.61
AG	001	$ 518	36	0.70	2,603	1	0	1	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.60	$ 0.60	$ 0.60
V	004	$ 449	25	0.90	3,163	1	0	1	0.04	0.04	0.04	0.04	$ 18	$ 0.78	$ 0.75	$ 0.75	$ 0.75
V	005	$ 506	35	0.91	3,912	1	0	2	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.60	$ 0.60	$ 0.60
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.41	$ 0.41	$ 0.41
B	004	$ 707	52	0.70	4,390	1	0	0	0.04	0.04	0.04	0.04	$ 14	$ 0.59	$ 0.57	$ 0.57	$ 0.57
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.41	$ 0.41	$ 0.41
V	005	$ 506	73	0.91	6,865	1	0	2		0.04	0.04	0.04	$ 7	$ -	$ 0.29	$ 0.29	$ 0.29
								SUM	1.00	1.00	1.00	1.00		$ 1.00	$ 2.00	$ 3.00	$ 4.00
									1.00	1.00	1.00	1.00		$22.91	$21.19	$20.69	$21.22

Table 94: Outdoor Sales Lots Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.06	0.06	0.05	0.05	$ 21	$ 1.30	$ 1.22	$ 1.09	$ 0.95
A	001	$ 1,450	95	0.84	7,312	2	0	2	0.06	0.06	0.05	0.05	$ 15	$ 0.95	$ 0.90	$ 0.80	$ 0.69
A	001	$ 1,450	95	0.84	7,572	3	0	2	0.06	0.06	0.05	0.05	$ 15	$ 0.95	$ 0.90	$ 0.80	$ 0.69
W	004	$ 1,063	96	0.89	10,231	3	0	2	0.06	0.06	0.05	0.05	$ 11	$ 0.69	$ 0.65	$ 0.58	$ 0.50
C	009	$ 863	124	0.95	14,200	2	0	3	0.06	0.06	0.05	0.05	$ 7	$ 0.44	$ 0.41	$ 0.37	$ 0.32
V	002	$ 1,074	125	0.91	13,999	3	0	1	0.06	0.06	0.05	0.05	$ 9	$ 0.54	$ 0.51	$ 0.45	$ 0.39
C	008	$ 1,544	149	0.96	18,132	3	0	3	0.06	0.06	0.05	0.05	$ 10	$ 0.65	$ 0.61	$ 0.55	$ 0.47
W	005	$ 960	183	0.88	18,162	3	0	3	0.06	0.06	0.05	0.05	$ 5	$ 0.33	$ 0.31	$ 0.28	$ 0.24
V	002	$ 1,081	163	0.91	17,683	3	0	3	0.06	0.06	0.05	0.05	$ 7	$ 0.41	$ 0.39	$ 0.35	$ 0.30
C	009	$ 1,114	210	0.90	23,769	3	0	4	0.06	0.06	0.05	0.05	$ 5	$ 0.33	$ 0.31	$ 0.28	$ 0.24
V	002	$ 1,159	241	0.91	24,870	3	0	4	0.06	0.06	0.05	0.05	$ 5	$ 0.30	$ 0.28	$ 0.25	$ 0.22
C	009	$ 1,384	448	0.90	45,673	3	0	5	0.06	0.06	0.05	0.05	$ 3	$ 0.19	$ 0.18	$ 0.16	$ 0.14
V	003	$ 1,603	448	0.91	45,686	4	0	5	0.06	0.06	0.05	0.05	$ 4	$ 0.22	$ 0.21	$ 0.19	$ 0.16
								SUM	0.81	0.76	0.68	0.59		$ 7.31	$ 6.88	$ 6.16	$ 5.32
Flood																	
AT	001	$ 571	70	0.93	7,389	na	na	na	0.06	0.06	0.05	0.05	$ 8	$ 0.51	$ 0.48	$ 0.43	$ 0.37
AL	001	$ 256	64	0.87	9,275	na	na	na	0.06	0.06	0.05	0.05	$ 4	$ 0.25	$ 0.24	$ 0.21	$ 0.18
AT	002	$ 953	90	0.92	10,699	na	na	na	0.06	0.06	0.05	0.05	$ 11	$ 0.66	$ 0.62	$ 0.56	$ 0.48
C	007	$ 1,305	99	0.70	11,100	na	na	na	0.06	0.06	0.05	0.05	$ 13	$ 0.82	$ 0.78	$ 0.69	$ 0.60
AT	002	$ 1,017	135	0.92	13,709	na	na	na	0.06	0.06	0.05	0.05	$ 8	$ 0.47	$ 0.44	$ 0.40	$ 0.34
AT	002	$ 1,079	175	0.92	17,615	na	na	na	0.06	0.06	0.05	0.05	$ 6	$ 0.39	$ 0.36	$ 0.32	$ 0.28
W	001	$ 1,039	213	0.96	20,138	na	na	na	0.06	0.06	0.05	0.05	$ 5	$ 0.30	$ 0.29	$ 0.26	$ 0.22
V	001	$ 690	244	0.96	28,237	na	na	na	0.06	0.06	0.05	0.05	$ 3	$ 0.18	$ 0.17	$ 0.15	$ 0.13
								SUM	0.50	0.47	0.42	0.36		$ 3.58	$ 3.37	$ 3.02	$ 2.61
Wall Mounted																	
V	005	$ 506	35	0.91	3,912	1	0	2	0.06	0.06	0.05	0.05	$ 14	$ 0.90	$ 0.85	$ 0.76	$ 0.66
V	004	$ 490	50	0.90	6,025	1	0	1	0.06	0.06	0.05	0.05	$ 10	$ 0.61	$ 0.58	$ 0.52	$ 0.45
W	007	$ -	52	0.99	6,076	1	0	2	0.06	0.06	0.05	0.05	$ -	$ -	$ -	$ -	$ -
V	004	$ 490	50	0.90	6,025	1	0	1	0.06	0.06	0.05	0.05	$ 10	$ 0.61	$ 0.58	$ 0.52	$ 0.45
V	005	$ 506	73	0.91	6,865	1	0	2	0.06	0.06	0.05	0.05	$ 7	$ 0.43	$ 0.41	$ 0.36	$ 0.31
W	004	$ 1,027	76	0.70	8,051	3	0	3	0.06	0.06	0.05	0.05	$ 14	$ 0.84	$ 0.79	$ 0.71	$ 0.61
W	004	$ 1,107	101	0.70	12,064	2	0	2	0.06	0.06	0.05	0.05	$ 11	$ 0.68	$ 0.64	$ 0.58	$ 0.50
								SUM	0.44	0.41	0.37	0.32		$ 4.09	$ 3.85	$ 3.44	$ 2.98
									0.58	0.55	0.49	0.42		$ 5.00	$ 4.70	$ 4.21	$ 3.63

Table 95: Vehicle Service Station Hardscape Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt				
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.50	0.20	0.11	0.09	$ 21	$ 10.40	$ 4.16	$ 2.31	$ 1.89
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.20	0.11	0.09	$ 15	$ -	$ 3.05	$ 1.70	$ 1.39
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.20	0.11	0.09	$ 11	$ -	$ 2.21	$ 1.23	$ 1.01
C	009	$ 863	124	0.95	14,200	2	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.77	$ 0.63
V	002	$ 1,074	125	0.91	13,999	3	0	1	0.50	0.20	0.11	0.09	$ 9	$ 4.29	$ 1.72	$ 0.95	$ 0.78
C	008	$ 1,544	149	0.96	18,132	3	0	3			0.11	0.09	$ 10	$ -	$ -	$ 1.15	$ 0.94
W	005	$ 960	183	0.88	18,162	3	0	3			0.11	0.09	$ 5	$ -	$ -	$ 0.58	$ 0.48
V	002	$ 1,081	163	0.91	17,683	3	0	3			0.11	0.09	$ 7	$ -	$ -	$ 0.74	$ 0.60
C	009	$ 1,114	210	0.90	23,769	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.48
V	002	$ 1,159	241	0.91	24,870	3	0	4				0.09	$ 5	$ -	$ -	$ -	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$ 14.69	$14.20	$11.13	$10.03
Ground Mounted Floodlight																	
AT	001	$ 571	70	0.93	7,389	na	na	na		1.00	0.25	0.13	$ 8	$ -	$ 8.16	$ 2.04	$ 1.02
AL	001	$ 256	64	0.87	9,275	na	na	na			0.25	0.13	$ 4	$ -	$ -	$ 1.00	$ 0.50
AT	002	$ 953	90	0.92	10,699	na	na	na			0.25	0.13	$ 11	$ -	$ -	$ 2.65	$ 1.32
C	007	$ 1,305	99	0.70	11,100	na	na	na			0.25	0.13	$ 13	$ -	$ -	$ 3.30	$ 1.65
AT	002	$ 1,017	135	0.92	13,709	na	na	na				0.13	$ 8	$ -	$ -	$ -	$ 0.94
AT	002	$ 1,079	175	0.92	17,615	na	na	na				0.13	$ 6	$ -	$ -	$ -	$ 0.77
W	001	$ 1,039	213	0.96	20,138	na	na	na				0.13	$ 5	$ -	$ -	$ -	$ 0.61
V	001	$ 690	244	0.96	28,237	na	na	na				0.13	$ 3	$ -	$ -	$ -	$ 0.35
								SUM	0.00	1.00	1.00	1.00		$ -	$ 8.16	$ 8.98	$ 7.17
Wall Mounted																	
V	005	$ 381	19	0.91	2,031	1	0	1	0.10	0.08	0.08	0.08	$ 20	$ 2.01	$ 1.67	$ 1.54	$ 1.54
AE	001	$ 163	27	0.70	2,075	1	1	0	0.10	0.08	0.08	0.08	$ 6	$ 0.60	$ 0.50	$ 0.46	$ 0.46
AF	002	$ 368	20	0.70	2,054	1	1	1	0.10	0.08	0.08	0.08	$ 19	$ 1.88	$ 1.56	$ 1.44	$ 1.44
V	005	$ 381	26	0.91	2,623	1	0	1	0.10	0.08	0.08	0.08	$ 15	$ 1.47	$ 1.22	$ 1.13	$ 1.13
AG	001	$ 518	36	0.70	2,603	1	0	1	0.10	0.08	0.08	0.08	$ 14	$ 1.44	$ 1.20	$ 1.11	$ 1.11
V	004	$ 449	25	0.90	3,163	1	0	1	0.10	0.08	0.08	0.08	$ 18	$ 1.80	$ 1.50	$ 1.38	$ 1.38
V	005	$ 506	35	0.91	3,912	1	0	2	0.10	0.08	0.08	0.08	$ 14	$ 1.44	$ 1.20	$ 1.11	$ 1.11
V	004	$ 490	50	0.90	6,025	1	0	1	0.10	0.08	0.08	0.08	$ 10	$ 0.98	$ 0.82	$ 0.75	$ 0.75
B	004	$ 707	52	0.70	4,390	1	0	0	0.10	0.08	0.08	0.08	$ 14	$ 1.36	$ 1.13	$ 1.05	$ 1.05
V	004	$ 490	50	0.90	6,025	1	0	1	0.10	0.08	0.08	0.08	$ 10	$ 0.98	$ 0.82	$ 0.75	$ 0.75
V	005	$ 506	73	0.91	6,865	1	0	2		0.08	0.08	0.08	$ 7	$ -	$ 0.58	$ 0.53	$ 0.53
W	004	$ 1,027	76	0.70	8,051	3	0	3			0.08	0.08	$ 14	$ -	$ -	$ 1.04	$ 1.04
W	004	$ 1,107	101	0.70	12,064	2	0	2		0.08	0.08	0.08	$ 11	$ -	$ 0.91	$ 0.84	$ 0.84
								SUM	1.00	1.00	1.00	1.00		$ 13.96	$13.12	$13.15	$13.15
									0.67	1.00	1.00	1.00		$ 9.55	$11.83	$11.09	$10.12

Table 96: Vehicle Service Station Canopies Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
Downlight																
K	002	$ 236	23	0.70	1,860	2	0	0	0.06	0.06	0.06	0.06	$ 10	$ 0.60	$ 0.57	$ 0.57	$ 0.57
P	001	$ 237	36	0.89	1,995	2	1	0	0.06	0.06	0.06	0.06	$ 7	$ 0.39	$ 0.37	$ 0.37	$ 0.37
C	005	$ 94	21	0.70	1,914	2	0	0	0.06	0.06	0.06	0.06	$ 4	$ 0.26	$ 0.25	$ 0.25	$ 0.25
P	001	$ 237	35	0.89	2,130	2	1	0	0.06	0.06	0.06	0.06	$ 7	$ 0.40	$ 0.37	$ 0.37	$ 0.37
C	005	$ 112	28	0.70	2,203	2	0	0	0.06	0.06	0.06	0.06	$ 4	$ 0.24	$ 0.23	$ 0.23	$ 0.23
K	002	$ 251	30	0.70	2,521	2	0	0	0.06	0.06	0.06	0.06	$ 9	$ 0.50	$ 0.47	$ 0.47	$ 0.47
P	001	$ 257	41	0.89	2,621	3	1	0	0.06	0.06	0.06	0.06	$ 6	$ 0.37	$ 0.35	$ 0.35	$ 0.35
K	002	$ 266	37	0.70	2,917	3	0	0	0.06	0.06	0.06	0.06	$ 7	$ 0.43	$ 0.40	$ 0.40	$ 0.40
K	002	$ 310	48	0.70	3,029	3	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.38	$ 0.36	$ 0.36	$ 0.36
P	001	$ 256	44	0.89	3,184	3	1	0	0.06	0.06	0.06	0.06	$ 6	$ 0.34	$ 0.32	$ 0.32	$ 0.32
C	005	$ 112	42	0.70	3,300	3	0	0	0.06	0.06	0.06	0.06	$ 3	$ 0.16	$ 0.15	$ 0.15	$ 0.15
K	002	$ 295	48	0.70	3,839	3	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.36	$ 0.34	$ 0.34	$ 0.34
K	002	$ 310	47	0.70	4,234	3	0	0	0.06	0.06	0.06	0.06	$ 7	$ 0.39	$ 0.37	$ 0.37	$ 0.37
K	002	$ 324	49	0.70	4,982	3	0	0	0.06	0.06	0.06	0.06	$ 7	$ 0.39	$ 0.37	$ 0.37	$ 0.37
K	002	$ 427	75	0.70	6,168	3	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.34	$ 0.32	$ 0.32	$ 0.32
AR	002	$ 585	57	0.70	5,716	3	1	1	0.06	0.06	0.06	0.06	$ 10	$ 0.60	$ 0.57	$ 0.57	$ 0.57
C	005	$ 175	115	0.70	7,816	4	0	0	0.06	0.06	0.06	0.06	$ 2	$ 0.09	$ 0.08	$ 0.08	$ 0.08
K	002	$ 530	115	0.70	11,296	3	0	0		0.06	0.06	0.06	$ 5	$ -	$ 0.26	$ 0.26	$ 0.26
								SUM	1.00	1.00	1.00	1.00		$ 6.23	$ 6.14	$ 6.14	$ 6.14
Surface Mounted Downlight																
AC	001	$ 99	20	0.70	1,813	1	0	1	0.13	0.11	0.11	0.11	$ 5	$ 0.61	$ 0.54	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.13	0.11	0.11	0.11	$ 42	$ 5.22	$ 4.64	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.13	0.11	0.11	0.11	$ 5	$ 0.57	$ 0.50	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2	0.13	0.11	0.11	0.11	$ 11	$ 1.40	$ 1.24	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.13	0.11	0.11	0.11	$ 13	$ 1.62	$ 1.44	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1	0.13	0.11	0.11	0.11	$ 15	$ 1.84	$ 1.63	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2	0.13	0.11	0.11	0.11	$ 8	$ 0.97	$ 0.86	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2	0.13	0.11	0.11	0.11	$ 9	$ 1.11	$ 0.98	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2		0.11	0.11	0.11	$ 9	$ -	$ 0.95	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00		$13.33	$12.79	$12.79	$12.79
									0.56	0.56	0.56	0.56		$ 3.42	$ 3.34	$ 3.34	$ 3.34

