DOCKETED

Docket Number:	17-BSTD-02
Project Title:	2019 Title 24, Part 6, Building Energy Efficiency Standards Rulemaking
TN #:	222186
Document Title:	CASE Report Indoor Lighting Power Densities
Description:	Codes and Standards Enhancement (CASE) Initiative Report for the 2019 California Building Energy Efficiency Standards.
Filer:	Adrian Ownby
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	1/18/2018 2:41:26 PM
Docketed Date:	1/18/2018

Codes and Standards Enhancement (CASE) Initiative

2019 California Building Energy Efficiency Standards

Indoor Lighting Power Densities – Final Report

Measure Number**:** 2019-NR-LIGHT2-F

Nonresidential Lighting

August 2017

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.

Document Information

Category:	Codes and Standards
Keywords:	Statewide Codes and Standards Enhancement (CASE) Initiative, Statewide Utility Codes and Standards Team, Codes and Standards Enhancements, 2019 Title 24 Part 6, efficiency, indoor lighting power density (LPD)
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EXECUTIVE SUMMARY

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison, and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – 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 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

Measure Description

This proposal updates the allowed lighting power density (LPD) values (watts of lighting per square foot of room floor area) for indoor lighting to reflect the increased efficacy and increased optical control associated with light emitting diode (LED) technology. The recommended revisions will modify the allowed lighting power for three calculation methods:

- Complete Building Method
- Area Category Method
- Tailored Method

The revised LPD values were developed accounting for increases in LED efficacy that have been occurring over the last several years in all varieties of nonresidential LED luminaires. In addition, increased efficacy has been mandated for certain lamp products by the California Appliance Efficiency Regulations (Title 20) that were adopted in 2016 and the United States (U.S.) Department of Energy (DOE) LED efficacy regulations that are being developed concurrently. This proposal builds upon efforts to update the LPD requirements in ASHRAE 189.1-2017: Standard for the Design of High Performance Green Buildings. However, this proposal does not mandate a particular technology; as long it requires no more adjusted lighting power than the allowed wattage, the technology can be used.

Scope of Code Change Proposal

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

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	Will Compliance Software Be Modified	Modified Compliance Document(s)
Modified LPDs	Prescriptive	Section 140.6(c)[a]		Yes	NRCC-LTI-01, NRCC-LTI-03, NRCC-LTI-05
Accommodating color tuning	Prescriptive	Section 140.6(a), 140.6(c)		Yes	NRCC-LTI-01, NRCC-LTI-03, NRCC-LTI-05
Streamlined lighting power	Mandatory	Section 130.0(c), 110.9(c) and (d)	NA7.7.3	Yes	NRCC-LTI-01, NRCC-LTI-05, NRCI-LTI-01, NRCI-LTI-03-E

a. Section 140.6(c) references Table 140.6-E, which is modified by the proposed code change.

Market Analysis and Regulatory Impact Assessment

This proposal is cost effective over the period of analysis. Overall, this proposal increases the wealth of the state of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure.

The proposed changes to Title 24, Part 6 will reduce the complexity of the standards in regard to calculating lighting power; clarify how the lighting power allowances are calculated; and should slightly reduce the cost of enforcement. When developing this code change proposal, the Statewide CASE Team interviewed building officials, energy analysts, and others involved in the code compliance process to simplify and streamline the compliance and enforcement of this proposal.

Most LED lamps and luminaires have an efficacy in the range of 60-150 lumens per watt (lm/W), whereas the incumbent lighting technologies range from 15 lm/W for incandescent sources to around 90 lm/W for linear fluorescent sources. In addition, the optical efficiency and controllability of LEDs are superior to certain incumbent light sources (e.g., fluorescent and metal halide), leading to energy savings that are greater than if one were to compare raw source luminous efficacy alone. LED technology can cost-effectively provide comparable, and often times improved, lighting amenity while reducing lifecycle cost. LPDs are designed to accommodate the needs of the occupants of different space types. In addition to accommodating varying light levels according to application, allowances are developed to account for color rendering index (CRI), spectral tuning, dim-to-warm, and other technologies that enhance the amenity of the space. Although the proposed lighting power allowances are based on good design practices for lighting spaces with LED sources, the proposed allowances are performance-based. This means that any combination of lighting technologies can be used as long as they achieve the allowed connected lighting load.

In recent years, LED quality has improved significantly while the cost of LEDs has decreased. This trend of improved quality and reduced costs is expected to continue into the future, which means the gap that has existed between the quality and cost of LEDs relative to incandescent technology is closing rapidly. Currently, Title 24, Part 6 assumes that inefficient incandescent lighting will ultimately populate luminaires with screw-base sockets. Previously, higher efficacious compact fluorescent lighting was expensive, had poor color quality, and did not last as long as its rated life. Since then, LED lamps have been introduced that are relatively inexpensive, have a long life, and excellent color quality. Additionally, LED technology is improving and costs are decreasing; therefore, the safeguards can be relaxed by allowing the wattage calculation procedure to be simplified. The proposed Title 24, Part 6 simplified calculation method is similar to the calculation method currently used in national model

codes. Specifically, this proposal recommends that the rated wattage of downlights with screw-base sockets be the greater of the luminaire labeled wattage or the lamp in the luminaire at the time of inspection. Similarly, track lighting luminaires can use the rated wattage of the installed current limiter.

In addition, new technologies are entering the market which must be accommodated. For example, this proposal recommends a range of approaches on how to specify how the wattage of Power over Ethernet (PoE) lighting systems, a new technology which is evolving rapidly, should be calculated.

Cost-Effectiveness

The proposed code change was found to be cost-effective for all climate zones where it is proposed to be required. The benefit-to-cost (B/C) ratio compares the lifecycle benefits (cost savings) to the lifecycle costs. Measures 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 savings. The B/C ratio for this measure is above one (i.e., cost-effective) for all scenarios; the B/C ratio is also above one for the majority of the individual luminaires that were evaluated. Detailed B/C ratios for each luminaire type can be found in Section 5.5. See Section 5 for a detailed description of the cost-effectiveness analysis.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first 12 months the proposed LPD requirements would be in effect. See Section 6 for more details.

Table 2: Estimated Statewide First-Year[a] Energy and Water Savings

First-Year Electricity Savings (GWh/yr)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Water Savings (million gallons/yr)	First-Year Natural Gas Savings (million therms/yr)
368.0	50.7	N/A	N/A

a. First-year savings from all buildings completed statewide in 2020.

Compliance and Enforcement

The Statewide CASE Team worked with stakeholders to develop changes to the compliance and enforcement process and to identify the impacts this process will have on various market actors. In particular, the Statewide CASE Team took great efforts to streamline, simplify, and clarify code requirements. The compliance process is described in Section 2.5. The impacts the proposed measure will have on various market actors is described in Section 3.3 and Appendix B. The key issues related to compliance and enforcement are summarized below:

- The current limiter requirement for track lighting was introduced into Title 24, Part 6 to prevent gaming. At the time, there was a concern that builders could bypass the LPD requirements by either claiming a certain amount of wattage installed per track for code compliance and then installing extra heads after compliance verification, or replacing higher efficacy track heads with incandescent track heads after compliance verification. However, the current limiter requirement adds complexity to the code, is difficult to enforce, and might now be unnecessary given vast improvements in lighting efficiency and quality since the current limiter requirements were introduced in 2001. Some stakeholders have recommended removing this requirement, which would simplify the code language and could lead to simplification of the associated compliance documents. However, this proposal does not recommend eliminating the current limiter option. Instead, when current limiters are used, the standard no longer uses the higher of the current limiter's rated wattage and a wattage value based on the length of track

lighting. Instead, the proposal aligns with ASHRAE 90.1 by using the wattage of the current limiter regardless of the length of the track.

- In addition, in the current code, recessed luminaires with line voltage medium screw-base sockets are required to be rated at 50 watts per socket for the LPD calculations in nonresidential spaces. This is problematic because it discourages the use of highly efficacious lamps (since wattage rating will always be 50 watts even if lower wattage lamps are used), and adds unnecessary complexity to the code. For new construction, the Statewide CASE Team recommends that the higher of the luminaire labeled wattage, or the wattage of the installed lamp be used. For alterations, the Statewide CASE Team recommends that the installed light source wattage in the screw-base socket (of the luminaire) at time of inspection be used rather than requiring that luminaires be relabeled. This removes a questionable expense from lighting retrofit projects and thus removes a barrier to greater energy efficiency.

Although a needs analysis has been conducted with the affected market actors during the development of the code change proposal, the code requirements may change between the time the final CASE Report is submitted and the time the 2019 Standards are adopted. The recommended compliance process and compliance documentation may also evolve with the code language. To effectively implement the adopted 2019 Title 24, Part 6 code requirements, a plan should be developed that identifies potential barriers to compliance and suggests approaches to minimize the barriers.

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison, and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency in 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 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

The overall goal of this CASE Report is to propose a code change to reduce the allowed lighting power in new and remodeled nonresidential buildings as well as in the common spaces in high-rise residential buildings. 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 building officials, manufacturers, builders, utility incentive program managers, energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during public stakeholder workshops that the Statewide CASE Team held on September 8, 2016, and March 22, 2017.