Table 97: Sales Canopies Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt				
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Downlight																	
J	001	$ 561	10	0.70	647	1	0	0	0.04	0.04	0.04	0.04	$ 56	$ 2.44	$ 2.25	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.04	0.04	0.04	0.04	$ 17	$ 0.74	$ 0.68	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.04	0.04	0.04	0.04	$ 40	$ 1.74	$ 1.60	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.04	0.04	0.04	0.04	$ 15	$ 0.65	$ 0.60	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.04	0.04	0.04	0.04	$ 13	$ 0.57	$ 0.52	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.04	0.04	0.04	0.04	$ 12	$ 0.54	$ 0.49	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.04	0.04	0.04	0.04	$ 13	$ 0.56	$ 0.51	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.04	0.04	0.04	0.04	$ 10	$ 0.44	$ 0.41	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.19	$ 0.18	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.18	$ 0.16	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.04	0.04	0.04	0.04	$ 9	$ 0.37	$ 0.34	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.25	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.32	$ 0.29	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.26	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.04	0.04	0.04	0.04	$ 3	$ 0.12	$ 0.11	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.27	$ 0.25	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.04	0.04	0.04	0.04	$ 10	$ 0.45	$ 0.41	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0		0.04	0.04	0.04	$ 2	$ -	$ 0.06	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0		0.04	0.04	0.04	$ 5	$ -	$ 0.18	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00		$11.77	$11.07	$11.07	$11.07
Recessed Linear																	
AB	002	$ 424	18	0.70	1,371	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.03	0.03	0.03	0.03	$ 11	$ 0.36	$ 0.36	$ 0.35	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.03	0.03	0.03	0.03	$ 4	$ 0.13	$ 0.13	$ 0.12	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 23	$ 0.73	$ 0.73	$ 0.70	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 28	$ 0.89	$ 0.89	$ 0.87	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.59	$ 0.59	$ 0.57	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.43	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 44	$ 1.41	$ 1.41	$ 1.37	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 34	$ 1.11	$ 1.11	$ 1.07	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 22	$ 0.72	$ 0.72	$ 0.69	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.54	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.03	0.03	0.03	0.03	$ 11	$ 0.34	$ 0.34	$ 0.33	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.03	0.03	0.03	0.03	$ 27	$ 0.86	$ 0.86	$ 0.83	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 25	$ 0.81	$ 0.81	$ 0.78	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.52	$ 0.52	$ 0.51	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 12	$ 0.38	$ 0.38	$ 0.37	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.63	$ 0.63	$ 0.61	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.52	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.43	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.03	0.03	0.03	0.03	$ 31	$ 1.01	$ 1.01	$ 0.98	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 72	$ 2.31	$ 2.31	$ 2.24	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 49	$ 1.60	$ 1.60	$ 1.55	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 30	$ 0.96	$ 0.96	$ 0.93	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 24	$ 0.77	$ 0.77	$ 0.75	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 19	$ 0.62	$ 0.62	$ 0.60	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1			0.03	0.03	$ 9	$ -	$ -	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.03	0.03	0.03	0.03	$ 14	$ 0.46	$ 0.46	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.34	$22.34	$21.91	$21.91

Table 98: Sales Canopies Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.13	0.13	0.11	0.11	$ 5	$ 0.61	$ 0.61	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.13	0.13	0.11	0.11	$ 42	$ 5.22	$ 5.22	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.13	0.13	0.11	0.11	$ 5	$ 0.57	$ 0.57	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2	0.13	0.13	0.11	0.11	$ 11	$ 1.40	$ 1.40	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.13	0.13	0.11	0.11	$ 13	$ 1.62	$ 1.62	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1	0.13	0.13	0.11	0.11	$ 15	$ 1.84	$ 1.84	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2	0.13	0.13	0.11	0.11	$ 8	$ 0.97	$ 0.97	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2	0.13	0.13	0.11	0.11	$ 9	$ 1.11	$ 1.11	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2			0.11	0.11	$ 9	$ -	$ -	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00		$13.33	$13.33	$12.79	$12.79
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$24.03	$24.03	$23.55	$23.55
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
H	002	$ 639	14	0.70	846	0	4	0	0.06	0.06	0.06	0.06	$ 46	$ 2.54	$ 2.54	$ 2.54	$ 2.54
S	001	$ 147	26	0.70	823	1	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.31	$ 0.31	$ 0.31	$ 0.31
AH	001	$ 815	24	0.70	950	1	3	1	0.06	0.06	0.06	0.06	$ 34	$ 1.89	$ 1.89	$ 1.89	$ 1.89
C	001	$ 409	16	0.95	1,084	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
S	002	$ 162	18	0.70	1,189	1	1	0	0.06	0.06	0.06	0.06	$ 9	$ 0.50	$ 0.50	$ 0.50	$ 0.50
C	001	$ 409	16	0.95	1,214	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.06	0.06	0.06	0.06	$ 66	$ 3.68	$ 3.68	$ 3.68	$ 3.68
AF	001	$ 809	40	0.70	1,290	1	1	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
V	005	$ 381	13	0.91	1,415	0	0	1	0.06	0.06	0.06	0.06	$ 29	$ 1.63	$ 1.63	$ 1.63	$ 1.63
V	004	$ 408	12	0.90	1,494	0	0	0	0.06	0.06	0.06	0.06	$ 34	$ 1.89	$ 1.89	$ 1.89	$ 1.89
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.06	0.06	0.06	0.06	$ 20	$ 1.09	$ 1.09	$ 1.09	$ 1.09
V	005	$ 381	19	0.91	1,957	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
V	005	$ 381	19	0.91	2,031	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
AE	001	$ 163	27	0.70	2,075	1	1	0	0.06	0.06	0.06	0.06	$ 6	$ 0.34	$ 0.34	$ 0.34	$ 0.34
AF	002	$ 368	20	0.70	2,054	1	1	1	0.06	0.06	0.06	0.06	$ 19	$ 1.04	$ 1.04	$ 1.04	$ 1.04
V	004	$ 449	25	0.90	3,163	1	0	1	0.06	0.06	0.06	0.06	$ 18	$ 1.00	$ 1.00	$ 1.00	$ 1.00
V	004	$ 490	50	0.90	6,025	1	0	1	0.06	0.06	0.06	0.06	$ 10	$ 0.54	$ 0.54	$ 0.54	$ 0.54
								SUM	1.00	1.00	1.00	1.00		$24.18	$24.18	$24.18	$24.18
									1.00	1.00	1.00	1.00		$19.13	$18.99	$18.70	$18.70

Table 99: Non-sales Canopies and Tunnels Cost per Watt

2019 LED									Weighting				Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
Downlight																
J	001	$ 561	10	0.70	647	1	0	0	0.04	0.04	0.04	0.04	$ 56	$ 2.44	$ 2.25	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.04	0.04	0.04	0.04	$ 17	$ 0.74	$ 0.68	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.04	0.04	0.04	0.04	$ 40	$ 1.74	$ 1.60	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.04	0.04	0.04	0.04	$ 15	$ 0.65	$ 0.60	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.04	0.04	0.04	0.04	$ 13	$ 0.57	$ 0.52	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.04	0.04	0.04	0.04	$ 12	$ 0.54	$ 0.49	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.04	0.04	0.04	0.04	$ 13	$ 0.56	$ 0.51	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.04	0.04	0.04	0.04	$ 10	$ 0.44	$ 0.41	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.19	$ 0.18	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.18	$ 0.16	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.04	0.04	0.04	0.04	$ 9	$ 0.37	$ 0.34	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.25	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.32	$ 0.29	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.26	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.04	0.04	0.04	0.04	$ 3	$ 0.12	$ 0.11	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.27	$ 0.25	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.04	0.04	0.04	0.04	$ 10	$ 0.45	$ 0.41	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0		0.04	0.04	0.04	$ 2	$ -	$ 0.06	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0		0.04	0.04	0.04	$ 5	$ -	$ 0.18	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00		$11.77	$11.07	$11.07	$11.07
Recessed Linear																
AB	002	$ 424	18	0.70	1,371	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.03	0.03	0.03	0.03	$ 11	$ 0.36	$ 0.36	$ 0.35	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.03	0.03	0.03	0.03	$ 4	$ 0.13	$ 0.13	$ 0.12	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 23	$ 0.73	$ 0.73	$ 0.70	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 28	$ 0.89	$ 0.89	$ 0.87	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.59	$ 0.59	$ 0.57	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.43	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 44	$ 1.41	$ 1.41	$ 1.37	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 34	$ 1.11	$ 1.11	$ 1.07	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 22	$ 0.72	$ 0.72	$ 0.69	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.54	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.03	0.03	0.03	0.03	$ 11	$ 0.34	$ 0.34	$ 0.33	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.03	0.03	0.03	0.03	$ 27	$ 0.86	$ 0.86	$ 0.83	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 25	$ 0.81	$ 0.81	$ 0.78	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.52	$ 0.52	$ 0.51	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 12	$ 0.38	$ 0.38	$ 0.37	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.63	$ 0.63	$ 0.61	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.52	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.43	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.03	0.03	0.03	0.03	$ 31	$ 1.01	$ 1.01	$ 0.98	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 72	$ 2.31	$ 2.31	$ 2.24	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 49	$ 1.60	$ 1.60	$ 1.55	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 30	$ 0.96	$ 0.96	$ 0.93	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 24	$ 0.77	$ 0.77	$ 0.75	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 19	$ 0.62	$ 0.62	$ 0.60	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1			0.03	0.03	$ 9	$ -	$ -	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.03	0.03	0.03	0.03	$ 14	$ 0.46	$ 0.46	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.34	$22.34	$21.91	$21.91

Table 100: Non-sales Canopies and Tunnels Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.13	0.13	0.11	0.11	$ 5	$ 0.61	$ 0.61	$ 0.54	$ 0.54
BB	001	$ 793	19	0.70	1,509	1	0	0	0.13	0.13	0.11	0.11	$ 42	$ 5.22	$ 5.22	$ 4.64	$ 4.64
Q	002	$ 61	14	0.70	1,081	1	1	0	0.13	0.13	0.11	0.11	$ 5	$ 0.57	$ 0.57	$ 0.50	$ 0.50
T	001	$ 272	24	0.70	3,055	2	3	2	0.13	0.13	0.11	0.11	$ 11	$ 1.40	$ 1.40	$ 1.24	$ 1.24
C	006	$ 363	28	0.70	3,293	1	0	1	0.13	0.13	0.11	0.11	$ 13	$ 1.62	$ 1.62	$ 1.44	$ 1.44
AL	002	$ 455	31	0.70	4,210	2	2	1	0.13	0.13	0.11	0.11	$ 15	$ 1.84	$ 1.84	$ 1.63	$ 1.63
T	001	$ 296	38	0.70	4,443	2	3	2	0.13	0.13	0.11	0.11	$ 8	$ 0.97	$ 0.97	$ 0.86	$ 0.86
C	006	$ 398	45	0.70	4,949	3	0	2	0.13	0.13	0.11	0.11	$ 9	$ 1.11	$ 1.11	$ 0.98	$ 0.98
T	001	$ 465	55	0.70	6,959	2	3	2			0.11	0.11	$ 9	$ -	$ -	$ 0.95	$ 0.95
								SUM	1.00	1.00	1.00	1.00		$13.33	$13.33	$12.79	$12.79
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$24.03	$24.03	$23.55	$23.55
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
H	002	$ 639	14	0.70	846	0	4	0	0.06	0.06	0.06	0.06	$ 46	$ 2.54	$ 2.54	$ 2.54	$ 2.54
S	001	$ 147	26	0.70	823	1	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.31	$ 0.31	$ 0.31	$ 0.31
AH	001	$ 815	24	0.70	950	1	3	1	0.06	0.06	0.06	0.06	$ 34	$ 1.89	$ 1.89	$ 1.89	$ 1.89
C	001	$ 409	16	0.95	1,084	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
S	002	$ 162	18	0.70	1,189	1	1	0	0.06	0.06	0.06	0.06	$ 9	$ 0.50	$ 0.50	$ 0.50	$ 0.50
C	001	$ 409	16	0.95	1,214	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.47	$ 1.47	$ 1.47	$ 1.47
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.06	0.06	0.06	0.06	$ 66	$ 3.68	$ 3.68	$ 3.68	$ 3.68
AF	001	$ 809	40	0.70	1,290	1	1	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
V	005	$ 381	13	0.91	1,415	0	0	1	0.06	0.06	0.06	0.06	$ 29	$ 1.63	$ 1.63	$ 1.63	$ 1.63
V	004	$ 408	12	0.90	1,494	0	0	0	0.06	0.06	0.06	0.06	$ 34	$ 1.89	$ 1.89	$ 1.89	$ 1.89
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.06	0.06	0.06	0.06	$ 20	$ 1.09	$ 1.09	$ 1.09	$ 1.09
V	005	$ 381	19	0.91	1,957	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
V	005	$ 381	19	0.91	2,031	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.11	$ 1.11	$ 1.11	$ 1.11
AE	001	$ 163	27	0.70	2,075	1	1	0	0.06	0.06	0.06	0.06	$ 6	$ 0.34	$ 0.34	$ 0.34	$ 0.34
AF	002	$ 368	20	0.70	2,054	1	1	1	0.06	0.06	0.06	0.06	$ 19	$ 1.04	$ 1.04	$ 1.04	$ 1.04
V	004	$ 449	25	0.90	3,163	1	0	1	0.06	0.06	0.06	0.06	$ 18	$ 1.00	$ 1.00	$ 1.00	$ 1.00
V	004	$ 490	50	0.90	6,025	1	0	1	0.06	0.06	0.06	0.06	$ 10	$ 0.54	$ 0.54	$ 0.54	$ 0.54
								SUM	1.00	1.00	1.00	1.00		$24.18	$24.18	$24.18	$24.18
									1.00	1.00	1.00	1.00		$19.13	$18.99	$18.70	$18.70

Table 101: Guard Stations Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area																	
AF	003	$ 1,776	48	0.70	4,247	1	0	1	0.33	0.17	0.10	0.08	$ 37	$ 12.33	$ 6.17	$ 3.70	$ 3.08
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.33	0.17	0.10	0.08	$ 21	$ 6.93	$ 3.47	$ 2.08	$ 1.73
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.17	0.10	0.08	$ 15	$ -	$ 2.54	$ 1.53	$ 1.27
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.17	0.10	0.08	$ 15	$ -	$ 2.54	$ 1.53	$ 1.27
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.17	0.10	0.08	$ 11	$ -	$ 1.85	$ 1.11	$ 0.92
C	009	$ 863	124	0.95	14,200	2	0	3			0.10	0.08	$ 7	$ -	$ -	$ 0.70	$ 0.58
V	002	$ 1,074	125	0.91	13,999	3	0	1	0.33	0.17	0.10	0.08	$ 9	$ 2.86	$ 1.43	$ 0.86	$ 0.72
C	008	$ 1,544	149	0.96	18,132	3	0	3			0.10	0.08	$ 10	$ -	$ -	$ 1.04	$ 0.86
W	005	$ 960	183	0.88	18,162	3	0	3			0.10	0.08	$ 5	$ -	$ -	$ 0.52	$ 0.44
V	002	$ 1,081	163	0.91	17,683	3	0	3			0.10	0.08	$ 7	$ -	$ -	$ 0.66	$ 0.55
C	009	$ 1,114	210	0.90	23,769	3	0	4				0.08	$ 5	$ -	$ -	$ -	$ 0.44
V	002	$ 1,159	241	0.91	24,870	3	0	4				0.08	$ 5	$ -	$ -	$ -	$ 0.40
C	009	$ 1,384	448	0.90	45,673	3	0	5					$ 3	$ -	$ -	$ -	$ -
V	003	$ 1,603	448	0.91	45,686	4	0	5					$ 4	$ -	$ -	$ -	$ -
								SUM	1.00	1.00	1.00	1.00		$ 22.13	$ 18.00	$ 13.72	$ 12.27
Ground Mounted Floodlight																	
AT	001	$ 571	70	0.93	7,389	na	na	na		0.50	0.25	0.13	$ 8	$ -	$ 4.08	$ 2.04	$ 1.02
AL	001	$ 256	64	0.87	9,275	na	na	na		0.50	0.25	0.13	$ 4	$ -	$ 2.00	$ 1.00	$ 0.50
AT	002	$ 953	90	0.92	10,699	na	na	na			0.25	0.13	$ 11	$ -	$ -	$ 2.65	$ 1.32
C	007	$ 1,305	99	0.70	11,100	na	na	na			0.25	0.13	$ 13	$ -	$ -	$ 3.30	$ 1.65
AT	002	$ 1,017	135	0.92	13,709	na	na	na				0.13	$ 8	$ -	$ -	$ -	$ 0.94
AT	002	$ 1,079	175	0.92	17,615	na	na	na				0.13	$ 6	$ -	$ -	$ -	$ 0.77
W	001	$ 1,039	213	0.96	20,138	na	na	na				0.13	$ 5	$ -	$ -	$ -	$ 0.61
V	001	$ 690	244	0.96	28,237	na	na	na				0.13	$ 3	$ -	$ -	$ -	$ 0.35
								SUM	0.00	1.00	1.00	1.00		$ -	$ 6.08	$ 8.98	$ 7.17
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	002	$ 639	14	0.70	846	0	4	0	0.04	0.04	0.04	0.04	$ 46	$ 1.98	$ 1.83	$ 1.76	$ 1.76
S	001	$ 147	26	0.70	823	1	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.24	$ 0.22	$ 0.22	$ 0.22
AH	001	$ 815	24	0.70	950	1	3	1	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
C	001	$ 409	16	0.95	1,084	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
S	002	$ 162	18	0.70	1,189	1	1	0	0.04	0.04	0.04	0.04	$ 9	$ 0.39	$ 0.36	$ 0.35	$ 0.35
C	001	$ 409	16	0.95	1,214	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.04	0.04	0.04	0.04	$ 66	$ 2.88	$ 2.65	$ 2.55	$ 2.55
AF	001	$ 809	40	0.70	1,290	1	1	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	13	0.91	1,415	0	0	1	0.04	0.04	0.04	0.04	$ 29	$ 1.28	$ 1.17	$ 1.13	$ 1.13
V	004	$ 408	12	0.90	1,494	0	0	0	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.04	0.04	0.04	0.04	$ 20	$ 0.85	$ 0.79	$ 0.75	$ 0.75
V	005	$ 381	19	0.91	1,957	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	19	0.91	2,031	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
AE	001	$ 163	27	0.70	2,075	1	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.26	$ 0.24	$ 0.23	$ 0.23
AF	002	$ 368	20	0.70	2,054	1	1	1	0.04	0.04	0.04	0.04	$ 19	$ 0.82	$ 0.75	$ 0.72	$ 0.72
V	005	$ 381	26	0.91	2,623	1	0	1	0.04	0.04	0.04	0.04	$ 15	$ 0.64	$ 0.59	$ 0.56	$ 0.56
AG	001	$ 518	36	0.70	2,603	1	0	1	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.55	$ 0.55
V	004	$ 449	25	0.90	3,163	1	0	1	0.04	0.04	0.04	0.04	$ 18	$ 0.78	$ 0.72	$ 0.69	$ 0.69
V	005	$ 506	35	0.91	3,912	1	0	2	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.56	$ 0.56
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
B	004	$ 707	52	0.70	4,390	1	0	0	0.04	0.04	0.04	0.04	$ 14	$ 0.59	$ 0.54	$ 0.52	$ 0.52
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
V	005	$ 506	73	0.91	6,865	1	0	2		0.04	0.04	0.04	$ 7	$ -	$ 0.28	$ 0.27	$ 0.27
W	004	$ 1,027	76	0.70	8,051	3	0	3			0.04	0.04	$ 14	$ -	$ -	$ 0.52	$ 0.52
W	004	$ 1,107	101	0.70	12,064	2	0	2		0.04	0.04	0.04	$ 11	$ -	$ 0.44	$ 0.42	$ 0.42
								SUM	1.00	1.00	1.00	1.00		$ 21.84	$ 20.80	$ 20.52	$ 20.52
									0.67	1.00	1.00	1.00		$ 14.65	$ 14.96	$ 14.41	$ 13.32