Section 2 of this CASE Report describes the measure and its background. This section also presents a detailed description of how this change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.

Section 3 presents the market analysis, including 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 presents the per-unit energy, demand, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate energy, demand, and energy cost savings.

Section 5 presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of additional 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 presents statewide energy savings and environmental impacts of the proposed code change for the first year after the 2019 Standards take effect. This includes the amount of energy that will be saved by California building owners and tenants, and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic.

Section 7 concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, Compliance Manual, and compliance documents.

2. MEASURE DESCRIPTION

2.1 Measure Overview

This measure proposes to use light emitting diodes (LEDs) as the basis for calculating allowable lighting power densities (LPDs) values (watts of lighting per square foot of room floor area) for all interior applications where technically feasible. LED technology continues to advance rapidly while costs continue to decline. As a result, the interior lighting market is experiencing increased adoption of LED light sources and this trend is expected to continue. This proposed change impacts the prescriptive lighting power allowances and the mandatory installed wattage calculation methods.

The proposed measure revises the indoor lighting allowances found in Tables 140.6-B, 140.6-C, 140.6-D, and 140.6-G. The Statewide CASE Team is proposing new indoor LPD requirements based on currently existing cost-effective LED luminaires. This proposal is based on LED sources that have color temperature and CRI comparable to legacy light sources, so that lighting color and fidelity are maintained. The Statewide CASE Team is committed to recommending code changes that will not compromise light quality or increase glare and will not exclude color-tuning systems. Additionally, the new LPD requirements do not prevent sufficient light levels from being achieved; use-it-or-lose-it adders, a wattage multiplier, and LPDs that are more conservative than the limit of reduction ensure proper light levels will still be achievable.

The use-it-or-lose-it additional LPDs assure there is sufficient light for task work, display, and ornamental lighting. There are also additional wattage allowances for a number of special needs and capabilities. For example, additional lighting wattage is allowed for providing extra light to areas occupied by elderly or visually impaired.

Installed lighting wattage is reduced to account for areas with high display lighting mounting heights, or where the lighting is small aperture and color-tuning. Installed lighting power for these luminaires are reduced by using a multiplier.

The Statewide CASE Team is aware of stakeholders' requests to revise the standards to allow the use of screw-base LED lamps without a wattage penalty. Some lighting alterations projects depend on the allowance of screw-base LED lamps; however, Title 24, Part 6 currently does not provide a way to claim the actual maximum rated wattage of screw-base LED replacement lamps when calculating LPDs in nonresidential spaces. The Statewide CASE Team is also aware that the current limiter allowance is potentially penalizing the usage of LEDs in track lighting. The proposed measure removes existing language that discourages the use of screw-base LED lamps and addresses the current limiter issue by eliminating the alternate minimum watts per linear foot of track when a current limiter is used. This aligns with how ASHRAE 90.1-2016 treats current limiters.

Finally, the Statewide CASE Team has simplified the code language through the recommended revisions to Section 130.0 and 110.9.

2.2 Measure History

The primary objective of this code change proposal is to update indoor LPD requirements. Indoor LPDs have changed very little since the 2013 code cycle, yet LED technology has since advanced rapidly. The 2013 and 2016 versions of Title 24, Part 6 are not based on LED technology but have been primarily

based on a combination of third generation T-8 and T-5 fluorescent technology, compact fluorescent lamps (CFLs) (for downlights), pulse start metal halide in industrial and warehouse spaces, and halogen infrared (IR) and ceramic metal halide for display lighting. The Statewide CASE Team is proposing new indoor LPDs that will reflect the LED efficiencies and costs that are experienced in 2017. It is expected that efficacies will continue to rise and costs will continue to decline through 2020 and beyond when this standard takes effect. The proposed revisions are similar to the recent revisions to ASHRAE 90.1-2016, which is mostly based on LED technology, and ASHRAE 189.1-2017, which was developed based entirely on LED sources. The Statewide CASE Team's proposal builds on the progress made while developing the two national model codes.

In addition to modifying LPD requirements, the Statewide CASE Team is proposing revised requirements for current limiters, screw-base LEDs, and variable correlated color temperature (CCT) systems (see below for definition). Current limiter requirements were adopted into Title 24, Part 6 during the 2001 code cycle. The Statewide CASE Team has explored opportunities to revise current limiter requirements for track lighting, to add quality and performance requirements for sources with traditionally low efficacy base types, and allowances for variable CCT systems. Current limiters are used in track lighting to ensure that specific wattages are not exceeded (i.e., to ensure that additional track heads are not added and/or that low wattage sources are not replaced with higher wattage sources after verifying compliance with Title 24, Part 6). The Statewide CASE Team proposes revisions to these requirements, due to increases in efficiency since the current limiter language was introduced into Title 24, Part 6 with the 2001 standards as well as due to the decreasing likelihood that end users will revert to less efficacious sources or otherwise game the requirements. LED sources are now higher quality, lower cost, and longer lasting than these sources were in the past. Outside of adding more light, the risk of increased lighting power for these systems is greatly reduced.

Regarding screw-base lamps, residential lighting standards were revised during the 2016 code change cycle to allow the use of screw-base lamps as highly efficacious sources, provided they meet lighting quality requirements outlined in Joint Appendix 8 for color temperature, color rendering, flicker, noise, and longevity, among other things. In this proposal, the Statewide CASE Team has taken a similar approach by eliminated the minimum wattage requirements for luminaires with screw-base sockets, so luminaires with lower wattage screw-base LED lamps can claim the appropriate wattage.

Variable CCT systems allow users to change the color temperature of their lighting systems. However, variable CCT could potentially result in a lower efficacy relative to fixed CCT systems. The Statewide CASE Team also recognizes that multiple color-tuning or color-changing design strategies exist and has evaluated their impact on rated power. Specifically, the Statewide CASE Team has accommodated the application of dim-to-warm and tunable white color-changing strategies in developing lighting power allowances.

Finally, the Statewide CASE Team is aware of concerns over increased standby energy consumption as more luminaires and lighting products become "connected" and include additional utility. Increased standby consumption can partially offset energy savings from lowered LPDs. The Statewide CASE Team recognizes this issue, but is not pursuing this topic for the 2019 code cycle.

This measure is intended to ensure that Title 24, Part 6 is at least as stringent as other national model codes. The proposed changes are loosely aligned with LPD requirements in ASHRAE 189.1-2017. ASHRAE 189.1-2017 was developed using a consensus-based process in which the design and manufacturing segments of the lighting industry were heavily involved. In many cases, the individuals and organizations that participate in the development of Title 24, Part 6 requirements are also engaged in the process to develop requirements for ASHRAE 189.1-2017. Many Title 24, Part 6 stakeholders are already familiar with LPD requirements in ASHRAE 189.1-2017, which the Title 24, Part 6 proposal builds upon. The Title 24, Part 6 changes will not take effect until nearly three years after the ASHRAE 189.1-2017 standards are adopted.

2.3 Summary of Proposed Changes to Code Documents

The sections below summarize how each of the Title 24, Part 6 documents will be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.3.1 Standards Change Summary

This proposal will modify the following sections of the Building Energy Efficiency Standards as shown below. See Section 7.1 of this report for the detailed proposed revisions to the code language.

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES AND SYSTEMS, BALLASTS, AND LUMINAIRES

Subsection 110.9(c) Track Lighting Integral Current Limiter: The proposed requirements will remove the certification requirements for integral current limiters.

Subsection 110.9(d) Track Lighting Supplementary Overcurrent Protection Panel: The proposed requirements will remove the certification requirements for supplementary overcurrent protection panels.

SECTION 130.0 – LIGHTING SYSTEMS AND EQUIPMENT, AND ELECTRICAL POWER DISTRIBUTION SYTSEMS –GENERAL

Subsection 130.0(c) Luminaire power: The proposed requirements will simplify the language and remove language that sets a fixed minimum wattage for screw-base luminaires. It also proposes to lower the default 45 watts per linear foot to 30 watts per linear foot for track lighting when current limiters are not used. This aligns with the 30 watts per linear foot value used by ASHRAE 90.1-2016. When current limiters are used, this proposal eliminates the requirement that the greater of 12.5 watts per linear foot of track or the rating of the current limiter used. Instead the calculated track lighting wattage is based on the current limiter rating only. The proposed track lighting calculated wattage is the same approach used by ASHRAE 90.1-2016.

Subsection 130.0(c)5 Power over Ethernet (PoE) and other plug-in, low voltage technologies served by a multi-port power supply: This proposal offers two options in regard to PoE. Both options are presented in terms of a policy choice and in terms of comparability of deemed power to other systems.

Option 1: Lighting system power is equal to the power supply or current limiter power. This approach is based on interpreting the current Section 130.0(c)9E, that allows “the addition of luminaires or light engines without rewiring," as being applicable to PoE systems. If plugging CAT5 cables into the PoE switch and into the input port of PoE luminaires is not considered rewiring, then under the current code, the input power of the PoE switch or midspan power supply would be the deemed wattage of all the luminaires served by the power supply. This is similar to the current code requirements for track lighting. This option does not take into account that the PoE switch might be powering non-lighting loads, and would create incentive for dedicated lighting load PoE switches. It would also incentivize PoE designs to fully load each switch or midspan.

Option 2: Lighting system power is luminaire power plus losses. The system power is equal to the total luminaire connected power plus losses (five percent for class two wiring losses) and divided by the power supply efficiency. This option does not accounting for the risk associated with a multi-port power supply which could easily have more luminaires added. This option also does not include the electrical overhead with operation of the switch; for smaller systems, this loss is significantly larger than the power supply losses. However, these systems offer the possibility of added control (down to the individual device level) and the possibility of recording lighting power consumption.

SECTION 130.4 – LIGHTING CONTROL ACCEPTANCE AND INSTALLATION CERTIFICATION REQUIREMENTS

Subsection 130.4(b) 3&4 Certification of track current limiters and supplementary overcurrent protection panels: This proposal requires that the compliance and installation forms indicate the volt-amps of the current limiting and overcurrent protection for track lighting. Separate forms and a detailed certification are not necessary. The wattage of these components are no more difficult to report than the wattage of luminaires.

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

Subsection 140.6(a) Calculation of Adjusted Indoor Lighting Power: The term Actual Indoor Lighting Power is changed to Adjusted Indoor Lighting Power. Discussions with energy code trainers revealed that this term was very confusing as it implies the watts of what is actually installed. However, the term is intended to represent the wattage of the lighting system after adjustments are made for:

- Interlocked lighting systems,
- Power Adjustment Factors (PAF) for advanced controls
- Excluded lighting power.

This proposal adds two new power adjustments: §140.6(a)4 small aperture tunable white and dim-to-warm luminaire Lighting Power adjustment, and §140.6(a)5 Tailored Method display lighting mounting height power adjustment. The power adjustment for color-changing was applied so it would cancel out the efficacy loss associated with small aperture color changing luminaires. This can be applied to qualifying lights in any space of building type. This is not a PAF as these systems do not reduce full load operating hours but are an offset for the amenity of color changing.

The Tailored Method display lighting mounting height power adjustment corrects a problem in the current code. As the mounting heights increase, the Adjustments for Mounting Height above Floor in Table 140.6-E decrease. The current code indicates that the "wall display mounting height multipliers shall be used to reduce the design watts of the space."

Subsection 140.6(c) Calculation of Allowed Indoor Lighting Power: Specific Methodologies

Subsection 140.6(c) 2. Area Category Method

Subsection 140.6(c) 2A: Clarifies that, similar to ASHRAE 90.1, for areas not defined in the tables, one can pick a "reasonably equivalent type" for developing an allowed lighting power density. The tailored lighting method no longer has an accommodation for "other" lighting applications.

Subsection 140.6(c) 2G: This section clarifies that the additional use-it-or-lose-it allowed power is now tabulated in the "Allowed Additional Lighting LPD" column of Table 140.6-C. Previously this was in footnotes to the table. This also indicates that the added power is "use-it-or lose-it" as it is the lesser of the allowance and the Adjusted Indoor Lighting Power for the application that receives an additional allowance.

Subsection 140.6(c) 3. Tailored Method

Subsection 140.6(c) 3H: Indoor Lighting Power for General Lighting not Listed in Table 140.6-D. This subsection is removed. For spaces not in Table 140.6-D, the user applies the allowances in the Area Category Method.

Subsection 140.6(c) 3Gv&Hi (new numbering): This defines when display cases can make use of the wall display lighting allowance or the floor display allowance. Display cases that are directly adjacent or attached to a wall are considered wall display lighting.

Subsection 140.6(c) 3J Very Valuable Display Case Lighting: Allowed wattage is updated from 0.8 W/sf to 0.55 W/sf for areas containing the display case. This changes is to account for LED based

display lighting. Alternatively the allowed wattage is updated from 12 W/sf to 8 W/sf for the area of the display case itself. This allowance is "use-it-or lose-it" and can be no more than the Adjusted Indoor Lighting Power for the display case.

Table 140.6-B: The proposed requirements update the LPD values for most applications in the Complete Building Method. The lighting power density values are based on LEDs as the light sources for calculations. These values are based on an average weighted LPD of the areas that make up the selected building types. The area calculations for Table 140.6-C are the basis of the weighted, averaged value.

Table 140.6-C: The proposed requirements update the LPD values for most applications in the Area Category Method. The lighting power density values are based on lighting designs that use a combination of LED luminaires to meet Illuminating Engineering Society (IES) illumination standards. These lighting designs are aligned with current lighting practice. The primary function areas have expanded to include sport arenas, health care functions, and special application for the aged eye/low-vision applications. The additional allowed lighting power is removed from the footnotes to the table for easier use of these allowances.

Table 140.6-D: The proposed requirements update the LPD values for the Tailored Method. The lighting power density values are based on detailed simulations of LED luminaires in typical layouts.

Table 140.6-G: The proposed requirements update the LPD values for the general lighting portion of the Tailored Method. The lighting power allowances are based on detailed simulations of LED luminaires in typical layouts.

2.3.2 Reference Appendices Change Summary

This proposal will modify the following sections of the Standards Appendices as shown below. See Section 7.2 of this report for the detailed proposed revisions to the text of the reference appendices.

NA7.7.3 – Track Lighting Integral Current Limiter: The proposed requirements will remove NA7.7.3 Track Lighting Integral Current Limiter. The primary data to be collected is whether claimed wattages listed in NRCC-LTI-01 are installed. With readily available and cost-effective highly efficacious display lighting, this approach is no longer required.

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

The ACM Reference Manual and compliance software will need to be updated to reflect the new LPD values. The LPD values appear in Appendix 5.4A of the ACM Reference Manual.

2.3.4 Compliance Manual Change Summary

The proposed code change will modify Chapter 5 of the Title 24, Part 6 Nonresidential Compliance Manual to update the values in the examples and tables. Language surrounding current limiters and recessed lighting will need to be revised.

2.3.5 Compliance Documents Change Summary

The proposed code change will modify the compliance documents listed below. It is not expected that any additional documents will need to be created. Examples of the revised documents are presented in Section 7.5.

- Document NRCC-LTI-01 "Indoor Lighting" will need to be modified to account for track lighting in the total installed lighting wattage.
- Document NRCC-LTI-05 "Line-Voltage Track Lighting Worksheet" will need to be revised to include new instructions and wattages.
- Document NRCC-LTI-01 "Indoor Lighting" will likely need to be modified to account for track lighting in the total installed lighting wattage.

- Document NRCC-LTI-03 "Indoor Lighting Power Allowance" will need to be revised to include additional criteria for additional lighting power allowances in C-3 Area Category Method Additional Lighting Wattage Allowance (from Table 140.6-C ~~Footnotes~~ Additional Lighting Power Columns)
- Installation Certificate NRCI-LTI-03-E "Track Lighting Integral Current Limiter or Supplementary Overcurrent Protection Panel," will be modified to match removal of Nonresidential Appendix NA7.7.3 Track Lighting Integral Current Limiter.
- Installation Certificate NRCI-LTI-01 "Indoor Lighting" can be modified to provide more clarity on the total installed wattage, where to find it on the plans, and how to understand the different methods of calculating installed wattage.

2.4 Regulatory Context

2.4.1 Existing Title 24, Part 6 Standards

The proposed code change will revise the existing 2016 Title 24, Part 6 LPD requirements. There is some overlap with the 2019 CASE Reports for indoor lighting controls and nonresidential lighting alterations. Both reports address requirements for interior lighting. The Statewide CASE Team will be using the same assumptions about 2019 LPDs in this report as well as the indoor lighting controls and the nonresidential lighting alterations CASE Reports.

2.4.2 Relationship to Other Parts of Title 24 Requirements

The proposed code changes do not affect other parts of Title 24.

2.4.3 Relationship to State or Federal Laws

There are federal standards and Title 20 Standards for certain lamps and luminaires. This measure does not set efficiency levels for lamps or luminaires. Rather, the Building Energy Efficiency Standards set specific maximum allowed adjusted wattages for indoor spaces. As such, this measure will not affect or duplicate any federal or Title 20 Standards. This measure will consider the Title 20 Standards for LED lamps (phase 2, Section 1605.3) and small diameter directional lamps (effective 2019 and 2018, respectively), and U.S. DOE lamp standards, when modeling for cost-effectiveness and establishing new LPD values. Since this measure does not require performance levels or test procedures for federally covered products, there are no pre-emption concerns.

2.4.4 Relationship to Industry Standards

ASHRAE 90.1-2016 and ASHRAE 189.1-2017 both include indoor lighting LPD requirements. The proposed code change leverages the lighting levels in the new LPD requirements in ASHRAE 189.1-2017 as well as build upon the existing 2016 Title 24, Part 6 requirements.