Table 102: Student Pick-up / Drop-off Zone Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area Light																	
B	002	$ 1,381	25	0.93	1,170	1	2	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.76	$ 2.76	$ 2.76
B	002	$ 1,381	25	0.93	1,216	1	1	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.76	$ 2.76	$ 2.76
B	002	$ 1,381	25	0.93	1,735	1	0	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.76	$ 2.76	$ 2.76
A	002	$ 1,553	21	0.83	2,051	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.70	$ 3.70	$ 3.70
A	002	$ 1,553	21	0.83	2,189	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.70	$ 3.70	$ 3.70
A	002	$ 1,553	21	0.83	2,114	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.70	$ 3.70	$ 3.70
A	002	$ 1,553	30	0.83	2,760	1	0	1	0.06	0.05	0.05	0.05	$ 52	$ 3.05	$ 2.59	$ 2.59	$ 2.59
B	002	$ 1,381	25	0.93	1,830	1	0	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.76	$ 2.76	$ 2.76
W	002	$ 1,970	22	0.84	2,117	1	0	1	0.06	0.05	0.05	0.05	$ 90	$ 5.27	$ 4.48	$ 4.48	$ 4.48
BD	001	$ 1,434	36	0.92	2,221	1	0	1	0.06	0.05	0.05	0.05	$ 40	$ 2.34	$ 1.99	$ 1.99	$ 1.99
W	003	$ 1,071	30	0.84	3,126	1	0	1	0.06	0.05	0.05	0.05	$ 36	$ 2.10	$ 1.78	$ 1.78	$ 1.78
BD	001	$ 1,434	52	0.92	3,178	1	0	1	0.06	0.05	0.05	0.05	$ 28	$ 1.62	$ 1.38	$ 1.38	$ 1.38
AF	003	$ 1,776	48	0.70	4,247	1	0	1	0.06	0.05	0.05	0.05	$ 37	$ 2.18	$ 1.85	$ 1.85	$ 1.85
A	001	$ 1,379	22	0.84	1,888	1	0	1	0.06	0.05	0.05	0.05	$ 63	$ 3.69	$ 3.13	$ 3.13	$ 3.13
A	001	$ 1,379	51	0.84	4,431	2	0	2	0.06	0.05	0.05	0.05	$ 27	$ 1.59	$ 1.35	$ 1.35	$ 1.35
A	001	$ 1,379	51	0.84	4,348	1	0	1	0.06	0.05	0.05	0.05	$ 27	$ 1.59	$ 1.35	$ 1.35	$ 1.35
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.06	0.05	0.05	0.05	$ 21	$ 1.22	$ 1.04	$ 1.04	$ 1.04
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.05	0.05	0.05	$ 15	$ -	$ 0.76	$ 0.76	$ 0.76
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.05	0.05	0.05	$ 15	$ -	$ 0.76	$ 0.76	$ 0.76
W	004	$ 1,063	96	0.89	10,231	3	0	2		0.05	0.05	0.05	$ 11	$ -	$ 0.55	$ 0.55	$ 0.55
								SUM	1.00	1.00	1.00	1.00		$50.70	$45.17	$45.17	$45.17
Cylindrical - Wall Mounted up/down																	
M	001	$ 950	8	0.70	900	1	1	0	0.33	0.33	0.33	0.33	$ 119	$39.57	$39.57	$39.57	$39.57
AO	001	$ 349	13	0.70	931	1	1	0	0.33	0.33	0.33	0.33	$ 27	$ 8.96	$ 8.96	$ 8.96	$ 8.96
H	003	$ 434	21	0.81	1,047	1	4	0	0.33	0.33	0.33	0.33	$ 21	$ 6.89	$ 6.89	$ 6.89	$ 6.89
								SUM	1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43
Downlight																	
J	001	$ 561	10	0.70	647	1	0	0	0.04	0.04	0.04	0.04	$ 56	$ 2.44	$ 2.25	$ 2.25	$ 2.25
K	001	$ 220	13	0.70	780	1	1	0	0.04	0.04	0.04	0.04	$ 17	$ 0.74	$ 0.68	$ 0.68	$ 0.68
J	001	$ 561	14	0.70	884	1	0	0	0.04	0.04	0.04	0.04	$ 40	$ 1.74	$ 1.60	$ 1.60	$ 1.60
P	001	$ 208	14	0.89	1,066	1	1	0	0.04	0.04	0.04	0.04	$ 15	$ 0.65	$ 0.60	$ 0.60	$ 0.60
K	001	$ 286	22	0.70	1,170	2	1	0	0.04	0.04	0.04	0.04	$ 13	$ 0.57	$ 0.52	$ 0.52	$ 0.52
K	001	$ 272	22	0.70	1,426	2	1	0	0.04	0.04	0.04	0.04	$ 12	$ 0.54	$ 0.49	$ 0.49	$ 0.49
K	002	$ 236	19	0.70	1,461	2	0	0	0.04	0.04	0.04	0.04	$ 13	$ 0.56	$ 0.51	$ 0.51	$ 0.51
K	002	$ 236	23	0.70	1,860	2	0	0	0.04	0.04	0.04	0.04	$ 10	$ 0.44	$ 0.41	$ 0.41	$ 0.41
P	001	$ 237	36	0.89	1,995	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
C	005	$ 94	21	0.70	1,914	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.19	$ 0.18	$ 0.18	$ 0.18
P	001	$ 237	35	0.89	2,130	2	1	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
C	005	$ 112	28	0.70	2,203	2	0	0	0.04	0.04	0.04	0.04	$ 4	$ 0.18	$ 0.16	$ 0.16	$ 0.16
K	002	$ 251	30	0.70	2,521	2	0	0	0.04	0.04	0.04	0.04	$ 9	$ 0.37	$ 0.34	$ 0.34	$ 0.34
P	001	$ 257	41	0.89	2,621	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.25	$ 0.25	$ 0.25
K	002	$ 266	37	0.70	2,917	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.32	$ 0.29	$ 0.29	$ 0.29
K	002	$ 310	48	0.70	3,029	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.28	$ 0.26	$ 0.26	$ 0.26
P	001	$ 256	44	0.89	3,184	3	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
C	005	$ 112	42	0.70	3,300	3	0	0	0.04	0.04	0.04	0.04	$ 3	$ 0.12	$ 0.11	$ 0.11	$ 0.11
K	002	$ 295	48	0.70	3,839	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.27	$ 0.25	$ 0.25	$ 0.25
K	002	$ 310	47	0.70	4,234	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.26	$ 0.26	$ 0.26
K	002	$ 324	49	0.70	4,982	3	0	0	0.04	0.04	0.04	0.04	$ 7	$ 0.29	$ 0.27	$ 0.27	$ 0.27
K	002	$ 427	75	0.70	6,168	3	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.25	$ 0.23	$ 0.23	$ 0.23
AR	002	$ 585	57	0.70	5,716	3	1	1	0.04	0.04	0.04	0.04	$ 10	$ 0.45	$ 0.41	$ 0.41	$ 0.41
C	005	$ 175	115	0.70	7,816	4	0	0		0.04	0.04	0.04	$ 2	$ -	$ 0.06	$ 0.06	$ 0.06
K	002	$ 530	115	0.70	11,296	3	0	0		0.04	0.04	0.04	$ 5	$ -	$ 0.18	$ 0.18	$ 0.18
								SUM	1.00	1.00	1.00	1.00		$11.77	$11.07	$11.07	$11.07
Flood																	
AT	001	$ 571	70	0.93	7,389					0.50	0.25	0.17	$ 8	$ -	$ 4.08	$ 2.04	$ 1.36
AL	001	$ 256	64	0.87	9,275					0.50	0.25	0.17	$ 4	$ -	$ 2.00	$ 1.00	$ 0.67
AT	002	$ 953	90	0.92	10,699						0.25	0.17	$ 11	$ -	$ -	$ 2.65	$ 1.77
C	007	$ 1,305	99	0.70	11,100						0.25	0.17	$ 13	$ -	$ -	$ 3.30	$ 2.20
AT	002	$ 1,017	135	0.92	13,709							0.17	$ 8	$ -	$ -	$ -	$ 1.26
AT	002	$ 1,079	175	0.92	17,615							0.17	$ 6	$ -	$ -	$ -	$ 1.03
								SUM	0.00	1.00	1.00	1.00		$ -	$ 6.08	$ 8.98	$ 8.27

Table 103: Student Pick-up / Drop-off Zone, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Recessed Linear																	
AB	002	$ 424	18	0.70	1,371	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
AB	002	$ 424	38	0.70	2,560	1	0	1	0.03	0.03	0.03	0.03	$ 11	$ 0.36	$ 0.36	$ 0.35	$ 0.35
AB	001	$ 151	39	0.70	3,088	1	0	1	0.03	0.03	0.03	0.03	$ 4	$ 0.13	$ 0.13	$ 0.12	$ 0.12
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
AV	001	$ 549	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 23	$ 0.73	$ 0.73	$ 0.70	$ 0.70
AW	001	$ 610	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 28	$ 0.89	$ 0.89	$ 0.87	$ 0.87
AW	001	$ 610	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.59	$ 0.59	$ 0.57	$ 0.57
AW	001	$ 610	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.43	$ 0.43
Y	001	$ 631	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 44	$ 1.41	$ 1.41	$ 1.37	$ 1.37
Y	001	$ 631	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 34	$ 1.11	$ 1.11	$ 1.07	$ 1.07
Y	001	$ 631	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 22	$ 0.72	$ 0.72	$ 0.69	$ 0.69
Y	001	$ 631	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.54	$ 0.54
AA	001	$ 440	42	0.70	2,050	1	1	0	0.03	0.03	0.03	0.03	$ 11	$ 0.34	$ 0.34	$ 0.33	$ 0.33
AZ	001	$ 329	12	0.70	580	0	1	0	0.03	0.03	0.03	0.03	$ 27	$ 0.86	$ 0.86	$ 0.83	$ 0.83
AZ	001	$ 376	30	0.70	1,520	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Z	002	$ 574	23	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 25	$ 0.81	$ 0.81	$ 0.78	$ 0.78
Z	002	$ 574	36	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.52	$ 0.52	$ 0.51	$ 0.51
Z	002	$ 574	49	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 12	$ 0.38	$ 0.38	$ 0.37	$ 0.37
Z	001	$ 599	31	0.70	2,914	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.63	$ 0.63	$ 0.61	$ 0.61
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.52	$ 0.52
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.43	$ 0.43
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.40	$ 0.40	$ 0.39	$ 0.39
AX	001	$ 589	19	0.70	1,008	1	2	1	0.03	0.03	0.03	0.03	$ 31	$ 1.01	$ 1.01	$ 0.98	$ 0.98
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 574	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 72	$ 2.31	$ 2.31	$ 2.24	$ 2.24
AY	001	$ 574	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 49	$ 1.60	$ 1.60	$ 1.55	$ 1.55
AY	001	$ 574	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 30	$ 0.96	$ 0.96	$ 0.93	$ 0.93
AY	001	$ 574	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 24	$ 0.77	$ 0.77	$ 0.75	$ 0.75
AY	001	$ 574	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 19	$ 0.62	$ 0.62	$ 0.60	$ 0.60
AY	001	$ 574	65	0.70	8,800	2	3	1			0.03	0.03	$ 9	$ -	$ -	$ 0.28	$ 0.28
Z	001	$ 599	42	0.70	3,885	2	2	1	0.03	0.03	0.03	0.03	$ 14	$ 0.46	$ 0.46	$ 0.44	$ 0.44
								SUM	1.00	1.00	1.00	1.00		$22.34	$22.34	$21.91	$21.91
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$24.03	$24.03	$23.55	$23.55

Table 104: Student Pick-up / Drop-off Zone, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	002	$ 639	14	0.70	846	0	4	0	0.04	0.04	0.04	0.04	$ 46	$ 1.98	$ 1.83	$ 1.76	$ 1.76
S	001	$ 147	26	0.70	823	1	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.24	$ 0.22	$ 0.22	$ 0.22
AH	001	$ 815	24	0.70	950	1	3	1	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
C	001	$ 409	16	0.95	1,084	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
S	002	$ 162	18	0.70	1,189	1	1	0	0.04	0.04	0.04	0.04	$ 9	$ 0.39	$ 0.36	$ 0.35	$ 0.35
C	001	$ 409	16	0.95	1,214	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.04	0.04	0.04	0.04	$ 66	$ 2.88	$ 2.65	$ 2.55	$ 2.55
AF	001	$ 809	40	0.70	1,290	1	1	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	13	0.91	1,415	0	0	1	0.04	0.04	0.04	0.04	$ 29	$ 1.28	$ 1.17	$ 1.13	$ 1.13
V	004	$ 408	12	0.90	1,494	0	0	0	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.04	0.04	0.04	0.04	$ 20	$ 0.85	$ 0.79	$ 0.75	$ 0.75
V	005	$ 381	19	0.91	1,957	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	19	0.91	2,031	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
AE	001	$ 163	27	0.70	2,075	1	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.26	$ 0.24	$ 0.23	$ 0.23
AF	002	$ 368	20	0.70	2,054	1	1	1	0.04	0.04	0.04	0.04	$ 19	$ 0.82	$ 0.75	$ 0.72	$ 0.72
V	005	$ 381	26	0.91	2,623	1	0	1	0.04	0.04	0.04	0.04	$ 15	$ 0.64	$ 0.59	$ 0.56	$ 0.56
AG	001	$ 518	36	0.70	2,603	1	0	1	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.55	$ 0.55
V	004	$ 449	25	0.90	3,163	1	0	1	0.04	0.04	0.04	0.04	$ 18	$ 0.78	$ 0.72	$ 0.69	$ 0.69
V	005	$ 506	35	0.91	3,912	1	0	2	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.56	$ 0.56
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
B	004	$ 707	52	0.70	4,390	1	0	0	0.04	0.04	0.04	0.04	$ 14	$ 0.59	$ 0.54	$ 0.52	$ 0.52
V	004	$ 490	50	0.90	6,025	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
V	005	$ 506	73	0.91	6,865	1	0	2		0.04	0.04	0.04	$ 7	$ -	$ 0.28	$ 0.27	$ 0.27
W	004	$ 1,027	76	0.70	8,051	3	0	3			0.04	0.04	$ 14	$ -	$ -	$ 0.52	$ 0.52
W	004	$ 1,107	101	0.70	12,064	2	0	2		0.04	0.04	0.04	$ 11	$ -	$ 0.44	$ 0.42	$ 0.42
								SUM	1.00	1.00	1.00	1.00		$21.84	$20.80	$20.52	$20.52
									1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43