2.5 Compliance and Enforcement

The Statewide CASE Team collected input during the stakeholder outreach process on what compliance and enforcement issues may be associated with these measures. This section summarizes how the proposed code change will modify the code compliance process. Appendix B presents a detailed description of how the proposed code changes could impact various market actors. When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced.

This code change proposal will primarily affect buildings that use the mandatory and prescriptive approach to compliance. The key steps changes to the compliance process are summarized below:

- **Design Phase**: The new lower LPDs may result in designers having less wattage to trade off with HVAC and envelope measures. This may result in designers (and others) needing to ensure their HVAC and envelope designs are more efficient as lighting power limitations would be more stringent. No additional changes to the design phase are expected.
- **Permit Application Phase**: Though this proposal is not changing the permit application process, the simplified lighting wattage calculation description and improved clarity of code language should speed up filing compliance documentation. Also with more clear requirements, this potentially leads to less lost time addressing code requirement misunderstandings.
- **Construction Phase**: No changes are expected.
- **Inspection Phase**: The proposed code change will result in a simplified compliance and enforcement process as current limiters will no longer need to be inspected.

If this code change proposal is adopted, the Statewide CASE Team recommends that information presented in this section, Section 3, and Appendix B be used to develop a plan that identifies a process to develop compliance documentation and minimize barriers to compliance.

This proposed code change is expected to update compliance documents, but does not modify compliance methods other than simplifying the current limiter requirements. This results in a more streamlined inspection phase of compliance. Aside from simplification, the proposed code change increases the stringency of existing requirements, so the Statewide CASE Team does not foresee any compliance and enforcement issues. The Statewide CASE Team and Statewide Utility Compliance Improvement team interviewed stakeholders to identify potential barriers to code compliance and enforcement. The key takeaways from the discussions include:

- Simplification of the current limiter requirements would be helpful.
- Alignment with ASHRAE is welcomed (current limiters and rating of luminaires that contain screw-base sockets).

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goal of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market actors. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, Energy Commission staff, and a wide range of industry players who were invited to participate in utility-sponsored stakeholder meetings held on September 8, 2016, and March 22, 2017.

3.1 Market Structure

As LED efficiency increases rapidly and costs decrease, more people are voluntarily electing to use LED technology. Three major manufacturers, GE, Philips, and Osram-Sylvania, who historically produced incandescent and fluorescent lighting, have shifted most of their research and development toward more LED applications, though they still manufacture other lighting technology, such as incandescent and fluorescent. Many other manufacturers also have been involved in the transition to LEDs, including many that only produce LED products, such as Cree, Soraa, and Green Creative (National Electrical Manufacturers Association 2017). A study by the Bonneville Power Administration noted significant changes to several lighting manufacturers' product offerings, illustrating the industry-wide shift toward LEDs. Specifically, the study found that Acuity Brands' revenue from LED-based sales rose, in a span of six years, from zero to likely half of its total revenue in 2015; similarly, TCP, a

lamp manufacturer that focused on CFLs, grew its LED sales from four percent to nearly 40 percent of its total revenue in three years (Bonneville Power Association 2015). There are now thousands of different LED product types available to supply dozens, if not hundreds, of application needs, as evidenced by product listings, such as the U.S. DOE Lighting Facts program and DesignLights Consortium's Qualified Product Lists. According to a 2015 U.S. DOE report, LEDs only accounted for roughly three percent of the indoor lighting market in 2014; however, U.S. DOE forecasted that LEDs will represent 84 percent of all lighting sales by 2030 (U.S. Department of Energy 2015b). In the nonresidential sector, lighting designers and electrical contractors frequently specify LED products. In large projects, products are obtained through distributors. In smaller projects, some products are obtained through distributors while some lamps and luminaires may also be obtained through retail channels, such as big box stores. LEDs that can be used to meet the new lower LPDs are widely available.

The Statewide CASE Team conducted a number of manufacturer interviews and field surveys to further validate the market shift toward LED. The Statewide CASE Team collected the following information from these manufacturer interviews:

- Some manufacturers are beginning to discontinue legacy products.
- LED sales represented the majority of manufacturing and sales in general commercial applications.
- LED sales represented the majority of manufacturing and sales in hospitality and retail lighting.

The Statewide CASE Team collected the following information from the field surveys:

- The majority of retail and hospitality spaces re-lamped and retrofitted with LED products.
- The majority of new construction and major remodels within retail and hospitality used LED products.

See Appendix C for more details.

3.2 Technical Feasibility, Market Availability, and Current Practices

The Statewide CASE Team does not anticipate challenges in terms of technical feasibility or market availability as a result of this proposal. The current nonresidential indoor lighting market consists of a wide array of lighting technologies, including primarily fluorescent and LED offerings. The market is heading toward more efficient fixtures as the rapid improvement of LEDs combined with dropping costs continues. This measure leverages and builds upon revisions to LPD requirements in ASHRAE 90.1-2016 and ASHRAE 189.1-2017, so manufacturers are aware that new, more stringent standards are being introduced nation-wide. LEDs for indoor usage are quickly becoming standard for many applications. The current and proposed lighting power requirements are performance-based; as a result, any higher efficiency new lighting technology is not prevented from being used.

3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

The Statewide CASE Team expects builders will not be impacted significantly by any one proposed code change or the collective effect of all of the proposed changes to Title 24, Part 6. Builders could be impacted for change in demand for new buildings and by construction costs. Demand for new buildings is driven more by factors such as the overall health of the economy and population growth than the cost of construction. The cost of complying with Title 24, Part 6 requirements represents a very small portion

of the total building value. Increasing the building cost by a fraction of a percent is not expected to have a significant impact on demand for new buildings or the builders' profits.

While some training and education can help ensure the workforce, including designers and those working in construction trades, know how to comply with the proposed requirements, workforce training is not unique to the building industry, and is common in many fields associated with the production of goods and services. Costs associated with workforce training are typically accounted for in long-term financial planning and spread out across the unit price of many units as to avoid price spikes when changes in designs and/or processes are implemented.

The market is experiencing a shift toward LEDs, so builders are already familiar with the technology. Additionally, the proposed code changes increase the stringency of current regulations and simplify certain aspects, so it will have minimal effects 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 the California Building code and model national building codes published by the International Code Council, the International Association of Plumbing and Mechanical Officials, and ASHRAE 90.1) are typically updated on a three-year revision cycles. As discussed in Section 3.3.1 all market actors, including building designers and energy consultants, should (and do) plan for training and education that may be required to adjusting design practices to accommodate compliance with new building codes. As a whole, the measures the Statewide CASE Team is proposing for the 2019 code cycle aim to provide designers and energy consultants with opportunities to comply with code requirements in multiple ways, thereby providing flexibility in requirements can be met.

Lower LPDs may make it more difficult for building designers to trade off excess wattage with HVAC and envelope allowances. As a result, building designers will need to ensure their HVAC and envelope systems are designed with more efficiency in mind. The proposed changes to the current limiter requirements reduce claimed wattages, allowing designers to claim the actual wattage of the current limiter for track head lighting. This provides flexibility as designers effectively have more wattage to design lighting in spaces with track lighting.

The Statewide CASE Team conducted interviews and solicited feedback from a small group of lighting designer stakeholders. The group's responses to key questions are summarized below:

- A code based on 100 percent LED technology; the stakeholders were accepting of this approach as they are using primarily LED in current new designs.
- Aligning Title 24, Part 6 more closely to ASHRAE/IES 90.1; stakeholders were not opposed to this approach.
- Eliminating the 50 watt socket requirement (Medium Based Incandescent); stakeholders were unanimously in favor of the proposed change.
- Simplifying the Current limiter requirements (line voltage track lighting); stakeholders were unanimously in favor of the proposed change.

The Statewide CASE Team also solicited the stakeholder group to review preliminary daft language and proposed LPD targets. The stakeholder group found most of the proposal to be acceptable. They did submit several recommendations for adjustments to the proposed LPDs and/or for an LPD adder to be applied to a few additional space types.

3.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health. All existing health and safety rules will remain in place. Complying with the proposed code

change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

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

Building owners and occupants will benefit from lower energy bills. As discussed in Section 3.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy, thereby creating jobs and economic growth for the California economy.

Building owners and occupants will also benefit from reduced maintenance costs associated with LED products. LEDs have expected lifetimes longer than the 15-year period of analysis, so owners and occupants can expect to not replace fixtures at the same rate as legacy products. This results in additional environmental and cost-savings benefits.

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

The proposed requirements could prompt manufacturers to provide more products that have high optical efficiency and high luminous efficacy. Additionally, manufacturers might experience a decrease in demand for legacy products and low efficacy luminaires. The Statewide CASE Team has noted that some manufacturers are already discontinuing production of legacy products, and the market is heading toward higher efficacy LEDs. See Appendix C for more details.

3.3.6 Impact on Building Inspectors

The changes to the calculation of lighting power are significantly simplified, which should result in the standard being easier to enforce.

3.3.7 Impact on Statewide Employment

Section 3.4.1 discusses statewide job creation from the energy efficiency sector in general, including updates to Title 24, Part 6. These changes have a negligible impact on employment since an inefficient light source is being replaced with a more efficient light source. Installation labor is approximately the same for both light sources.