Table 105: Outdoor Dining Cost per Watt

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area Light																	
N	001	$ 22	1	0.70	90	0	1	0	0.05	0.04	0.04	0.04	$ 23	$ 1.09	$ 1.00	$ 1.00	$ 1.00
R	001	$ 45	1	0.70	42	0	3	1	0.05	0.04	0.04	0.04	$ 45	$ 2.14	$ 1.95	$ 1.95	$ 1.95
R	001	$ 45	3	0.70	256	0	3	1	0.05	0.04	0.04	0.04	$ 15	$ 0.71	$ 0.65	$ 0.65	$ 0.65
O	001	$ 806	13	0.70	925	1	0	0	0.05	0.04	0.04	0.04	$ 61	$ 2.89	$ 2.63	$ 2.63	$ 2.63
B	002	$ 1,381	25	0.93	1,170	1	2	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.40	$ 2.40	$ 2.40
B	002	$ 1,381	25	0.93	1,216	1	1	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.40	$ 2.40	$ 2.40
B	002	$ 1,381	25	0.93	1,735	1	0	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.40	$ 2.40	$ 2.40
A	002	$ 1,553	21	0.83	2,051	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.22	$ 3.22	$ 3.22
A	002	$ 1,553	21	0.83	2,189	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.22	$ 3.22	$ 3.22
A	002	$ 1,553	21	0.83	2,114	1	0	1	0.05	0.04	0.04	0.04	$ 74	$ 3.52	$ 3.22	$ 3.22	$ 3.22
A	002	$ 1,553	30	0.83	2,760	1	0	1	0.05	0.04	0.04	0.04	$ 52	$ 2.47	$ 2.25	$ 2.25	$ 2.25
B	002	$ 1,381	25	0.93	1,830	1	0	1	0.05	0.04	0.04	0.04	$ 55	$ 2.63	$ 2.40	$ 2.40	$ 2.40
W	002	$ 1,970	22	0.84	2,117	1	0	1	0.05	0.04	0.04	0.04	$ 90	$ 4.26	$ 3.89	$ 3.89	$ 3.89
BD	001	$ 1,434	36	0.92	2,221	1	0	1	0.05	0.04	0.04	0.04	$ 40	$ 1.90	$ 1.73	$ 1.73	$ 1.73
W	003	$ 1,071	30	0.84	3,126	1	0	1	0.05	0.04	0.04	0.04	$ 36	$ 1.70	$ 1.55	$ 1.55	$ 1.55
BD	001	$ 1,434	52	0.92	3,178	1	0	1	0.05	0.04	0.04	0.04	$ 28	$ 1.31	$ 1.20	$ 1.20	$ 1.20
AF	003	$ 1,776	48	0.70	4,247	1	0	1	0.05	0.04	0.04	0.04	$ 37	$ 1.76	$ 1.61	$ 1.61	$ 1.61
A	001	$ 1,379	22	0.84	1,888	1	0	1	0.05	0.04	0.04	0.04	$ 63	$ 2.98	$ 2.72	$ 2.72	$ 2.72
A	001	$ 1,379	51	0.84	4,431	2	0	2	0.05	0.04	0.04	0.04	$ 27	$ 1.29	$ 1.18	$ 1.18	$ 1.18
A	001	$ 1,379	51	0.84	4,348	1	0	1	0.05	0.04	0.04	0.04	$ 27	$ 1.29	$ 1.18	$ 1.18	$ 1.18
W	003	$ 1,061	51	0.84	5,229	3	0	2	0.05	0.04	0.04	0.04	$ 21	$ 0.99	$ 0.90	$ 0.90	$ 0.90
A	001	$ 1,450	95	0.84	7,312	2	0	2		0.04	0.04	0.04	$ 15	$ -	$ 0.66	$ 0.66	$ 0.66
A	001	$ 1,450	95	0.84	7,572	3	0	2		0.04	0.04	0.04	$ 15	$ -	$ 0.66	$ 0.66	$ 0.66
								SUM	1.00	1.00	1.00	1.00		$47.87	$45.04	$45.04	$45.04
Cylindrical - Wall Mounted up/down																	
M	001	$ 950	8	0.70	900	1	1	0	0.33	0.33	0.33	0.33	$ 119	$39.57	$39.57	$39.57	$39.57
AO	001	$ 349	13	0.70	931	1	1	0	0.33	0.33	0.33	0.33	$ 27	$ 8.96	$ 8.96	$ 8.96	$ 8.96
H	003	$ 434	21	0.81	1,047	1	4	0	0.33	0.33	0.33	0.33	$ 21	$ 6.89	$ 6.89	$ 6.89	$ 6.89
								SUM	1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43
Surface Mounted Downlight																	
AC	001	$ 99	20	0.70	1,813	1	0	1	0.25	0.25	0.25	0.25	$ 5	$ 1.22	$ 1.22	$ 1.22	$ 1.22
BB	001	$ 793	19	0.70	1,509	1	0	0	0.25	0.25	0.25	0.25	$ 42	$10.43	$10.43	$10.43	$10.43
Q	002	$ 61	14	0.70	1,081	1	1	0	0.25	0.25	0.25	0.25	$ 5	$ 1.13	$ 1.13	$ 1.13	$ 1.13
T	001	$ 272	24	0.70	3,055	2	3	2	0.25	0.25	0.25	0.25	$ 11	$ 2.80	$ 2.80	$ 2.80	$ 2.80
								SUM	1.00	1.00	1.00	1.00		$15.58	$15.58	$15.58	$15.58
Surface Mounted Linear																	
AB	002	$ 524	18	0.70	1,663	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AB	002	$ 524	38	0.70	3,111	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
AB	003	$ 930	38	0.70	1,539	1	1	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.73	$ 0.73
AV	001	$ 549	30	0.95	2,068	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.58	$ 0.58	$ 0.56	$ 0.56
AV	001	$ 549	39	0.95	2,756	1	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.44	$ 0.44	$ 0.42	$ 0.42
AV	001	$ 579	24	0.95	3,444	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.74	$ 0.74	$ 0.72	$ 0.72
AW	001	$ 639	22	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 29	$ 0.91	$ 0.91	$ 0.88	$ 0.88
AW	001	$ 639	33	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 19	$ 0.60	$ 0.60	$ 0.58	$ 0.58
AW	001	$ 639	44	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 14	$ 0.45	$ 0.45	$ 0.44	$ 0.44
BC	001	$ 524	16	0.70	1,560	2	0	1	0.03	0.03	0.03	0.03	$ 33	$ 1.02	$ 1.02	$ 0.99	$ 0.99
BC	001	$ 524	32	0.70	3,100	2	0	1	0.03	0.03	0.03	0.03	$ 16	$ 0.51	$ 0.51	$ 0.50	$ 0.50
BC	001	$ 524	41	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 13	$ 0.40	$ 0.40	$ 0.39	$ 0.39
Y	001	$ 569	14	0.70	1,056	1	0	1	0.03	0.03	0.03	0.03	$ 40	$ 1.23	$ 1.23	$ 1.20	$ 1.20
Y	001	$ 569	18	0.70	1,328	1	0	1	0.03	0.03	0.03	0.03	$ 31	$ 0.97	$ 0.97	$ 0.94	$ 0.94
Y	001	$ 569	28	0.70	2,004	1	0	1	0.03	0.03	0.03	0.03	$ 20	$ 0.63	$ 0.63	$ 0.61	$ 0.61
Y	001	$ 569	37	0.70	2,580	1	0	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 405	12	0.70	560	0	1	0	0.03	0.03	0.03	0.03	$ 34	$ 1.06	$ 1.06	$ 1.02	$ 1.02
AZ	001	$ 470	30	0.70	1,680	1	1	1	0.03	0.03	0.03	0.03	$ 15	$ 0.48	$ 0.48	$ 0.47	$ 0.47
AZ	001	$ 529	30	0.70	2,480	1	1	1	0.03	0.03	0.03	0.03	$ 17	$ 0.54	$ 0.54	$ 0.53	$ 0.53
Z	002	$ 624	17	0.70	2,000	1	0	1	0.03	0.03	0.03	0.03	$ 38	$ 1.18	$ 1.18	$ 1.15	$ 1.15
Z	002	$ 624	26	0.70	3,000	1	0	1	0.03	0.03	0.03	0.03	$ 24	$ 0.76	$ 0.76	$ 0.74	$ 0.74
Z	002	$ 624	35	0.70	4,000	2	0	1	0.03	0.03	0.03	0.03	$ 18	$ 0.56	$ 0.56	$ 0.54	$ 0.54
BE	001	$ 160	10	0.70	1,236	0	1	0	0.03	0.03	0.03	0.03	$ 17	$ 0.52	$ 0.52	$ 0.50	$ 0.50
BE	001	$ 245	18	0.70	1,696	0	1	0	0.03	0.03	0.03	0.03	$ 14	$ 0.43	$ 0.43	$ 0.42	$ 0.42
BE	001	$ 329	26	0.70	2,308	0	1	0	0.03	0.03	0.03	0.03	$ 12	$ 0.39	$ 0.39	$ 0.38	$ 0.38
AX	001	$ 589	19	0.70	1,008	0	2	1	0.03	0.03	0.03	0.03	$ 31	$ 0.98	$ 0.98	$ 0.95	$ 0.95
AX	001	$ 589	35	0.70	1,876	1	2	1	0.03	0.03	0.03	0.03	$ 17	$ 0.53	$ 0.53	$ 0.51	$ 0.51
AY	001	$ 524	8	0.70	1,400	1	2	1	0.03	0.03	0.03	0.03	$ 66	$ 2.05	$ 2.05	$ 1.99	$ 1.99
AY	001	$ 524	12	0.70	2,200	1	2	1	0.03	0.03	0.03	0.03	$ 45	$ 1.41	$ 1.41	$ 1.37	$ 1.37
AY	001	$ 524	19	0.70	3,200	1	3	1	0.03	0.03	0.03	0.03	$ 27	$ 0.85	$ 0.85	$ 0.83	$ 0.83
AY	001	$ 524	24	0.70	4,000	1	3	1	0.03	0.03	0.03	0.03	$ 22	$ 0.68	$ 0.68	$ 0.66	$ 0.66
AY	001	$ 524	30	0.70	4,800	2	3	1	0.03	0.03	0.03	0.03	$ 17	$ 0.55	$ 0.55	$ 0.53	$ 0.53
AY	001	$ 524	65	0.70	8,800	2	3	1			0.03	0.03	$ 8	$ -	$ -	$ 0.24	$ 0.24
								SUM	1.00	1.00	1.00	1.00		$24.03	$24.03	$23.55	$23.55

Table 106: Outdoor Dining Cost per Watt, continued

2019 LED									Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Wall Mounted																	
C	001	$ 409	16	0.95	696	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.65	$ 1.65	$ 1.65	$ 1.65
H	002	$ 639	14	0.70	846	0	4	0	0.06	0.06	0.06	0.06	$ 46	$ 2.85	$ 2.85	$ 2.85	$ 2.85
S	001	$ 147	26	0.70	823	1	0	0	0.06	0.06	0.06	0.06	$ 6	$ 0.35	$ 0.35	$ 0.35	$ 0.35
AH	001	$ 815	24	0.70	950	1	3	1	0.06	0.06	0.06	0.06	$ 34	$ 2.12	$ 2.12	$ 2.12	$ 2.12
C	001	$ 409	16	0.95	1,084	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.65	$ 1.65	$ 1.65	$ 1.65
S	002	$ 162	18	0.70	1,189	1	1	0	0.06	0.06	0.06	0.06	$ 9	$ 0.56	$ 0.56	$ 0.56	$ 0.56
C	001	$ 409	16	0.95	1,214	0	4	0	0.06	0.06	0.06	0.06	$ 26	$ 1.65	$ 1.65	$ 1.65	$ 1.65
H	001	$ 1,125	17	0.81	1,216	1	1	0	0.06	0.06	0.06	0.06	$ 66	$ 4.14	$ 4.14	$ 4.14	$ 4.14
AF	001	$ 809	40	0.70	1,290	1	1	1	0.06	0.06	0.06	0.06	$ 20	$ 1.25	$ 1.25	$ 1.25	$ 1.25
V	005	$ 381	13	0.91	1,415	0	0	1	0.06	0.06	0.06	0.06	$ 29	$ 1.83	$ 1.83	$ 1.83	$ 1.83
V	004	$ 408	12	0.90	1,494	0	0	0	0.06	0.06	0.06	0.06	$ 34	$ 2.13	$ 2.13	$ 2.13	$ 2.13
B	004	$ 1,719	88	0.70	3,003	1	3	0	0.06	0.06	0.06	0.06	$ 20	$ 1.23	$ 1.23	$ 1.23	$ 1.23
V	005	$ 381	19	0.91	1,957	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.25	$ 1.25	$ 1.25	$ 1.25
V	005	$ 381	19	0.91	2,031	1	0	1	0.06	0.06	0.06	0.06	$ 20	$ 1.25	$ 1.25	$ 1.25	$ 1.25
AE	001	$ 163	27	0.70	2,075	1	1	0	0.06	0.06	0.06	0.06	$ 6	$ 0.38	$ 0.38	$ 0.38	$ 0.38
AF	002	$ 368	20	0.70	2,054	1	1	1	0.06	0.06	0.06	0.06	$ 19	$ 1.17	$ 1.17	$ 1.17	$ 1.17
								SUM	1.00	1.00	1.00	1.00		$25.47	$25.47	$25.47	$25.47
									1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43

Table 107: Special Security Lighting for Retail Parking and Pedestrian Hardscape Cost per Watt

2019 LED											Weighting					Weighted Cost per Watt			
Luminaire Manufacturer Letter	Luminaire Product Number	2019 Luminaire Cost	2019 System Watts	LED L70 lifetime hours (LLD)	Initial Luminaire Lumens	Maintained Luminaire Lumens	Lumens per Watt (LPW)	B	U	G	LZ1	LZ2	LZ3	LZ4		LZ1	LZ2	LZ3	LZ4
Area Light																			
B	002	$ 1,381	25	0.93	1,170	1,088	44	1	2	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.63	$ 2.51	$ 2.51
B	002	$ 1,381	25	0.93	1,216	1,131	45	1	1	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.63	$ 2.51	$ 2.51
B	002	$ 1,381	25	0.93	1,735	1,614	65	1	0	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.63	$ 2.51	$ 2.51
A	002	$ 1,553	21	0.83	2,051	1,702	81	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.52	$ 3.36	$ 3.36
A	002	$ 1,553	21	0.83	2,189	1,817	87	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.52	$ 3.36	$ 3.36
A	002	$ 1,553	21	0.83	2,114	1,755	84	1	0	1	0.06	0.05	0.05	0.05	$ 74	$ 4.35	$ 3.52	$ 3.36	$ 3.36
A	002	$ 1,553	30	0.83	2,760	2,291	76	1	0	1	0.06	0.05	0.05	0.05	$ 52	$ 3.05	$ 2.47	$ 2.35	$ 2.35
B	002	$ 1,381	25	0.93	1,830	1,702	68	1	0	1	0.06	0.05	0.05	0.05	$ 55	$ 3.25	$ 2.63	$ 2.51	$ 2.51
W	002	$ 1,970	22	0.84	2,117	1,778	81	1	0	1	0.06	0.05	0.05	0.05	$ 90	$ 5.27	$ 4.26	$ 4.07	$ 4.07
BD	001	$ 1,434	36	0.92	2,221	2,043	57	1	0	1	0.06	0.05	0.05	0.05	$ 40	$ 2.34	$ 1.90	$ 1.81	$ 1.81
W	003	$ 1,071	30	0.84	3,126	2,626	88	1	0	1	0.06	0.05	0.05	0.05	$ 36	$ 2.10	$ 1.70	$ 1.62	$ 1.62
BD	001	$ 1,434	52	0.92	3,178	2,924	56	1	0	1	0.06	0.05	0.05	0.05	$ 28	$ 1.62	$ 1.31	$ 1.25	$ 1.25
AF	003	$ 1,776	48	0.70	4,247	2,973	62	1	0	1	0.06	0.05	0.05	0.05	$ 37	$ 2.18	$ 1.76	$ 1.68	$ 1.68
A	001	$ 1,379	22	0.84	1,888	1,586	72	1	0	1	0.06	0.05	0.05	0.05	$ 63	$ 3.69	$ 2.98	$ 2.85	$ 2.85
A	001	$ 1,379	51	0.84	4,431	3,722	73	2	0	2	0.06	0.05	0.05	0.05	$ 27	$ 1.59	$ 1.29	$ 1.23	$ 1.23
A	001	$ 1,379	51	0.84	4,348	3,652	72	1	0	1	0.06	0.05	0.05	0.05	$ 27	$ 1.59	$ 1.29	$ 1.23	$ 1.23
W	003	$ 1,061	51	0.84	5,229	4,392	86	3	0	2	0.06	0.05	0.05	0.05	$ 21	$ 1.22	$ 0.99	$ 0.95	$ 0.95
A	001	$ 1,450	95	0.84	7,312	6,142	65	2	0	2		0.05	0.05	0.05	$ 15	$ -	$ 0.73	$ 0.69	$ 0.69
A	001	$ 1,450	95	0.84	7,572	6,360	67	3	0	2		0.05	0.05	0.05	$ 15	$ -	$ 0.73	$ 0.69	$ 0.69
W	004	$ 1,063	96	0.89	10,231	9,106	95	3	0	2		0.05	0.05	0.05	$ 11	$ -	$ 0.53	$ 0.50	$ 0.50
C	009	$ 863	124	0.95	14,200	13,490	109	2	0	3			0.05	0.05	$ 7	$ -	$ -	$ 0.32	$ 0.32
V	002	$ 1,074	125	0.91	13,999	12,683	101	3	0	1		0.05	0.05	0.05	$ 9	$ -	$ 0.41	$ 0.39	$ 0.39
										SUM	1.00	1.00	1.00	1.00		$50.70	$43.43	$41.77	$41.77
Cylindrical - WM u/d																			
M	001	$ 950	8	0.70	900	630	79	1	1	0	0.33	0.33	0.33	0.33	$ 119	$39.57	$39.57	$39.57	$39.57
AO	001	$ 349	13	0.70	931	652	50	1	1	0	0.33	0.33	0.33	0.33	$ 27	$ 8.96	$ 8.96	$ 8.96	$ 8.96
H	003	$ 434	21	0.81	1,047	848	40	1	4	0	0.33	0.33	0.33	0.33	$ 21	$ 6.89	$ 6.89	$ 6.89	$ 6.89
										SUM	1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43
Flood																			
AT	001	$ 571	70	0.93	7,389	6,857	98	na	na	na		0.50	0.25	0.17	$ 8	$ -	$ 4.08	$ 2.04	$ 1.36
AL	001	$ 256	64	0.87	9,275	8,069	126	na	na	na		0.50	0.25	0.17	$ 4	$ -	$ 2.00	$ 1.00	$ 0.67
AT	002	$ 953	90	0.92	10,699	9,854	109	na	na	na			0.25	0.17	$ 11	$ -	$ -	$ 2.65	$ 1.77
C	007	$ 1,305	99	0.70	11,100	7,770	78	na	na	na			0.25	0.17	$ 13	$ -	$ -	$ 3.30	$ 2.20
AT	002	$ 1,017	135	0.92	13,709	12,626	94	na	na	na				0.17	$ 8	$ -	$ -	$ -	$ 1.26
AT	002	$ 1,079	175	0.92	17,615	16,223	93	na	na	na				0.17	$ 6	$ -	$ -	$ -	$ 1.03
										SUM	0.00	1.00	1.00	1.00		$ -	$ 6.08	$ 8.98	$ 8.27
Wall Mounted																			
C	001	$ 409	16	0.95	696	661	43	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	002	$ 639	14	0.70	846	592	42	0	4	0	0.04	0.04	0.04	0.04	$ 46	$ 1.98	$ 1.83	$ 1.76	$ 1.76
S	001	$ 147	26	0.70	823	576	22	1	0	0	0.04	0.04	0.04	0.04	$ 6	$ 0.24	$ 0.22	$ 0.22	$ 0.22
AH	001	$ 815	24	0.70	950	665	28	1	3	1	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
C	001	$ 409	16	0.95	1,084	1,030	66	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
S	002	$ 162	18	0.70	1,189	832	46	1	1	0	0.04	0.04	0.04	0.04	$ 9	$ 0.39	$ 0.36	$ 0.35	$ 0.35
C	001	$ 409	16	0.95	1,214	1,153	74	0	4	0	0.04	0.04	0.04	0.04	$ 26	$ 1.15	$ 1.06	$ 1.02	$ 1.02
H	001	$ 1,125	17	0.81	1,216	985	58	1	1	0	0.04	0.04	0.04	0.04	$ 66	$ 2.88	$ 2.65	$ 2.55	$ 2.55
AF	001	$ 809	40	0.70	1,290	903	22	1	1	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	13	0.91	1,415	1,288	99	0	0	1	0.04	0.04	0.04	0.04	$ 29	$ 1.28	$ 1.17	$ 1.13	$ 1.13
V	004	$ 408	12	0.90	1,494	1,345	112	0	0	0	0.04	0.04	0.04	0.04	$ 34	$ 1.48	$ 1.36	$ 1.31	$ 1.31
B	004	$ 1,719	88	0.70	3,003	2,102	24	1	3	0	0.04	0.04	0.04	0.04	$ 20	$ 0.85	$ 0.79	$ 0.75	$ 0.75
V	005	$ 381	19	0.91	1,957	1,781	94	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
V	005	$ 381	19	0.91	2,031	1,848	97	1	0	1	0.04	0.04	0.04	0.04	$ 20	$ 0.87	$ 0.80	$ 0.77	$ 0.77
AE	001	$ 163	27	0.70	2,075	1,453	54	1	1	0	0.04	0.04	0.04	0.04	$ 6	$ 0.26	$ 0.24	$ 0.23	$ 0.23
AF	002	$ 368	20	0.70	2,054	1,438	73	1	1	1	0.04	0.04	0.04	0.04	$ 19	$ 0.82	$ 0.75	$ 0.72	$ 0.72
V	005	$ 381	26	0.91	2,623	2,387	92	1	0	1	0.04	0.04	0.04	0.04	$ 15	$ 0.64	$ 0.59	$ 0.56	$ 0.56
AG	001	$ 518	36	0.70	2,603	1,822	51	1	0	1	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.55	$ 0.55
V	004	$ 449	25	0.90	3,163	2,847	114	1	0	1	0.04	0.04	0.04	0.04	$ 18	$ 0.78	$ 0.72	$ 0.69	$ 0.69
V	005	$ 506	35	0.91	3,912	3,560	102	1	0	2	0.04	0.04	0.04	0.04	$ 14	$ 0.63	$ 0.58	$ 0.56	$ 0.56
V	004	$ 490	50	0.90	6,025	5,423	108	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
B	004	$ 707	52	0.70	4,390	3,073	59	1	0	0	0.04	0.04	0.04	0.04	$ 14	$ 0.59	$ 0.54	$ 0.52	$ 0.52
V	004	$ 490	50	0.90	6,025	5,423	108	1	0	1	0.04	0.04	0.04	0.04	$ 10	$ 0.43	$ 0.39	$ 0.38	$ 0.38
V	005	$ 506	73	0.91	6,865	6,247	86	1	0	2		0.04	0.04	0.04	$ 7	$ -	$ 0.28	$ 0.27	$ 0.27
W	004	$ 1,027	76	0.70	8,051	5,636	74	3	0	3			0.04	0.04	$ 14	$ -	$ -	$ 0.52	$ 0.52
W	004	$ 1,107	101	0.70	12,064	8,445	84	2	0	2		0.04	0.04	0.04	$ 11	$ -	$ 0.44	$ 0.42	$ 0.42
										SUM	1.00	1.00	1.00	1.00		$21.84	$20.80	$20.52	$20.52
							Average:				1.00	1.00	1.00	1.00		$55.43	$55.43	$55.43	$55.43

Appendix K: General Hardscape Lighting Power Allowance Calculations

The General Hardscape lighting levels are taken from the IES RP-8-18 Chapter 17 Addendum 1 Parking Facilities. IES is recommending lower parking lot lighting levels based on recent research by VTTI, which found that lower lighting levels are necessary than previously published. This research also found that task visibility does not change depending on pavement surface type. Due to these findings, the surface classification distinction would be removed from Title 24, Part 6 Table 140.7-A to simplify code compliance.

The general hardscape lighting power allowance calculations are based on 46 different products by 17 different manufacturers that represent typical area luminaires. These products include architectural area lights and post top lights with Type III, Type IV, and Type V distributions. Each luminaire studied was selected to meet the backlight, uplight, and glare (BUG) ratings specified in Title 24, Part 11, Table 5.106.8 (CALGreen). Luminaires installed within two mounting heights have a property line have minimal backlight to reduce light trespass across the adjacent property line.

The luminaire wattage, lumen output, and unit cost can be found in Table 108 below. Low lumen output luminaires were considered for lighting zones with less ambient light (LZ1 and LZ2) and lower luminaire mounting heights. The real design calculation for LZ1 and LZ2 were performed for mounting heights of 10 feet to 35 feet. The LZ3 calculations were performed for mounting heights of 15 feet to 40 feet. The LZ4 calculations were performed for mounting heights of 15 feet to 50 feet. The amount of times each luminaire was studied within each LZ is shown in Table 109.

Table 108: General Hardscape Luminaire Characteristics and Cost

Luminaire ID	Wattage	Lumens	Unit Cost	Cost per Lumen	Cost per Watt
A 01	95	7,312	$ 1,450	$ 0.20	$ 15.26
A 02	21	2,189	$ 1,553	$ 0.71	$ 73.97
A 03	31	2,653	$ 1,379	$ 0.52	$ 44.48
A 04	161	18,928	$ 301	$ 0.02	$ 1.87
AF 03	70	6,096	$ 1,776	$ 0.29	$ 25.37
AQ 02	124	10,128	$ 1,060	$ 0.10	$ 8.58
AQ 02	95	8,070	$ 1,060	$ 0.13	$ 11.22
AQ 03	75	5,948	$ 1,060	$ 0.18	$ 14.13
AQ 04	105	7,541	$ 1,060	$ 0.14	$ 10.14
AT 02	126	11,685	$ 2,090	$ 0.18	$ 16.64
AU 02	43	3,745	$ 1,628	$ 0.43	$ 37.85
AU 03	122	12,727	$ 2,103	$ 0.17	$ 17.24
AU 04	81	7,492	$ 2,007	$ 0.27	$ 24.78
AU 05	81	7,956	$ 2,103	$ 0.26	$ 25.96
B 03	130	11,718	$ 2,332	$ 0.20	$ 17.94
B 05	38	2,226	$ 1,778	$ 0.80	$ 47.04
B 06	130	11,718	$ 2,332	$ 0.20	$ 17.94
BD 01	53	3,127	$ 1,434	$ 0.46	$ 27.20
BF 01	67	4,843	$ 1,731	$ 0.36	$ 25.83
BF 02	45	4,260	$ 1,620	$ 0.38	$ 35.99
BF 02	45	4,187	$ 1,620	$ 0.39	$ 35.99
BF 03	64	4,843	$ 1,591	$ 0.33	$ 25.05
BG 01	54	3,937	$ 1,060	$ 0.27	$ 19.81
BH 01	18	2,190	$ 1,060	$ 0.48	$ 58.89
BH 02	56	6,694	$ 1,060	$ 0.16	$ 18.93
C 04	24	2,061	$ 1,741	$ 0.84	$ 72.53
C 08	25	2,905	$ 686	$ 0.24	$ 27.77
C 09	66	8,175	$ 747	$ 0.09	$ 11.32
C 10	44	4,612	$ 643	$ 0.14	$ 14.60
D 01	186	24,600	$ 742	$ 0.03	$ 3.99
D 02	58	6,200	$ 679	$ 0.11	$ 11.70
D 02	58	5,800	$ 679	$ 0.12	$ 11.70
D 03	35	3,800	$ 762	$ 0.20	$ 21.78
D 04	43	4,800	$ 820	$ 0.17	$ 19.06
E 01	25	3,789	$ 1,187	$ 0.31	$ 46.73
E 02	45	3,905	$ 1,253	$ 0.32	$ 27.85
E 03	38	4,280	$ 662	$ 0.15	$ 17.42
I 02	72	5,126	$ 1,060	$ 0.21	$ 14.72
I 03	72	4,639	$ 1,060	$ 0.23	$ 14.72
I 04	72	6,959	$ 1,060	$ 0.15	$ 14.72
T 02	62	6,455	$ 618	$ 0.10	$ 9.96
V 02	54	6,710	$ 1,074	$ 0.16	$ 19.88
V 03	80	27,301	$ 1,338	$ 0.05	$ 16.72
V 04	50	6,025	$ 490	$ 0.08	$ 9.80
V 06	75	5,398	$ 1,492	$ 0.28	$ 19.89
V 07	35	4,123	$ 570	$ 0.14	$ 16.28
W 02	31	2,881	$ 1,970	$ 0.68	$ 63.55
W 03	30	3,126	$ 1,071	$ 0.34	$ 35.69
W 04	51	5,229	$ 1,061	$ 0.20	$ 20.80
W 05	56	6,044	$ 960	$ 0.16	$ 17.23
W 06	37	3,458	$ 379	$ 0.11	$ 10.29
W 07	28	2,687	$ 379	$ 0.14	$ 13.62

Table 109: General Hardscape Weighting

2019 Weighting						
0.10%	4.95%	4.95%	45.00%	45.00%	0.00%	0.00%
2019 Studied						
LZ1-A	LZ2-A	LZ2-C	LZ3-A	LZ3-C	LZ4-A	LZ4-C
0	0.13	0.13	0.05	0.05	0.04	0.04
0.01	0.02	0.02	0.02	0.02	0	0
0.01	0.05	0.05	0.02	0.02	0	0
0	0	0	0	0	0.06	0.06
0	0	0	0	0	0.01	0.01
0.01	0	0	0	0	0.01	0.01
0.04	0	0	0.03	0.03	0.01	0.01
0	0	0	0.03	0.03	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0	0	0.03	0.03
0	0.02	0.02	0	0	0	0
0	0.02	0.02	0	0	0.04	0.04
0	0.03	0.03	0	0	0.01	0.01
0.04	0.02	0.02	0.02	0.02	0	0
0	0	0	0.05	0.05	0.04	0.04
0.04	0.02	0.02	0	0	0	0
0.03	0.03	0.03	0	0	0.01	0.01
0.01	0.03	0.03	0.02	0.02	0.07	0.07
0	0	0	0.02	0.02	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0.03	0.03	0	0
0	0	0	0.02	0.02	0	0
0.07	0	0	0	0	0.01	0.01
0.18	0.05	0.05	0.07	0.07	0	0
0	0	0	0	0	0.06	0.06
0.06	0.03	0.03	0	0	0.04	0.04
0	0	0	0	0	0.03	0.03
0.01	0	0	0	0	0.06	0.06
0	0.08	0.08	0.07	0.07	0	0
0.08	0.03	0.03	0	0	0.01	0.01
0	0.02	0.02	0	0	0	0
0	0.02	0.02	0	0	0	0
0	0.02	0.02	0	0	0	0
0.06	0.05	0.05	0.02	0.02	0.06	0.06
0	0.02	0.02	0	0	0	0
0.04	0.03	0.03	0	0	0.01	0.01
0	0	0	0.02	0.02	0.06	0.06
0.07	0.02	0.02	0.13	0.13	0.07	0.07
0.04	0.03	0.03	0.1	0.1	0.01	0.01
0	0	0	0	0	0.04	0.04
0	0.05	0.05	0	0	0	0
0	0.02	0.02	0	0	0	0
0.03	0.03	0.03	0.08	0.08	0	0
0	0.02	0.02	0	0	0	0
0.01	0	0	0	0	0.01	0.01
0	0.07	0.07	0.05	0.05	0.03	0.03
0	0.02	0.02	0.02	0.02	0.09	0.09
0.08	0.02	0.02	0	0	0	0
0.04	0.03	0.03	0	0	0	0

2022 Weighting			
0.10%	9.90%	90.00%	0.00%
2022 Studied			
LZ1	LZ2	LZ3	LZ4
0	0.13	0.05	0.04
0.01	0.02	0.02	0
0.01	0.05	0.02	0
0	0	0	0.06
0	0	0	0.01
0.01	0	0	0.01
0.04	0	0.03	0.01
0	0	0.03	0
0	0	0.03	0
0	0	0	0.03
0	0.02	0	0
0	0.02	0	0.04
0	0.03	0	0.01
0.04	0.02	0.02	0
0	0	0.05	0.04
0.04	0.02	0	0
0.03	0.03	0	0.01
0.01	0.03	0.02	0.07
0	0	0.02	0
0	0	0.03	0
0	0	0.03	0
0	0	0.03	0
0	0	0.03	0
0	0	0.03	0
0	0	0.02	0
0.07	0	0	0.01
0.18	0.05	0.07	0
0	0	0	0.06
0.06	0.03	0	0.04
0	0	0	0.03
0.01	0	0	0.06
0	0.08	0.07	0
0.08	0.03	0	0.01
0	0.02	0	0
0	0.02	0	0
0	0.02	0	0
0.06	0.05	0.02	0.06
0	0.02	0	0
0.04	0.03	0	0.01
0	0	0.02	0.06
0.07	0.02	0.13	0.07
0.04	0.03	0.1	0.01
0	0	0	0.04
0	0.05	0	0
0	0.02	0	0
0.03	0.03	0.08	0
0	0.02	0	0
0.01	0	0	0.01
0	0.07	0.05	0.03
0	0.02	0.02	0.09
0.08	0.02	0	0
0.04	0.03	0	0

Luminaire ID
A 01
A 02
A 03
A 04
AF 03
AQ 02
AQ 02
AQ 03
AQ 04
AT 02
AU 02
AU 03
AU 04
AU 05
B 03
B 05
B 06
BD 01
BF 01
BF 02
BF 02
BF 03
BG 01
BH 01
BH 02
C 04
C 08
C 09
C 10
D 01
D 02
D 02
D 03
D 04
E 01
E 02
E 03
I 02
I 03
I 04
T 02
V 02
V 03
V 04
V 06
V 07
W 02
W 03
W 04
W 05
W 06
W 07

The weighting factors listed below in Table 110 and Table 111 were used to determine the statewide luminaire pricing listed Table 112. The statewide weighting factors were multiplied by the unit cost of each luminaire studied to determine the average statewide cost per each lighting zone.