3.4 Economic Impacts

The estimated impacts that the proposed code change will have on California's economy are discussed below.

3.4.1 Creation or Elimination of Jobs

In 2015, California's building energy efficiency industry employed more than 321,000 workers who worked at least part time or a fraction of their time on activities related to building efficiency. Employment in the building energy efficiency industry grew six percent between 2014 and 2015 while the overall statewide employment grew three percent (BW Research Partnership 2016). Lawrence Berkeley National Laboratory's report titled *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth (2010)* report provides a detail on the types of jobs in the energy efficiency sector that are likely to be supported by revisions to building codes (Goldman, et al. 2010).

Building codes that reduce energy consumption provide jobs through *direct employment*, *indirect employment*, and *induced employment*.[1] Title 24, Part 6 creates jobs in all three categories with a significant amount attributed to induced employment, which accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees (e.g., non-industry jobs created such as teachers, grocery store clerks, and postal workers). A large portion of the induced jobs from energy efficiency are the jobs created by the energy cost savings due to the energy efficiency measures. Wei, Patadia, and Kammen (2010) estimate that energy efficiency creates 0.17 to 0.59 net job-years[2] per gigawatt-hours (GWh) saved. By comparison, they estimate that the coal and natural gas industries create 0.11 net job-years per GWh produced. Using the mid-point for the energy efficiency range (0.38 net job-years per GWh saved) and estimates that this proposed code change will result in a statewide first-year savings of 368 GWh, this measure will result in approximately 140 additional jobs. See Section 6.1 for statewide savings estimates.

These changes have negligible impact on employment since an inefficient light source is being replaced with a more efficient light source. Labor requirements are comparable for both types of lighting.

3.4.2 Creation or Elimination of Businesses in California

There are approximately 43,000 businesses that play a role in California's advanced energy economy (BW Research Partnership 2016). California's clean economy grew 10 times more than the total state economy between 2002 and 2012 (20 percent compared to 2 percent). The energy efficiency industry, which is driven in part by recurrent updates to the building code, is the largest component of the core clean economy (Ettenson and Heavey 2015). Adopting cost effective code changes for the 2019 Title 24, Part 6 code cycle will help maintain the energy efficiency industry.

Table 3 lists industries that will likely benefit from the proposed code change classified by their North American Industry Classification System (NAICS) Code.

[1] The definitions of direct, indirect, and induced jobs vary widely by study. Wei et al. (2010) describes the definitions and usage of these categories as follows: "*Direct employment* includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration. *Indirect employment* refers to the ''supplier effect'' of upstream and downstream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an indirect job. *Induced employment* accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees, e.g. non industry jobs created such as teachers, grocery store clerks, and postal workers."

[2] One job-year (or ''full-time equivalent'' FTE job) is full time employment for one person for a duration of 1 year.

Table 3: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Nonresidential Building Construction	2362
Electrical Contractors	23821
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Industrial Machinery Manufacturing	3332
Electric Lighting Equipment Manufacturing	3351
Used Household and Office Goods Moving	484210
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maint.	811310

The rapid expansion of LED technology has been disruptive to the status quo in the lighting industry. Many new market entrants into the industry have been from the semiconductor and electronics industry, and many existing manufacturers have converted many of their products to LED. Some of these new and existing businesses have settled in California and include:

- Feit Electric
- Finelite
- Green Creative
- Soraa

Many existing lighting manufacturers are adapting to this market change by increasing LED production. National Electrical Manufacturers Association (NEMA) data shows the rapid growth of LED sales, and stagnation and decline in legacy sales and market penetration (National Electrical Manufacturers Association 2017).

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

In 2014, California's electricity statewide costs were 1.7 percent of the state's gross domestic product (GDP) while electricity costs in the rest of the U.S. were 2.4 percent of GDP (Thornberg, Chong and Fowler 2016). As a result of spending a smaller portion of overall GDP on electricity relative to other states, Californians and California businesses save billions of dollars in energy costs per year relative to businesses located elsewhere. Money saved on energy costs can be otherwise invested, which provides California businesses with an advantage that will only be strengthened by the adoption of the proposed code changes that impact nonresidential buildings.

Reduced LPDs encourage the use of innovative technologies. This is an advantage for nimble innovative companies that tend to congregate in California.

3.4.4 Increase or Decrease of Investments in the State of California

The proposed changes to the building code are not expected to impact investments in California on a macroeconomic scale, nor are they expected to affect investments by individual firms. The allocation of resources for the production of goods in California is not expected to change as a result of this code change proposal.

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

The proposed code changes are not expected to have a significant impact on California's General Fund, any state special funds, or local government funds. Revenue to these funds comes from taxes levied.

The most relevant taxes to consider for this proposed code change are: personal income taxes, corporation taxes, sales and use taxes, and property taxes. The proposed changes for the 2019 Title 24, Part 6 Standards are not expected to result in noteworthy changes to personal or corporate income, so the revenue from personal income taxes or corporate taxes is not expected to change. As discussed, reductions in energy expenditures are expected to increase discretionary income. State and local sales tax revenues may increase if building owners spend their additional discretionary income on taxable items. Although logic indicates there may be changes to sales tax revenue, the impacts that are directly related to revisions to Title 24, Part 6 have not been quantified. Finally, revenue generated from property taxes is directly linked to the value of the property, which is usually linked to the purchase price of the property. The proposed changes will increase construction costs. As discussed in Section 3.3.1, however, there is no statistical evidence that Title 24, Part 6 drives construction costs or that construction costs have a significant impact on building price. Since compliance with Title 24, Part 6 does not have a clear impact on purchase price, it can follow that Title 24, Part 6 cannot be shown to impact revenues from property taxes.

3.4.5.1 Cost of Enforcement

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals.

This proposal relies on the same LPD structure that has been in Title 24, Part 6 for many code cycles. The same tables are used, but with updated LPD values. Included in this proposal is a significant streamlining of Section 130.0, which explains how to calculate installed lighting power. This may reduce the amount time and resources needed to calculate lighting power. Additionally, this proposal eliminates Section 110.9(c), mandatory requirements for current limiters. Removing this section results in a reduction in time and effort spent by the Energy Commission on compliance as the need to maintain the current limiter database would be eliminated.

Cost to Local Governments

All revisions to Title 24, Part 6 will result in changes to compliance determinations. Local governments will need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2019 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU Codes and Standards Program (such as Energy Code Ace). As noted in Section 2.5 and Appendix B, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

This proposal relies on the same LPD structure that has been in Title 24, Part 6 for many code cycles. The same tables are used but with updated LPD values. Included in this proposal is a significant streamlining of Section 130.0, which explains how to calculate installed lighting power. This should simplify the process and may result in a marginal reduction in time required to enforce the code during plan check.

3.4.6 Impacts on Specific Persons

The proposed changes to Title 24, Part 6 are not expected to have a differential impact on any groups relative to the state population as a whole, including migrant workers, commuters, or persons by age, race, or religion. Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed through from landlords. Renters who do not pay directly for energy costs may see some net savings, depending on if and how landlords account for energy cost when determining rent prices.

The changes to the LPD requirements apply across all occupancies. There is no group that will be affected disproportionately.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

The Statewide CASE Team calculated per-unit impacts and statewide impacts associated with both new construction and alterations by comparing energy use of lighting that is minimally compliant with the 2016 Title 24, Part 6 Standards to lighting that is minimally compliant with the proposed requirements for the 2019 Standards. That is, savings are based on a comparison between 2016 LPDs and the proposed LPDs for each building and area/space type. The proposed LPDs were developed assuming that all lighting would use LED technology.

The Statewide CASE Team used a modified version of the Lumen Method models used by ASHRAE 90.1-2016 and ASHRAE 189.1-2017 to establish LPDs for most occupancies. The analysis used detailed AGi32 modeling to calibrate and verify simpler Lumen Method models for some area/space types.

The following assumptions and methodologies were used in the analysis:

- The LPDs in the 2016 Standards were assumed to be met using a mix of linear and compact fluorescent, metal halide and infrared (IR) halogen incandescent sources.
- Proposed LPDs for all space/area types were assumed to be met using LEDs:
    - Models for hospitality, museums, liturgical, some retail, dining, and some specialized office spaces include options for LEDs employing dim-to-warm and color-tuning technologies.
    - Models for retail, hospitality, museums, theatrical, and liturgical include options for High color rendering index (90+CRI) LED luminaires.
- Hours of operation were based upon operating schedules in the 2016 Nonresidential ACM Reference Manual.
- Foot-candle (FC) targets were based on guidance from ASHRAE 90.1-2016, ASHRAE 189.1-2017, the IES handbook and the IES Recommended Practices (RP). When appropriate, target FCs were modified to align with the building and space/area types in the current Title 24, Part 6 Standards.
- Hours of operation were based upon operating schedules in the 2016 Nonresidential ACM Reference Manual.
- Useful life was based on the 15-year period of analysis used to evaluate proposed changes to Title 24, Part 6. This impacts the calculation of lamp lumen depreciation factors. Therefore, this

analysis does not use L70[3] but rather takes into account the amount of light loss expected after 15 years.
- HVAC interaction effects are small compared to the primary effect of saving lighting energy and cost and are therefore ignored in this analysis.
- Lumen maintenance was assumed to be 85 percent at the end of the 15-year period of analysis.
- Dirt depreciation was assumed to be:
    - 0.90 (clean – medical, scientific, laboratory environments)
    - 0.80 (moderate – typical environments)
    - 0.65 (dirty – industrial environments)

The data inputs for each space type can be found in Appendix D.

4.2 Energy Savings Methodology

There are existing Title 24, Part 6 Standards that apply to both new construction and alterations, so the existing conditions assume the space/area type is minimally compliant with the 2016 Title 24, Part 6 Standards. Current LPDs can be found in Section 140.6 in Title 24, Part 6. Additional requirements are presented in Sections 110.9 and 130.0. To assess the energy, demand, and energy cost impacts, the Statewide CASE Team compared design practices used to meet the 2016 LPD requirements to design practices that will be needed to comply with the proposed LPD requirements.

The proposed conditions are defined as the design conditions that will comply with the proposed LPDs. To determine appropriate LPDs for the proposed code change, the Statewide CASE Team started with ASHRAE 189.1-2017 assumptions, prior Title 24 analysis for luminaire layouts and designs for general, task, ornamental, and wall washing, and the IES illuminance levels per space type. The Lumen Method was used to calculate watts per square foot (W/ft^2) based on high performance, highly efficacious luminaires. However, accurately calculating LPDs for wall washing requires more granularity, so AGi-32 modeling was also used. See Appendix F for more details on the lumen method models, light loss factors.

Wall washing cannot directly use the lumen method as the geometric relationships for the Lumen Method is for a uniform distribution of light on the floor. AGi32 models of various wall washing designs were used and parametrized so they could be applied to various room sizes and wall washing target illuminances. See Appendix G for more details.

The luminaire wattages used to develop the LPDs were multiplied by the area-specific annual operating schedules contained in the Nonresidential ACM Reference Manual. This was completed for the legacy luminaires (2016 LPDs) and compared to the proposed LPDs (based on 2019 LED luminaires) to yield an annual electricity (kilowatt hours, kWh) savings per square foot for each space/area type.

LEDs emit less heat than the incumbent technologies, resulting in increased heating loads and decreased cooling loads in the building. These impacts are secondary, however, and were not calculated for this analysis. Energy savings from revised LPDs were, therefore, assumed to be independent of climate and consistent across all California climate zones.

Energy savings, energy cost savings, and peak demand reductions were calculate using a TDV (Time Dependent Valuation) methodology.

The Statewide CASE Team estimated the statewide energy impacts by first calculating the per-luminaire savings, and then extrapolating the per-luminaire impacts to the entire state using estimates of statewide square footage of each type of indoor area that will be impacted by the proposed

[3] L70 is the time it takes for a luminaire to degrade to 70 percent of its original light output.

requirements. The total statewide indoor area was derived starting with the building construction forecasts that the Energy Commission provided, then applying assumptions about the type and size of hardscaped areas that are associated with typical nonresidential construction of different building types. See Appendix A for more details.

See Appendix D through Appendix G for more details on the Lumen Method models, light loss factors, and wall washing calculations.

4.3 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per square foot for new construction and alterations are presented in Table 4. See Section 6.1 of this report for estimated statewide savings from additions and alterations. The per-unit energy savings estimates do not take naturally occurring market adoption or compliance rates into account.

Table 4: First-Year Energy Impacts Per Square Foot – New Construction and Alterations

Building Type	Space Type Description	Luminaire Description	Per-Unit First-Year Savings[a]	
			Electricity Savings[b] (kWh/yr)	Natural Gas Savings (therms/yr)
All Buildings	Medical/ Industrial Research Laboratory	Narrow linear LED surface/suspended	55.7	N/A
	Education Laboratory	Narrow linear LED surface/suspended	50.6	N/A
	Corridor/Transition	Downlight	57.8	N/A
	Classroom/Lecture/Training	Linear LED lensed troffer	80.9	N/A
	Electrical/Mechanical	Industrial LED channel - surface or suspended	17.3	N/A
	Dining Area	Downlight	28.9	N/A
	Food Preparation	Linear LED lensed troffer	80.9	N/A
	Lounge/Recreation	Downlight	265.7	N/A
	Stairway	Narrow linear LED surface/suspended	57.8	N/A
	Stairway	Linear LED lensed troffer	80.9	N/A
	Restrooms	Wall mount linear LED (up/down light)	69.3	N/A
	Lobby	Indirect pendant - Linear LED	52.0	N/A
	Office - Enclosed	Linear LED direct/indirect troffer	90.9	N/A
	Office - Open plan	Linear LED suspended direct/indirect distribution	87.5	N/A
	Conference Meeting/Multipurpose	Narrow linear LED surface/suspended	69.3	N/A
	Active Storage	Industrial LED channel - surface or suspended	17.0	N/A
Auditorium	Audience/Seating Area	PAR downlight flood	599.3	N/A
		Wall washer	74.1	N/A
	Lobby	Downlight	390.1	N/A
Automotive Facility	Garage Service/Repair	Industrial LED channel - surface or suspended	46.4	N/A
Bank Customer Area		Narrow linear LED surface/suspended	80.8	N/A
Barber & Beauty Parlor		Linear LED lensed troffer	94.3	N/A
Convention Center	Exhibit Space	High-bay	606.0	N/A
	Audience/Seating Area	Downlight	67.3	N/A
Court House	Audience/Seating Area	Downlight	288.8	N/A
	Courtroom	Indirect pendant - LED Modules	181.9	N/A
	Judge's Chambers	Narrow linear LED recessed or suspended	114.9	N/A
Family Dining	Dining Area	Downlight	95.7	N/A
Fitness Center	Audience/Seating Area	Linear LED lensed troffer	134.0	N/A

Building Type	Space Type Description	Luminaire Description	Per-Unit First-Year Savings[a]	
			Electricity Savings[b] (kWh/yr)	Natural Gas Savings (therms/yr)
	Fitness Area	Indirect pendant - LED Modules	127.9	N/A
Gymnasium	Audience Seating/Permanent Seating	Low-bay (130W)	336.7	N/A
	Playing Area	Low-bay (88W)	105.4	N/A
	Fitness Area	Indirect pendant - LED Modules	88.2	N/A
Gymnasium/Fitness Center	Locker Room	Linear LED lensed troffer	189.1	N/A
Hospital/Healthcare	Exam/Treatment	Linear LED High Performance lensed troffer	79.7	N/A
	Hospital/Medical supplies	Linear LED lensed troffer	59.0	N/A
	Hospital - Nursery	Linear LED direct/indirect troffer	90.9	N/A
	Nurse station	Linear LED suspended direct/indirect distribution	87.5	N/A
	Physical therapy	Linear LED suspended direct/indirect distribution	87.5	N/A
	Patient Room	Linear LED direct/indirect troffer	62.7	N/A
	Pharmacy	Linear LED lensed troffer	65.0	N/A
	Radiology/Imaging	Linear LED direct/indirect troffer	90.9	N/A
	Operating Room	Linear LED High Performance lensed troffer	59.5	N/A
	Recovery	Linear LED High Performance lensed troffer	59.5	N/A
	Active storage	Industrial LED channel - surface or suspended	25.5	N/A
	Laundry - Washing	Linear LED lensed troffer	79.3	N/A
Hotel/Conference Center - Conference/Meeting		Indirect pendant - LED Modules	127.9	N/A
Laundry-Ironing & Sorting		Linear LED lensed troffer	94.3	N/A
Library	Stacks	Narrow linear LED Bat-Wing distribution	14.2	N/A
Lounge/Leisure Dining	Dining Area	MR16 downlight flood	81.3	N/A
Manufacturing Facility	General Low Bay	Low-bay	251.6	N/A
	General Low Bay	Low-bay	222.1	N/A
	General High Bay	High-bay	606.0	N/A
	Extra High Bay	Industrial super high-bay LED High Output	1952.7	N/A
Motion Picture Theatre	Audience/Seating Area	Downlight	67.3	N/A
	Lobby	Downlight	181.1	N/A
Museum	General exhibition	MR16 downlight flood	140.6	N/A
	Restoration	Linear LED High Performance lensed troffer	70.7	N/A
	Active Storage	Industrial LED channel - surface or suspended	30.3	N/A