Table 110: 2019 Title 24 Lighting Zone Weighting

LZ1	LZ2	LZ3	LZ4
0.1%	9.9%	90.0%	0.0%

Table 111: 2022 Title 24 Lighting Zone Weighting

LZ1	LZ2	LZ3	LZ4
5.0%	5.0%	90.0%	0.0%

Table 112: General Hardscape Weighted Cost Comparison

Luminaire ID	2022 Studied Cost Per kW. Statewide Results LZ1	LZ2	LZ3	LZ4	2019 Studied Cost Per kW. Statewide Results LZ1	LZ2	LZ3	LZ4
A01	$-	$ 3,502,942	$ 14,268,587	$-	$-	$ 4,490,409	$ 18,171,882	$-
A02	$ 15,537	$ 2,122,313	$ 23,052,937	$-	$ 16,084	$ 2,720,586	$ 29,359,266	$-
A03	$ 9,342	$ 3,828,069	$ 13,860,384	$-	$ 9,671	$ 4,907,188	$ 17,652,011	$-
A04	$-	$-	$-	$-	$-	$-	$-	$-
AF 03	$-	$-	$-	$-	$-	$-	$-	$-
AQ 02	$ 1,801	$-	$-	$-	$ 1,865	$-	$-	$-
AQ 02	$ 7,088	$-	$ 6,991,210	$-	$ 7,317	$-	$ 8,903,715	$-
AQ 03	$-	$-	$ 8,808,924	$-	$-	$-	$ 11,218,681	$-
AQ 04	$-	$-	$ 6,322,194	$-	$-	$-	$ 8,051,685	$-
AT 02	$-	$-	$-	$-	$-	$-	$-	$-
AU 02	$-	$ 1,085,885	$-	$-	$-	$ 1,391,993	$-	$-
AU 03	$-	$ 494,487	$-	$-	$-	$ 633,882	$-	$-
AU 04	$-	$ 1,421,929	$-	$-	$-	$ 1,822,766	$-	$-
AU 05	$ 16,358	$ 744,783	$ 8,089,967	$-	$ 16,933	$ 954,735	$ 10,303,048	$-
B 03	$-	$-	$ 16,771,124	$-	$-	$-	$ 21,359,009	$-
B 05	$ 29,639	$ 1,349,496	$-	$-	$ 30,682	$ 1,729,914	$-	$-
B 06	$ 7,536	$ 1,029,329	$-	$-	$ 7,801	$ 1,319,493	$-	$-
BD 01	$ 5,714	$ 1,560,979	$ 8,477,813	$-	$ 5,915	$ 2,001,013	$ 10,796,992	$-
BF 01	$-	$-	$ 8,049,663	$-	$-	$-	$ 10,251,718	$-
BF 02	$-	$-	$ 22,432,008	$-	$-	$-	$ 28,568,478	$-
BF 02	$-	$-	$ 22,432,008	$-	$-	$-	$ 28,568,478	$-
BF 03	$-	$-	$ 15,614,999	$-	$-	$-	$ 19,886,617	$-
BG 01	$-	$-	$ 12,348,959	$-	$-	$-	$ 15,727,123	$-
BH 01	$-	$-	$ 36,703,851	$-	$-	$-	$ 46,744,505	$-
BH 02	$-	$-	$ 5,898,833	$-	$-	$-	$ 7,512,510	$-
C 04	$ 76,166	$-	$-	$-	$ 78,847	$-	$-	$-
C 08	$ 75,836	$ 2,390,486	$ 34,621,171	$-	$ 78,506	$ 3,064,356	$ 44,092,091	$-
C 09	$-	$-	$-	$-	$-	$-	$-	$-
C 10	$ 12,270	$ 837,998	$-	$-	$ 12,702	$ 1,074,226	$-	$-
D 01	$-	$-	$-	$-	$-	$-	$-	$-
D 02	$ 2,458	$-	$-	$-	$ 2,545	$-	$-	$-
D 02	$-	$ 1,678,814	$ 14,588,455	$-	$-	$ 2,152,066	$ 18,579,253	$-
D 03	$ 27,451	$ 1,249,870	$-	$-	$ 28,417	$ 1,602,204	$-	$-
D 04	$-	$ 546,959	$-	$-	$-	$ 701,145	$-	$-
E 01	$-	$ 1,340,741	$-	$-	$-	$ 1,718,691	$-	$-
E 02	$-	$ 798,974	$-	$-	$-	$ 1,024,201	$-	$-
E 03	$ 14,633	$ 1,499,094	$ 5,427,805	$-	$ 15,148	$ 1,921,683	$ 6,912,628	$-
I 02	$-	$ 422,381	$-	$-	$-	$ 541,449	$-	$-
I 03	$ 9,277	$ 844,763	$-	$-	$ 9,603	$ 1,082,899	$-	$-
I 04	$-	$-	$ 4,587,981	$-	$-	$-	$ 5,843,063	$-
T 02	$ 10,462	$ 285,809	$ 24,836,019	$-	$ 10,830	$ 366,377	$ 31,830,126	$-
V02	$ 12,529	$ 1,140,898	$ 37,177,884	$-	$ 12,970	$ 1,462,513	$ 47,348,215	$-
V03	$-	$-	$-	$-	$-	$-	$-	$-
V04	$-	$ 843,798	$-	$-	$-	$ 1,081,661	$-	$-
V06	$-	$ 570,695	$-	$-	$-	$ 731,572	$-	$-
V07	$ 6,837	$ 933,870	$ 25,359,640	$-	$ 7,077	$ 1,197,124	$ 32,296,988	$-
W 02	$-	$ 1,823,392	$-	$-	$-	$ 2,337,400	$-	$-
W 03	$ 7,495	$-	$-	$-	$ 7,759	$-	$-	$-
W 04	$-	$ 2,386,541	$ 19,442,266	$-	$-	$ 3,059,298	$ 24,760,865	$-
W 05	$-	$ 494,231	$ 5,368,428	$-	$-	$ 633,553	$ 6,837,007	$-
W 06	$ 12,968	$ 295,219	$-	$-	$ 13,424	$ 378,440	$-	$-
W 07	$ 8,583	$ 781,587	$-	$-	$ 8,885	$ 1,001,914	$-	$-

	LZ1	LZ2	LZ3	LZ4	LZ1	LZ2	LZ3	LZ4
Average Statewide Cost on a Fixture	$ 7,115	$ 736,660	$ 7,721,791	$-	$ 7,365	$ 944,322	$ 9,834,153	$-
TOTAL	$ 369,958	$ 38,306,332	$ 401,533,112	$-	$ 382,981	$ 49,104,752	$ 511,375,954	$-

Appendix L: Mapping of IES Criteria

The target illuminance values proposed for the 2022 code cycle are found below. These proposed lighting levels are taken from current IES recommendations and the California Financial Code ATM lighting requirements. The parking lot lighting level criteria was recently revised by IES in the beginning of 2020 to revert back to the lighting levels recommended before 2014. This addendum is reflected in the applied parking lot lighting criteria below.

Table 113: Lighting Criteria Mapping

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Area Wattage Allowance (AWA); Linear Wattage Allowance (LWA); and Initial Wattage Allowance (IWA)	Not Applicable	RP-8-18 Chapter 17 Parking Facilities, Addendum 1 0.2 Horizontal FC Min, 0.1 Vertical FC Min, 20:1 Max:Min	RP-8-18 Chapter 17 Parking Facilities, Addendum 1 0.2 Horizontal FC Min, 0.1 Vertical FC Min, 20:1 Max:Min	RP-8-18 Chapter 17 Parking Facilities, Addendum 1 0.2 Horizontal FC Min, 0.1 Vertical FC Min, 20:1 Max:Min	RP-8-18 Chapter 17 Parking Facilities, Addendum 1 0.2 Horizontal FC Min, 0.1 Vertical FC Min, 20:1 Max:Min
Building Entrances or Exits. Allowance per door. Luminaires qualifying for this allowance shall be within 20 feet of the door.	Not Applicable	HB10 T22.2 "Non-Covered Entries/Exits - Medium Activity LZ1" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.4 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Non-Covered Entries/Exits - Medium Activity LZ2" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.6 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Non-Covered Entries/Exits - Medium Activity LZ3" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.8 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Non-Covered Entries/Exits - Medium Activity LZ4" 1.0 Horizontal FC Avg, 2:1 Avg:Min 1.0 Vertical FC Avg, 2:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not Applicable	HB10 T22.2 "Building Entries, Porte Cocheres - High Activity for Elderly LZ1" 2.0 Horizontal FC Avg, 2:1 Avg:Min 1.5 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Building Entries, Porte Cocheres - High Activity for Elderly LZ2" 4.0 Horizontal FC Avg, 2:1 Avg:Min 2.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Building Entries, Porte Cocheres - High Activity for Elderly LZ3" 5.0 Horizontal FC Avg, 2:1 Avg:Min 3.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Building Entries, Porte Cocheres - High Activity for Elderly LZ4" 7.5 Horizontal FC Avg, 2:1 Avg:Min 4.0 Vertical FC Avg, 2:1 Avg:Min
Drive Up Windows. Allowance per customer service location. Luminaires qualifying for this allowance shall be within two mounting heights of the sill of the window.	Not Applicable	HB10 T31.2 "Drive-Up Financial Services - Covered LZ1" 2.0 Horizontal FC Avg, 3:1 Avg:Min 0.8 Vertical FC Avg, 6:1 Avg:Min	HB10 T31.2 "Drive-Up Financial Services - Covered LZ2" 3.0 Horizontal FC Avg, 3:1 Avg:Min 1.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T31.2 "Drive-Up Financial Services - Covered LZ3" 4.0 Horizontal FC Avg, 3:1 Avg:Min 1.5 Vertical FC Avg, 6:1 Avg:Min	HB10 T31.2 "Drive-Up Financial Services - Covered LZ4" 5.0 Horizontal FC Avg, 3:1 Avg:Min 2.0 Vertical FC Avg, 3:1 Avg:Min
Vehicle Service Station Uncovered Fuel Dispenser. Allowance per fueling dispenser. Luminaires qualifying for this allowance shall be within two mounting heights of the dispenser.	Not Applicable	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ1 5.0 Horizontal FC Avg, 4:1 Avg:Min 5.0 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ2" 7.5 Horizontal FC Avg, 4:1 Avg:Min 7.5 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ3" 10.0 Horizontal FC Avg, 4:1 Avg:Min 10.0 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ4" 15.0 Horizontal FC Avg, 4:1 Avg:Min 15.0 Vertical FC Avg, 4:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
ATM Machine Lighting. Allowance per ATM machine. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	Not Applicable	California Financial Code 13041 10.0 Horizontal FC Min within 5ft 2.0 Horizontal FC Min within 60ft 10.0 Vertical FC Min on machine face	California Financial Code 13041 10.0 Horizontal FC Min within 5ft 2.0 Horizontal FC Min within 60ft 10.0 Vertical FC Min on machine face	California Financial Code 13041 10.0 Horizontal FC Min within 5ft 2.0 Horizontal FC Min within 60ft 10.0 Vertical FC Min on machine face	California Financial Code 13041 10.0 Horizontal FC Min within 5ft 2.0 Horizontal FC Min within 60ft 10.0 Vertical FC Min on machine face
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.	Not Applicable	NO ALLOWANCE	HB10 T34.2 "Automotive Sales Front Row - Medium Activity LZ2" 10.0 Horizontal FC Avg, 3:1 Avg:Min 10.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T34.2 "Automotive Sales Front Row - Medium Activity LZ3" 15.0 Horizontal FC Avg, 3:1 Avg:Min 15.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T34.2 "Automotive Sales Front Row - Medium Activity LZ4" 20.0 Horizontal FC Avg, 3:1 Avg:Min 20.0 Vertical FC Avg, 3:1 Avg:Min
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(d), and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not Applicable	NO ALLOWANCE	HB10 T34.2 "Centers, Outdoor, Plazas and Town Squares - Medium Activity LZ2" 0.2 Horizontal FC Avg, 5:1 Avg:Min 0.1 Vertical FC Avg, 10:1 Avg:Min	HB10 T34.2 "Centers, Outdoor, Plazas and Town Squares - Medium Activity LZ3" 0.4 Horizontal FC Avg, 5:1 Avg:Min 0.2 Vertical FC Avg, 10:1 Avg:Min	HB10 T34.2 "Centers, Outdoor, Plazas and Town Squares - Medium Activity LZ4" 0.6 Horizontal FC Avg, 5:1 Avg:Min 0.2 Vertical FC Avg, 5:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not Applicable	NO ALLOWANCE	HB10 T26.2 "Façade Fields - Medium Activity LZ2 Reflectance ≥ 50%" 2 FC AVG	HB10 T26.2 "Façade Fields - Medium Activity LZ3 Reflectance ≥ 50%" 3 FC AVG	HB10 T26.2 "Façade Fields - Medium Activity LZ4 Reflectance ≥ 50%" 4 FC AVG
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.	Not Applicable	HB10 T34.2 "Automotive Sales, Sales - Medium Activity LZ1" 4.0 Horizontal FC Avg, 3:1 Avg:Min 2.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T34.2 "Automotive Sales, Sales - Medium Activity LZ2" 5.0 Horizontal FC Avg, 3:1 Avg:Min 3.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T34.2 "Automotive Sales, Sales - Medium Activity LZ3" 7.5 Horizontal FC Avg, 3:1 Avg:Min 4.0 Vertical FC Avg, 6:1 Avg:Min	HB10 T34.2 "Automotive Sales, Sales - Medium Activity LZ4" 10.0 Horizontal FC Avg, 3:1 Avg:Min 5.0 Vertical FC Avg, 3:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not Applicable	HB10 T34.2 "Service Stations Outdoor Service - Medium Activity LZ1" 1.5 Horizontal FC Avg, 2:1 Avg:Min 1.5 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Service Stations Outdoor Service - Medium Activity LZ2" 2.0 Horizontal FC Avg, 2:1 Avg:Min 2.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Service Stations Outdoor Service - Medium Activity LZ3" 3.0 Horizontal FC Avg, 2:1 Avg:Min 3.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Service Stations Outdoor Service - Medium Activity LZ4" 4.0 Horizontal FC Avg, 2:1 Avg:Min 4.0 Vertical FC Avg, 2:1 Avg:Min
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.	Not Applicable	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ1" 5.0 Horizontal FC Avg, 4:1 Avg:Min 5.0 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ2" 7.5 Horizontal FC Avg, 4:1 Avg:Min 7.5 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ3" 10.0 Horizontal FC Avg, 4:1 Avg:Min 10.0 Vertical FC Avg, 8:1 Avg:Min	HB10 T34.2 "Service Stations Dispensing Islands - Medium Activity LZ4" 15.0 Horizontal FC Avg, 4:1 Avg:Min 15.0 Vertical FC Avg, 4:1 Avg:Min
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.	Not Applicable	HB10 T34.2 "Seasonal Open-Air Merchandise - LZ1" 1.5 Horizontal FC Avg, 2:1 Avg:Min 1.5 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Seasonal Open-Air Merchandise - LZ2" 2.0 Horizontal FC Avg, 2:1 Avg:Min 2.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Seasonal Open-Air Merchandise - LZ3" 3.0 Horizontal FC Avg, 2:1 Avg:Min 3.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T34.2 "Seasonal Open-Air Merchandise - LZ4" 4.0 Horizontal FC Avg, 2:1 Avg:Min 4.0 Vertical FC Avg, 4:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not Applicable	HB10 T22.2 "Canopied Entries - Medium Activity LZ1" 0.8 Horizontal FC Avg, 2:1 Avg:Min 0.4 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Canopied Entries - Medium Activity LZ2" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.6 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Canopied Entries - Medium Activity LZ3" 1.5 Horizontal FC Avg, 2:1 Avg:Min 0.8 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Canopied Entries - Medium Activity LZ1" 2.0 Horizontal FC Avg, 2:1 Avg:Min 1.0 Vertical FC Avg, 2:1 Avg:Min
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 two mounting heights of a vehicle lane or the guardhouse.	Not Applicable	HB10 T22.2 "Remote Monitored Site Gated Entries - Vehicles LZ1" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.8 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Remote Monitored Site Gated Entries - Vehicles LZ2" 1.5 Horizontal FC Avg, 2:1 Avg:Min 1.0 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Remote Monitored Site Gated Entries - Vehicles LZ3" 2.0 Horizontal FC Avg, 2:1 Avg:Min 1.5 Vertical FC Avg, 4:1 Avg:Min	HB10 T22.2 "Remote Monitored Site Gated Entries - Vehicles LZ4" 3.0 Horizontal FC Avg, 2:1 Avg:Min 2.0 Vertical FC Avg, 2:1 Avg:Min

	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 two mounting heights of the student pick-up/drop-off zone.	Not Applicable	NO ALLOWANCE HB10 T36.2	HB10 T36.2 "Aviation Terminals Covered Bus and Shuttle Pick-Up/Drop-Off - Medium Activity LZ2" 1.0 Horizontal FC Avg, 2:1 Avg:Min 0.6 Vertical FC Avg, 4:1 Avg:Min	HB10 T36.2 "Aviation Terminals Covered Bus and Shuttle Pick-Up/Drop-Off - Medium Activity LZ3" 1.5 Horizontal FC Avg, 2:1 Avg:Min 0.8 Vertical FC Avg, 4:1 Avg:Min	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 two mounting heights of the hardscape area of outdoor dining.	Not Applicable	HB10 T22.2 "Food Service, Restaurants - Fine Dining" 3.0 Horizontal FC Avg, 3:1 Avg:Min 1.0 Vertical FC Avg, 3:1 Avg:Min	HB10 T22.2 "Food Service, Restaurants - Fine Dining" 3.0 Horizontal FC Avg, 3:1 Avg:Min 1.0 Vertical FC Avg, 3:1 Avg:Min	HB10 T22.2 "Food Service, Restaurants - Fine Dining" 3.0 Horizontal FC Avg, 3:1 Avg:Min 1.0 Vertical FC Avg, 3:1 Avg:Min	HB10 T22.2 "Food Service, Restaurants - Fine Dining" 3.0 Horizontal FC Avg, 3:1 Avg:Min 1.0 Vertical FC Avg, 3:1 Avg:Min

	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
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.	Not Applicable	G-1-16 “Retail Stores and Centers - Parking Lot" 3.0 Horizontal FC Avg; 4:1 Avg:Min	G-1-16 “Retail Stores and Centers - Parking Lot" 3.0 Horizontal FC Avg; 4:1 Avg:Min	G-1-16 “Retail Stores and Centers - Parking Lot" 3.0 Horizontal FC Avg; 4:1 Avg:Min	NO ALLOWANCE

Appendix M: Nonresidential Use Schedules

The lighting zone reclassification and general hardscape energy savings are based on the following nonresidential electric use schedules. The following schedules were applied during the 2019 Code Cycle and are reused for the 2022 Code Cycle. The dimming profiles for both summer and winter months are shown in the following figures.

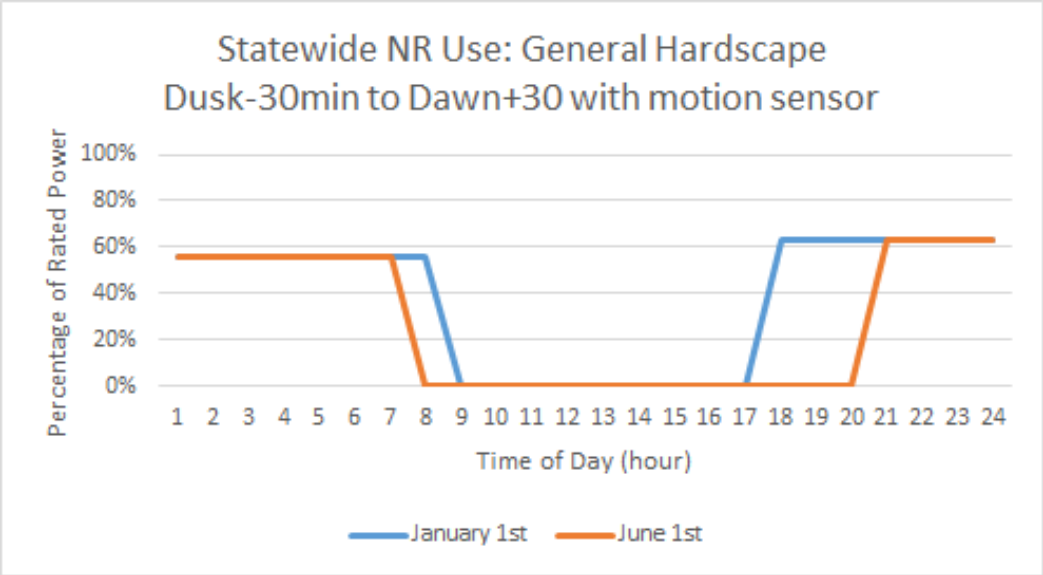

Figure 35: General Hardscape with Motion Sensor

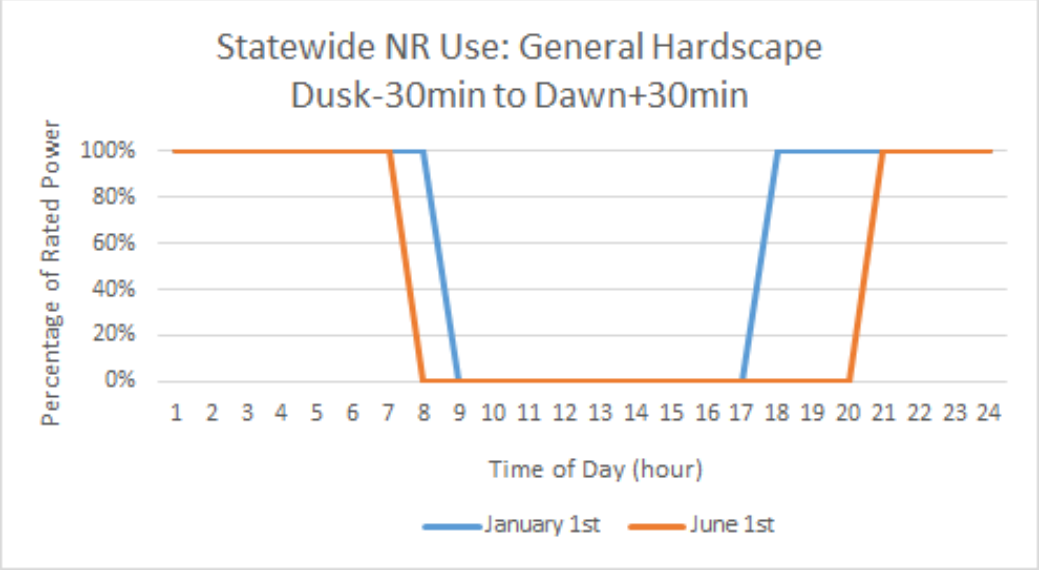

Figure 36: General Hardscape

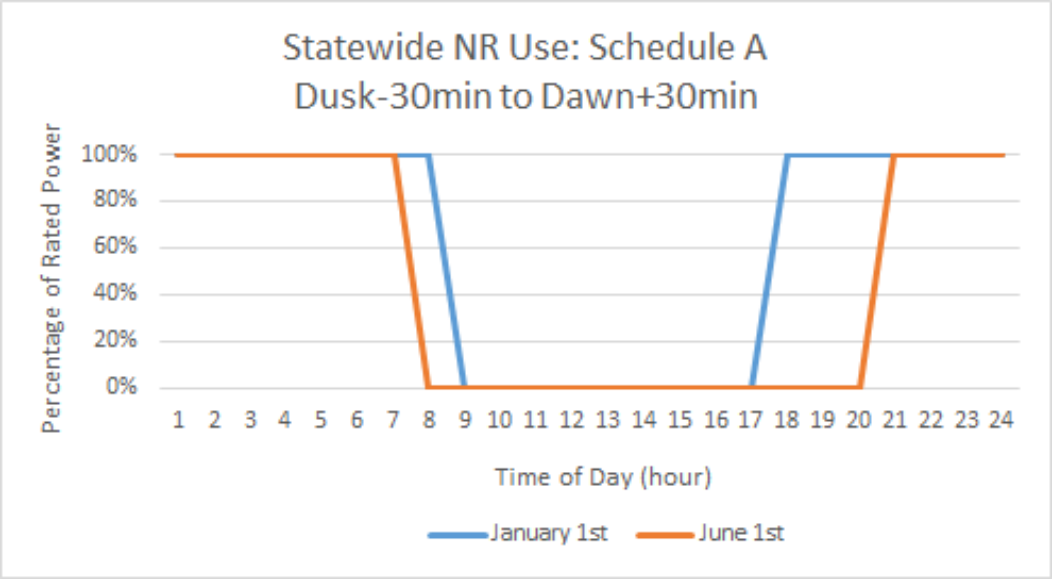

Figure 37: Schedule A

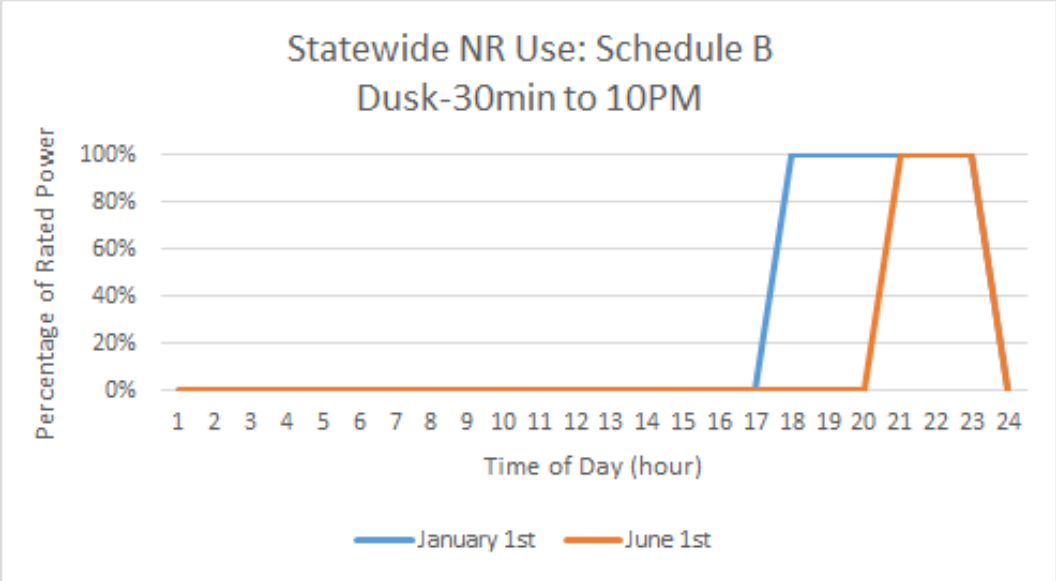

Figure 38: Schedule B

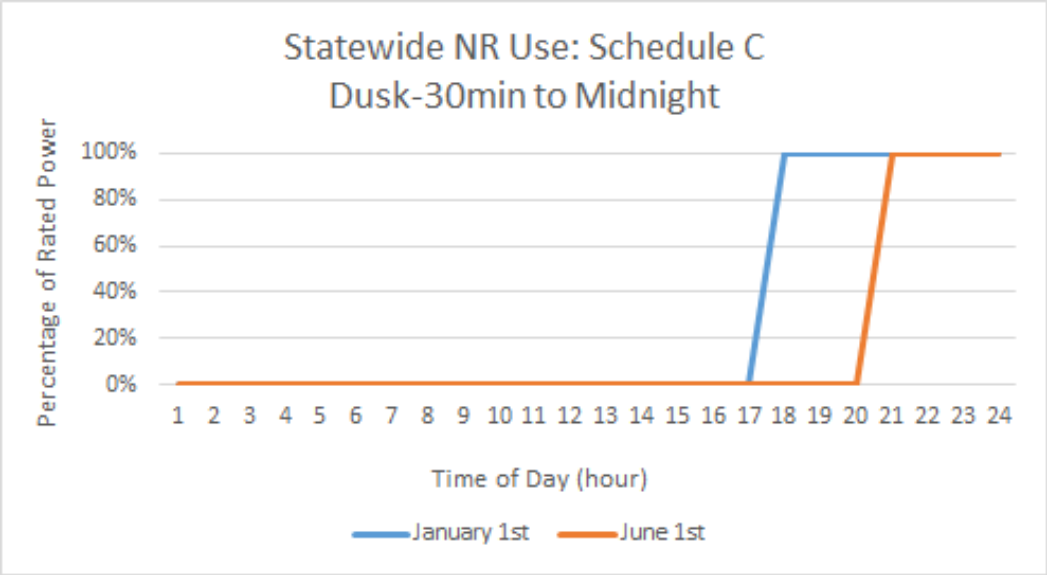

Figure 39: Schedule C

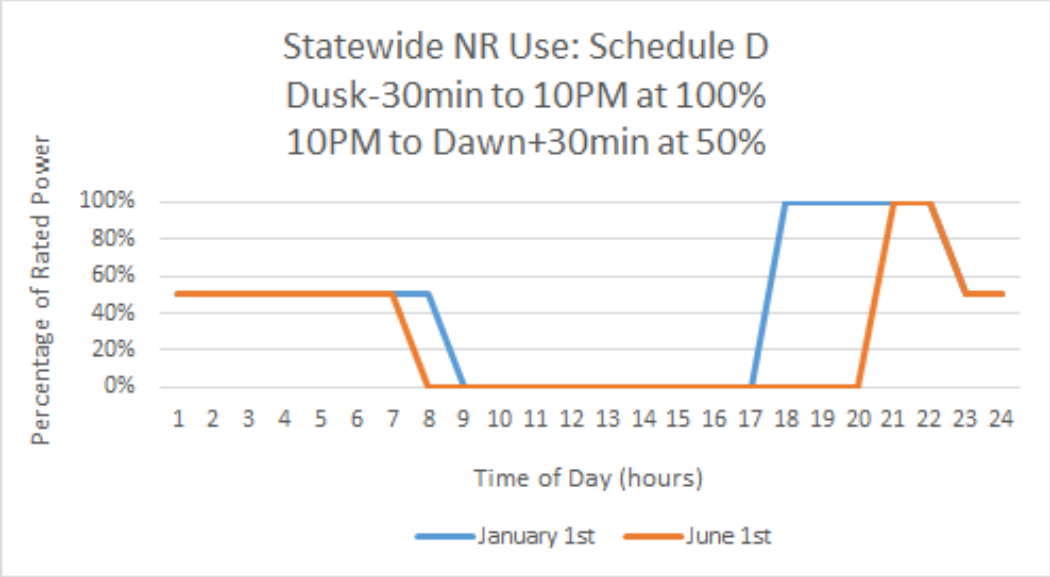

Figure 40: Schedule D

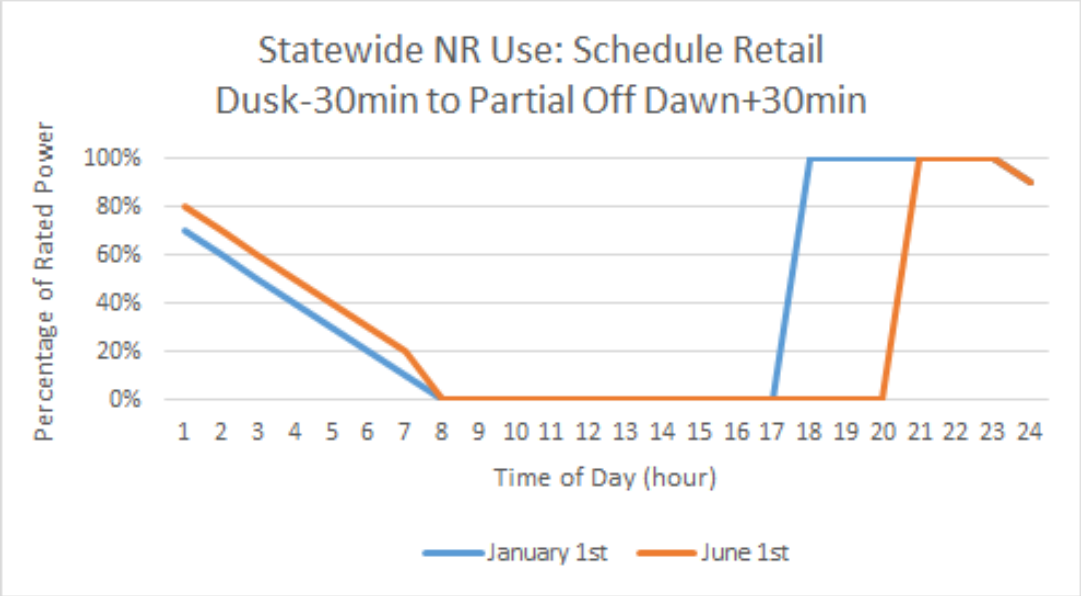

Figure 41: Schedule Retail

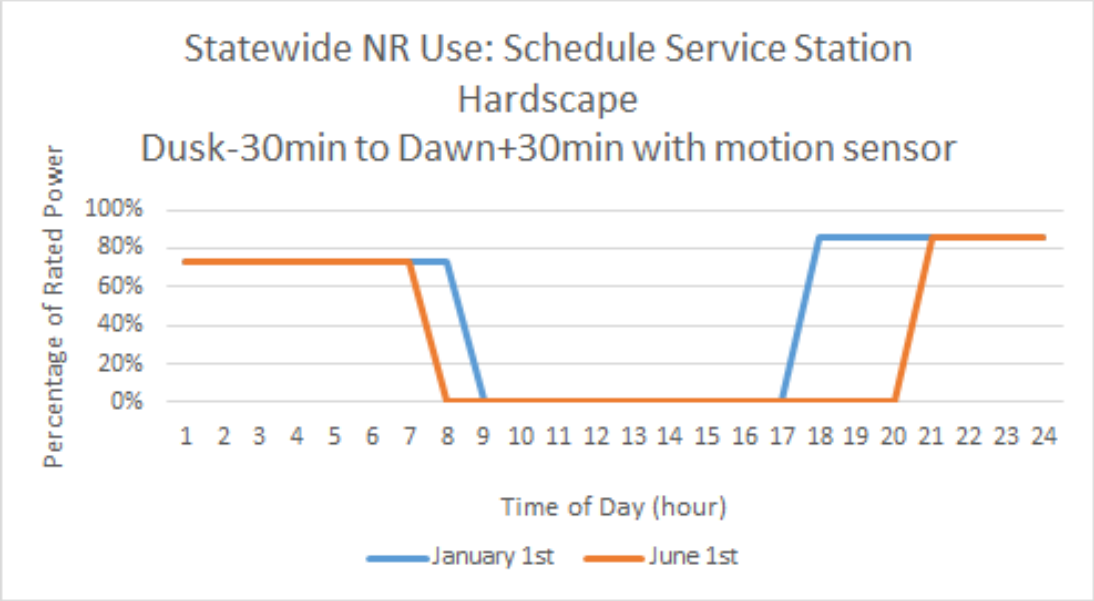

Figure 42: Schedule Service Station Hardscape

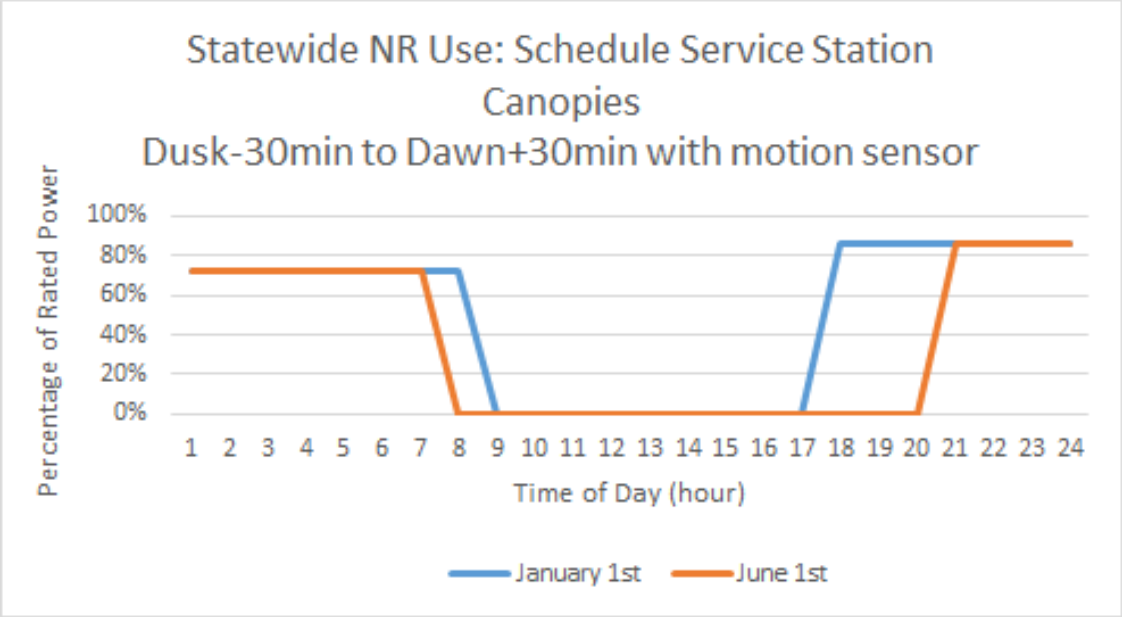

Figure 43: Schedule Service Station Canopies

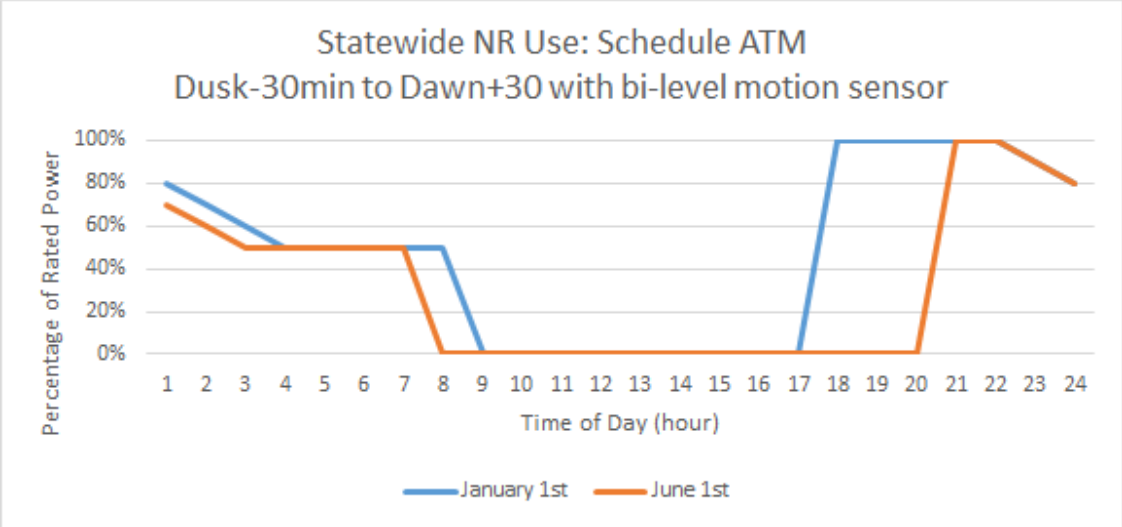

Figure 44: Schedule ATM.

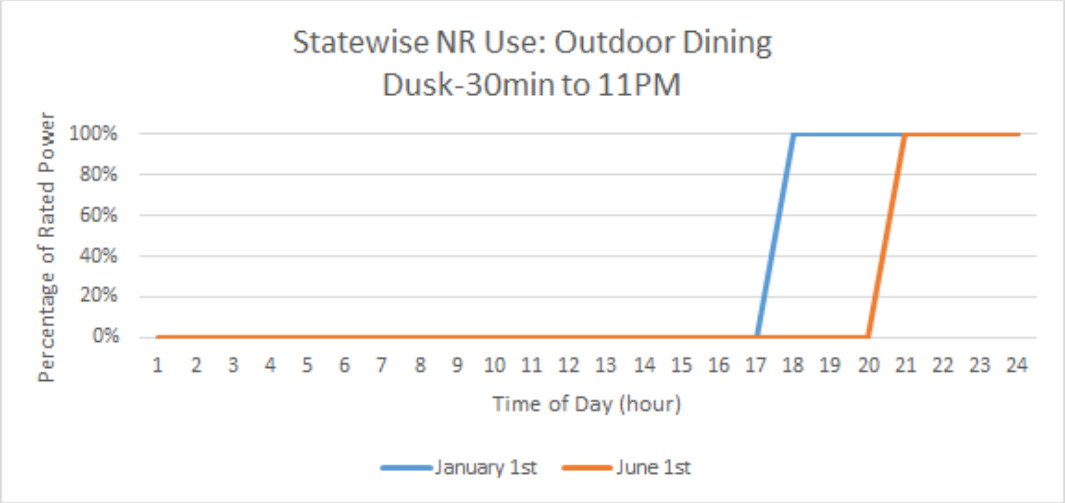

Figure 45: Schedule Outdoor Dining

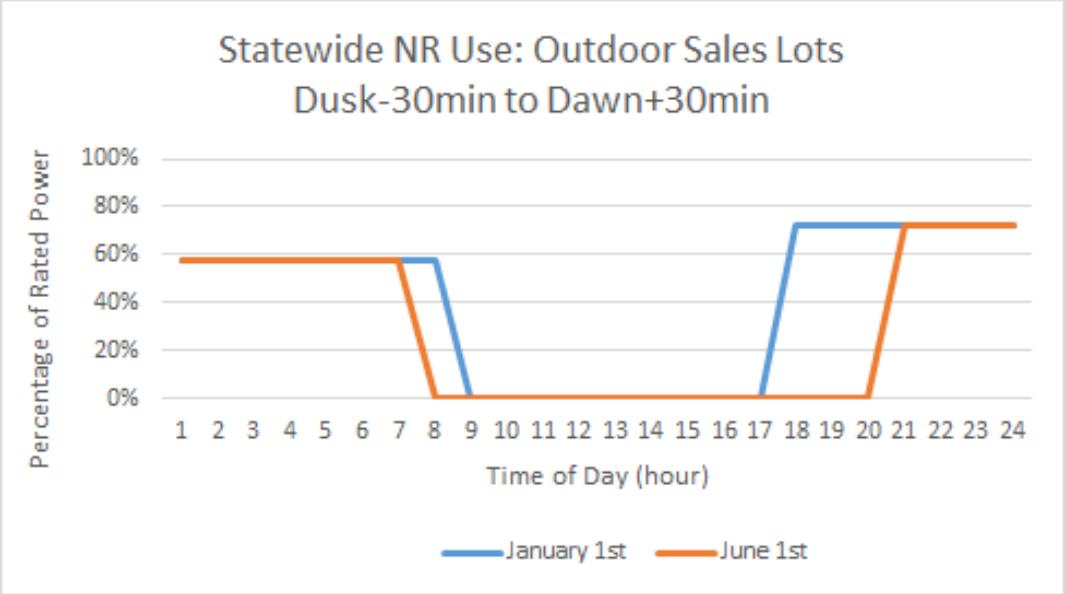

Figure 46: Schedule Outdoor Sales Lots

Appendix N: Nominal Cost Savings Tables

In Section 5.2 the energy cost savings of the proposed code changes over the 15-year period of analysis are presented in 2023 present value dollars. This appendix will present energy cost savings in nominal dollars. Energy costs are escalating as in the TDV analysis, but the time value of money is not included so the results are not discounted. The factor to convert Electric 15 Year Non-Residential costs to Nominal Cost Savings is 1.4099.

Table 114: Lighting Zone Reclassification: Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Unit – New Construction and Alterations

Lighting Application	Units	15-Year TDV Electricity Cost Savings (Nominal $)	15-Year TDV Natural Gas Cost Savings (Nominal $)	Total 15-Year TDV Energy Cost Savings (Nominal $)
General Hardscape	Per Square Foot	0.011	N/A	0.011
Building Entrances or Exits	Each	5.167	N/A	5.167
Primary Entrances	Each	17.227	N/A	17.227
Drive Up Windows	Each	8.413	N/A	8.413
Vehicle Service Station Uncovered Fuel Dispenser	Each Pump Face	18.95	N/A	18.95
ATM Machine Lighting	Each	0	N/A	0
Outdoor Sales Frontage	Per Linear Foot	4.268	N/A	4.268
Hardscape Ornamental Lighting	Per Square Foot	0.006	N/A	0.006
Building Facades	Per Square Foot	0.061	N/A	0.061
Outdoor Sales Lots	Per Linear Foot	0.083	N/A	0.083
Vehicle Service Station Hardscape	Per Square Foot	0.042	N/A	0.042

Vehicle Service Station Canopies	Per Square Foot	0.142	N/A	0.142
Sales Canopies	Per Square Foot	0.282	N/A	0.282
Non-sales Canopies and Tunnels	Per Square Foot	0.069	N/A	0.069
Guard Stations	Per Square Foot	0.082	N/A	0.082
Student Pick-up/Drop-off zone	Per Square Foot	0.018	N/A	0.018
Outdoor Dining	Per Square Foot	0.010	N/A	0.010
Special Security Lighting for Retail Parking and Pedestrian Hardscape	Per Square Foot	0.001	N/A	0.001

Table 115: General Hardscape Lighting Power Allowance: Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot

Lighting Application	Units	15-Year TDV Electricity Cost Savings (Nominal $)	15-Year TDV Natural Gas Cost Savings (Nominal $)	Total 15-Year TDV Energy Cost Savings (Nominal $)
General Hardscape – New Construction	Per Square Foot	$0.18	N/A	$0.18
General Hardscape – Alterations	Per Square Foot	$0.18	N/A	$0.18

Table 116: Multifamily Outdoor Lighting Power Allowance Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Dwelling Unit – New Construction and Alterations

Building Prototype	Units	15-Year TDV Electricity Cost Savings (Nominal $)	15-Year TDV Natural Gas Cost Savings (Nominal $)	Total 15-Year TDV Energy Cost Savings (Nominal $)
Low Rise Garden	Dwelling Unit	$163.24	N/A	$163.24
Loaded Corridor	Dwelling Unit	$42.21	N/A	$42.21
Mid-Rise Mixed Use	Dwelling Unit	$50.70	N/A	$50.70
High Rise Mixed Use	Dwelling Unit	$29.03	N/A	$29.03

Appendix O: Security Camera Technology

During the 2019 Title 24 code cycle, there were discussions that security cameras are not capable of identifying colors and objects of concern in nighttime environments with low lighting levels. The Statewide CASE Team is proposing a security camera adder to ensure that end users with security concerns could install cameras within the hardscape area to achieve lighting levels greater than those recommended in the IES RP-8-18 Addendum 1 Chapter 17.

The Statewide CASE Team contacted stakeholders in the security camera industry to ensure that the proposed general hardscape allowance would allow for the continued functioning of security cameras. The Statewide CASE Team coordinated with security camera manufacturers, security camera installers, and a building management team to better understand current security camera technology and applications. The Statewide CASE Team found that most building security teams use cameras to identify objects or activities of concern within hardscape areas. The object, concerning activity, or vehicle is identified and can be tracked to provide license plate or facial identification if necessary. The security teams will often use colors, such as a red shirt or blue baseball cap, to identify and track the object or person of concern through the space.

The Statewide CASE Team found that current security cameras are capable of identifying color in low lighted environments. Many security cameras have pan, tilt, and zoom (PTZ) capabilities. These cameras are able to zoom into area of concern and identify people and objects of concern within the camera's detection area. The Statewide CASE Team studied six cameras commonly installed in exterior environments in 2019 to determine the minimum lighting level necessary for them to operate while providing color detection. One of the cameras studied was capable of identifying color when the light within the camera's visual scene (the entire area viewed by the security camera) was 0.17 lux at 50 IRE F1.8 (0.016 fc). The average lighting level required for color detection was 0.33 lux at 50 IRE F1.6 (0.031 fc).