Building Type	Space Type Description	Luminaire Description	Per-Unit First-Year Savings[a]	
			Electricity Savings[b] (kWh/yr)	Natural Gas Savings (therms/yr)
Office	Banking Activity Area	Linear LED direct/indirect troffer	90.9	N/A
Parking Garage	Parking	Parking structure LED luminaire	178.3	N/A
Performing Arts Theatre	Audience/Seating Area	Downlight	291.5	N/A
	Lobby	Downlight	475.6	N/A
Religious	Audience/Seating Area	Downlight flood	185.2	N/A
	Worship - pulpit, choir	Downlight flood	185.2	N/A
Retail	Department Store Sales Area	2X2 Low brightness direct/indirect LED troffer	20.2	N/A
	Supermarket Sales Area	Narrow linear LED surface/suspended	53.9	N/A
	Mass Merchandising Sales Area	2X4 LED low-brightness direct/indirect basket	57.2	N/A
	Mall Concourse	Downlight flood	116.0	N/A
	Dressing/Fitting Room	Downlight	194.0	N/A
	Merchandising Sales Area	Downlight	70.3	N/A
Sports Arena	Audience/Seating Area	Indirect pendant - LED Modules	133.6	N/A
	Class 1 - Court Sports Area	High-bay	632.8	N/A
	Class 2 - Court Sports Area	High-bay	606.0	N/A
	Class 3 - Court Sports Area	Low-bay (130W)	488.2	N/A
	Class 4 - Court Sports Area	Low-bay (236W)	430.9	N/A
Transportation	Air/Train/Bus - Baggage Area	Narrow linear LED surface/suspended	80.8	N/A
	Terminal - Ticket counter	Narrow linear LED surface/suspended	50.6	N/A
Warehouse	Fine Material	Industrial LED channel - surface or suspended	53.9	N/A
	Medium/Bulky Material	High-bay	606.0	N/A
Workshop	Workshop	Industrial LED channel - surface or suspended	56.2	N/A

a. Savings from one unit for the first year the site is in operation.

b. Site electricity savings; does not include TDV or electricity savings.

5. LIFECYCLE COST AND COST-EFFECTIVENESS

5.1 Energy Cost Savings Methodology

TDV energy is a normalized format for comparing electricity and natural gas cost savings that takes into account the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long-term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2020 present value (PV) dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBtu." Peak demand reductions are presented in peak power reductions (kW). The Energy Commission derived the 2020 TDV values that were used in the analyses for this report (Energy + Environmental Economics 2016).

The hourly energy savings estimates for the first year of building operation were multiplied by the 2019 TDV cost values to arrive at the present valued cost savings' over the period of analysis. This measure is not climate sensitive, so energy savings estimates are the same for every California climate zone. An earlier evaluation found that given the same lighting profiles, the energy cost savings per kWh are relatively constant across climate zones. When evaluated across all building schedules, cost per kWh in the lowest cost climate zone was 95 percent of that for the average climate zone. Thus, this analysis used the average TDV cost savings to calculate cost savings. This provides the statewide average cost savings and, as long as the benefit-to-cost ratio is greater than 1.05, the measure will be cost-effective in the climate zone with lowest TDV electricity costs.

5.2 Energy Cost Savings Results

Per-unit energy cost savings for each space type over the 15-year period of analysis are presented in Table 5. The per-unit energy cost savings are the same for new construction and alterations. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 5: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot – New Construction and Alterations

Application	Base Case 2016 (W/ft^2)	Proposed 2019 (W/ft^2)	Wattage Reduction (W/ft^2)	Elec Saving ($kWh/yr/ft^2$)	Peak Demand Reduction (W/ft^2)	TDV Savings (TDV $kBtu/ft^2$)	TDV Cost Savings (PV $\$/ft^2$)
Auditorium: Audience/Seating Area	1.40	1.14	0.26	0.88	0.17	26.03	26.03
Corridor/Transition	0.60	0.60	0.00	0.01	0.00	0.28	0.28
Classroom/Lecture/Training	1.20	0.72	0.48	1.01	0.16	28.89	28.89
Court House: Audience/Seating Area	1.30	1.01	0.29	0.98	0.19	29.03	29.03
Court House: Courtroom	1.30	0.72	0.58	1.95	0.37	58.06	58.06
Electrical/Mechanical	0.55	0.39	0.16	0.28	0.01	7.20	7.20
Dining Area	1.00	0.40	0.60	2.87	0.50	84.24	84.24
Lounge/Leisure Dining: Dining Area	1.00	0.52	0.48	2.30	0.40	67.39	67.39

Application	Base Case 2016 (W/ft^2)	Proposed 2019 (W/ft^2)	Wattage Reduction (W/ft^2)	Elec Saving (kWh/yr/ft^2)	Peak Demand Reduction (W/ft^2)	TDV Savings (TDV kBtu/ft^2)	TDV Cost Savings (PV $/ft^2)
Family Dining: Dining Area	1.00	0.48	0.52	2.49	0.44	73.01	73.01
Food Preparation	1.20	0.92	0.28	1.35	0.24	39.55	39.55
Lounge/Recreation	0.90	0.60	0.30	1.01	0.19	29.99	29.99
Stairway	0.60	0.50	0.10	0.23	0.03	6.42	6.42
Stairway	0.60	0.50	0.10	0.23	0.03	6.42	6.42
Restrooms	0.60	0.65	-0.05	-0.13	-0.01	-3.47	-3.47
Parking Garage: Parking	0.14	0.11	0.03	0.20	0.03	5.74	5.74
Medical/Industrial Research Laboratory	1.40	1.08	0.32	1.21	0.15	33.79	33.79
Education Laboratory	1.40	1.08	0.32	1.21	0.15	33.75	33.75
Library: Stacks	1.50	1.08	0.42	0.98	0.12	26.94	26.94
Library: Reading Area	1.10	0.77	0.33	0.76	0.09	20.86	20.86
Lobby	0.95	0.82	0.13	0.44	0.08	13.14	13.14
Gymnasium/Fitness Center: Locker Room	0.70	0.45	0.25	0.83	0.16	24.58	24.58
Office - Enclosed	1.00	0.68	0.32	0.74	0.09	20.58	20.58
Office - Open Plan	0.75	0.60	0.15	0.35	0.04	9.71	9.71
Conference Meeting/Multipurpose	1.20	0.85	0.35	1.18	0.23	35.04	35.04
Workshop: Workshop	0.90	0.86	0.04	0.11	0.01	3.09	3.09
Manufacturing Facility: General Low Bay	0.90	0.61	0.29	0.81	0.08	22.04	22.04
Manufacturing Facility: General Low Bay	0.90	0.69	0.21	0.61	0.06	16.55	16.55
Manufacturing Facility: General High Bay	1.00	0.68	0.32	0.91	0.09	24.71	24.71
Manufacturing Facility: Extra High Bay	1.20	0.86	0.34	0.96	0.10	26.25	26.25
Active storage	0.60	0.42	0.18	0.31	0.01	8.08	8.08
Warehouse: Fine Material	0.70	0.58	0.12	0.21	0.01	5.39	5.39
Warehouse: Medium/Bulky Material	0.60	0.42	0.18	0.31	0.01	7.93	7.93
Transportation: Air/Train/Bus - Baggage Area	0.50	0.34	0.16	0.54	0.10	16.18	16.18
Transportation: Terminal - Ticket counter	1.00	0.42	0.58	1.96	0.38	58.38	58.38
Whole Building Analysis Only: Bank Customer Area	1.00	0.60	0.40	0.93	0.11	25.66	25.66
Office: Banking Activity Area	1.00	0.72	0.28	0.66	0.08	18.25	18.25
Barber & Beauty Parlor	1.70	0.63	1.07	3.77	0.57	107.95	107.95
Religious: Audience/Seating Area	1.50	0.96	0.54	1.82	0.35	54.05	54.05
Religious: Worship - pulpit, choir	1.50	0.96	0.54	1.82	0.35	54.05	54.05
Court House: Judges Chambers	1.30	1.01	0.29	0.98	0.19	29.03	29.03