If the luminance within the security camera's visual scene falls below the camera's color detection capabilities the camera will provide video in black and white. The average security camera studied was capable of providing black and white images in lighted environments as low as 0.025 lux at 50 IRE F1.6 (0.002 fc) within the visual field. When the lighting in the environment falls below that level – or in the absence of light – the security camera's infrared filter will be deactivated, and the camera will provide infrared video of the area. This infrared capability allows the security camera to identify people, animals, and capture other heat signatures in the absence of light.

The Statewide CASE Team expects that security camera technology will continue to quickly advance over the next couple years. The security camera experts contacted anticipate that security cameras installed in 2022 will be capable of differentiating

between various colors at half the luminance levels required by current technologies. Based on these discussions and the analysis of products currently available on the market, the Statewide CASE Team is confident that security cameras installed in 2022 will be capable of identifying security concerns throughout the general hardscape areas. The Statewide CASE Team is proposing the security camera adder for the 2022 code cycle to ensure that security cameras can be added to existing general hardscape applications with minimal lighting alterations in the future.

The Statewide CASE Team applied the proposed security camera allowance to the real hardscape site designs to determine the average illuminance levels that could be achieved with products currently available on the market. With the allowance a horizontal average of 32 lux (3 fc) can be achieved in the general hardscape area. This allowance would allow for higher lighting levels to be implemented in spaces with security concerns.

Appendix P: Ornamental Hardscape LED Conversion

During the 2019 Title 24 code cycle all the non-residential outdoor lighting sources were updated to an LED baseline. At that time the definition for ornamental hardscape luminaires in the 2019 Title 24, Part 6, Section 100.1 was updated to a 30-watt limit to match the average LED wattage of the hardscape ornamental luminaires studied during the 2019 code cycle. Unfortunately, this wattage limit was not included in 2019 Title 24, Part 6, Section 140.7. To resolve this, the Statewide CASE Team is proposing a reduction in the hardscape ornamental wattage to match the current LED baseline. The Statewide CASE Team has updated the 2019 code cycle analysis to only consider LED luminaires with initial luminaire lumens equivalent to each 100-watt legacy initial luminaire lumens. The Statewide CASE Team studied 35 different LED products offered by 24 different manufacturers to determine the proposed 50-watt limit for hardscape ornamental lighting. The products studied can be found in Table 117.

Table 117: LED Equivalent Ornamental Hardscape Products

Legacy Source						2019 LED Equivalent				
Luminaire Manufacturer Letter	Luminaire Product Number	Lamp Wattage	Lamp Type	Initial Luminaire Lumens	Lumens per Watt (LPW)	Luminaire Manufacturer Letter	Luminaire Product Number	System Watts	Initial Luminaire Lumens	Lumens per Watt (LPW)
LA	002	100	A19, Shatter Resistant Incandescent	960	10	LA	001	11	1,100	100
LB	003	100	A19, Frosted Incandescent	960	10	LB	001	11	1,100	100
LA	003	100	G40, Clear Incandescent	1,150	12	LC	001	6.5	810	125
LA	004	100	A19, Silver Bowl Incandescent	960	10	LD	001	7.5	680	91
LA	005	100	G40, Frosted Incandescent	1,150	12	LE	001	8.5	800	94
LE	002	100	A21 Incandescent	1,540	15	LB	002	16	1,550	97
LI	001	100	A21, Frosted Incandescent	1,042	10	LF	001	13.5	1,100	81
LE	003	100	G25, Silver Bowl Incandescent	1,000	10	LG	001	11	1,200	109
LJ	001	100	A21, Frosted Silver Bowl Incandescent	800	8	LH	001	14	1,100	79
AT	003	100	PSMH	3,314	24	W	004	30	3,354	110
AT	003	100	PSMH	3,628	26	E	001	25	3,789	149
W	008	100	PSMH	3,899	28	B	005	38	3,844	102
AT	003	100	PSMH	3,939	29	BD	001	71	3,943	56
AT	003	100	PSMH	4,354	32	V	007	35	4,348	124
A	005	100	PSMH	4,375	32	A	001	51	4,431	87
A	005	100	PSMH	4,437	32	BH	001	37	4,431	120
W	009	100	PSMH	4,572	33	E	003	38	4,552	120
W	008	100	PSMH	4,681	34	AU	003	42	4,570	109
AT	003	100	PSMH	4,683	34	C	010	44	4,612	105
W	009	100	PSMH	4,689	34	I	003	72	4,639	64
AT	003	100	PSMH	4,832	35	BF	001	67	4,843	111
W	009	100	PSMH	5,094	37	I	004	72	5,068	72
AT	003	100	PSMH	5,168	38	AQ	003	59	5,216	88
V	008	100	PSMH	5,313	39	C	008	52	5,396	104
AT	003	100	PSMH	5,394	39	V	006	75	5,398	72
AT	003	100	PSMH	5,623	41	B	005	58	5,638	97
W	008	100	PSMH	5,704	42	D	002	58	5,800	100
AT	003	100	PSMH	5,751	42	W	004	52	5,800	111
W	008	100	PSMH	5,795	42	T	002	59	5,888	100
W	008	100	PSMH	5,856	43	C	008	52	5,889	113
AT	003	100	PSMH	5,863	43	BF	003	64	5,983	94
AU	006	100	CMH	6,102	52	AF	003	70	6,102	87
AT	003	100	PSMH	6,114	45	D	002	58	6,200	107
A	005	100	PSMH	6,220	45	V	002	54	6,278	116
W	008	100	PSMH	6,255	46	BG	001	51	6,320	124
W	008	100	PSMH	6,280	46	BF	002	67	6,343	95
V	008	100	PSMH	6,779	49	B	006	81	6,779	84
A	005	100	PSMH	6,974	51	I	003	108	6,959	64
W	009	100	PSMH	7,205	53	AU	005	81	7,341	91
W	009	100	PSMH	7,241	53	AU	004	81	7,492	92
W	009	100	PSMH	7,315	53	AQ	004	104	7,529	72
Average				**4,464**	**33**	**Average**		**49**	**4,493**	**98**