Application	Base Case 2016 (W/ft^2)	Proposed 2019 (W/ft^2)	Wattage Reduction (W/ft^2)	Elec Saving (kWh/yr/ft^2)	Peak Demand Reduction (W/ft^2)	TDV Savings (TDV kBtu/ft^2)	TDV Cost Savings (PV $/ft^2)
Hospital/Healthcare: Exam/Treatment	1.20	1.16	0.04	0.11	0.01	3.08	3.08
Hospital/Healthcare: Hospital/Medical supplies	0.54	0.54	-0.01	-0.01	0.00	-0.40	-0.40
Hospital/Healthcare: Nurse station	0.81	0.75	0.06	0.17	0.02	4.62	4.62
Hospital/Healthcare: Physical therapy	0.84	0.85	-0.01	-0.02	0.00	-0.43	-0.43
Hospital/Healthcare: Patient Room	0.62	0.45	0.17	0.49	0.05	13.11	13.11
Hospital/Healthcare: Pharmacy	1.22	1.13	0.09	0.25	0.03	6.76	6.76
Hospital/Healthcare: Radiology/Imaging	1.06	0.98	0.08	0.23	0.02	6.25	6.25
Hospital/Healthcare: Operating Room	2.17	1.87	0.29	0.85	0.09	22.89	22.89
Hospital/Healthcare: Recovery	1.03	0.88	0.15	0.44	0.05	11.93	11.93
Hospital/Healthcare: Active storage	0.60	0.43	0.17	0.48	0.05	12.86	12.86
Convention Center: Exhibit space	1.20	0.85	0.35	1.18	0.23	35.04	35.04
Hotel/Conference Center - Conference/Meeting	1.20	0.85	0.35	1.18	0.23	35.04	35.04
Laundry-Ironing & Sorting	0.70	0.43	0.27	0.77	0.08	20.98	20.98
Museum: General exhibition	1.80	0.61	1.19	4.01	0.77	119.12	119.12
Museum: Restoration	1.80	0.77	1.03	3.48	0.67	103.53	103.53
Museum: Active Storage	0.60	0.42	0.18	0.61	0.12	18.02	18.02
Automotive Facility: Garage Service/Repair	0.90	0.53	0.37	1.05	0.11	28.69	28.69
Performing Arts Theatre: Audience/Seating Area	1.40	1.08	0.32	1.08	0.21	32.03	32.03
Motion Picture Theatre: Audience/Seating Area	0.90	0.67	0.23	0.77	0.15	23.02	23.02
Performing Arts theatre: Lobby	1.40	1.08	0.32	1.08	0.21	32.03	32.03
Auditorium: Lobby	1.40	0.82	0.58	1.95	0.37	58.06	58.06
Motion Picture Theatre: Lobby	0.95	0.82	0.13	0.44	0.08	13.01	13.01
Religious Buildings: Lobby	0.95	0.82	0.13	0.44	0.08	13.01	13.01
Retail: Department Store Sales Area	1.20	1.06	0.14	0.51	0.08	14.52	14.52
Retail: Supermarket Sales Area	1.20	1.16	0.04	0.14	0.02	4.02	4.02
Retail: Mass Merchandising Sales Area	1.20	1.06	0.14	0.49	0.07	14.08	14.08
Retail: Mall Concourse	0.95	0.79	0.16	0.55	0.08	15.87	15.87
Retail: Dressing/Fitting Room	0.70	0.60	0.10	0.35	0.05	10.05	10.05

Application	Base Case 2016 (W/ft^2)	Proposed 2019 (W/ft^2)	Wattage Reduction (W/ft^2)	Elec Saving (kWh/yr/ft^2)	Peak Demand Reduction (W/ft^2)	TDV Savings (TDV kBtu/ft^2)	TDV Cost Savings (PV $/ft^2)
Convention Center: Audience/Seating Area	1.20	0.48	0.72	2.42	0.47	72.07	72.07
Sports Arena: Audience/Seating Area	1.20	0.48	0.72	2.53	0.38	72.39	72.39
Gymnasium: Audience Seating/Permanent Seating	1.00	0.48	0.52	1.83	0.28	52.28	52.28
Fitness Center: Audience/Seating Area	1.00	0.48	0.52	1.83	0.28	52.28	52.28
Gymnasium: Playing Area	1.00	0.50	0.50	1.76	0.27	50.27	50.27
Fitness Center: Fitness Area	1.00	0.50	0.50	1.75	0.27	50.14	50.14
Gymnasium: Fitness Area	1.00	0.50	0.50	1.75	0.27	50.14	50.14
Sports Arena: Class 1 - Court Sports Area	2.47	2.26	0.21	0.74	0.11	21.08	21.08
Sports Arena: Class 2 - Court Sports Area	2.27	1.45	0.82	2.90	0.44	82.85	82.85
Sports Arena: Class 3 - Court Sports Area	1.70	1.08	0.62	2.17	0.33	62.13	62.13
Sports Arena: Class 4- Court Sports Area	1.13	0.72	0.41	1.45	0.22	41.42	41.42

5.3 Incremental First Cost

The Statewide CASE Team estimated first cost, maintenance cost, and total incremental cost by comparing the costs of incumbent products used to meet the 2016 LPDs to the LED luminaires modeled to meet the 2019 proposed LPDs. The first cost is the initial cost of the luminaire used for the specific space being examined. Generally, the legacy technology had a lower first cost. The maintenance cost represents the price of replacing luminaires when they burned out or otherwise reached the end of their life. The LEDs typically have reduced or no maintenance cost due to their long expected useful life. The 2016 first cost was subtracted from the 2019 first cost, and the 2016 maintenance cost was subtracted from the 2019 maintenance cost. These were then added together to develop the total incremental cost. However, negative maintenance costs resulted in no additional cost (or subtraction of cost) to the total incremental cost.

Per the Energy Commission's guidance, design costs are not included in the incremental first cost.

The Statewide CASE Team reached out to manufacturers and referenced distributor pricing to obtain cost data, in addition to relying on pricing projections to determine future costs. Maintenance and pricing of incumbent lighting were compared to LED options. Fixtures were matched as closely as possible for performance, function, and visual appearance. See Appendix I for a complete listing of first costs for the luminaires.

5.4 Lifetime Incremental Maintenance 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 period of analysis. The present value of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2019 TDV. The present value of maintenance costs that occurs in the nth year is calculated as follows:

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left[\frac{1}{1+\text{d}}\right]^{\text{n}}$$

Maintenance costs associated with LED lighting products are generally reduced from the incumbent technology. The lifecycle cost and cost-effectiveness analysis uses a 15-year life cycle, during which some maintenance is expected for some of the LED lighting equipment. This is due to high usage hours which results in some products being replaced right before the end of the 15-year period of analysis. The Statewide CASE Team used a reasonable cross-section of incumbent lamps to calculate maintenance costs for incumbent and LED systems. The energy savings associated with reduced LPDs persists for the entire length of the installation of the lighting equipment. There is no field verification, maintenance, or commissioning required ensuring that the savings are maintained. See Appendix I for a complete listing of maintenance costs for the luminaires.

5.5 Lifecycle Cost-Effectiveness

This measure proposes mandatory and prescriptive requirements. As such, a lifecycle 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 lifecycle cost effectiveness. The Statewide CASE Team collaborated with Energy Commission staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. In this case, 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 was the incremental cost 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 total present lifecycle cost benefits by the present value of the total incremental costs.

Results of the per-unit lifecycle cost-effectiveness analyses are presented in Table 6 for new construction and alterations.

Table 6: Lifecycle Cost-Effectiveness Summary Per-Unit[a] – New Construction and Alterations

Building Type	Space Type Description	Luminaire Description	Benefits TDV Energy Cost Savings + Other PV Savings[b] (2020 PV $)	Costs Total Incremental PV Costs[c] (2020 PV $)	Benefit-to-Cost Ratio
All Buildings	Medical/Industrial Research Laboratory	Narrow linear LED surface/suspended	$167	$70	2.38
	Education Laboratory	Narrow linear LED surface/suspended	$130	$45	2.88
	Corridor/Transition	Downlight	$210	$52	4.03
	Classroom/Lecture/Training	Linear LED lensed troffer	$209	$72	2.90
	Electrical/Mechanical	Industrial LED channel - surface or suspended	$192	$190	1.01
	Dining Area	Downlight	$192	$190	1.01
	Food Preparation	Linear LED lensed troffer	$209	$72	2.90
	Lounge/Recreation	Downlight	$210	$52	4.03
	Stairway	Narrow linear LED surface/suspended	$209	$72	2.90
	Stairway	Linear LED lensed troffer	$164	$45	3.65
	Restrooms	Wall mount linear LED (up/down light)	$164	$45	3.65
	Lobby	Indirect pendant - Linear LED	$75	$28	2.68
	Office - Enclosed	Linear LED direct/indirect troffer	$1,660	$358	4.64
	Office - Open Plan	Linear LED suspended direct/indirect distribution	$391	$100	3.91
	Conference Meeting/Multipurpose	Narrow linear LED surface/suspended	$210	$52	4.03
	Active storage	Industrial LED channel - surface or suspended	$208	$52	4.00
Auditorium	Audience/Seating Area	PAR downlight flood	$1,796	$324	5.54
		Wall washer	$223	$140	1.60
	Lobby	Downlight	$156	$104	1.50
Automotive Facility	Garage Service/Repair	Industrial LED channel - surface or suspended	$158	$52	3.04
Bank Customer Area		Narrow linear LED surface/suspended	$1,660	$358	4.64
Barber & Beauty Parlor		Linear LED lensed troffer	$1,660	$358	4.64
Convention Center	Exhibit space	High-bay	$1,067	$136	7.85
	Audience/Seating Area	Downlight	$391	$100	3.91
Court House	Audience/Seating Area	Downlight	$54	$40	1.34
	Courtroom	Indirect pendant - LED Modules	$224	$204	1.10
	Judge's Chambers	Narrow linear LED recessed or suspended	$643	$210	3.06
Family Dining	Dining Area	Downlight	$349	$204	1.71

Building Type	Space Type Description	Luminaire Description	Benefits TDV Energy Cost Savings + Other PV Savings[b] (2020 PV $)	Costs Total Incremental PV Costs[c] (2020 PV $)	Benefit-to-Cost Ratio
Fitness Center	Audience/Seating Area	Linear LED lensed troffer	$381	$52	7.33
	Fitness Area	Indirect pendant - LED Modules	$978	$236	4.14
Gymnasium	Audience Seating/Permanent Seating	Low-bay (130W)	$129	$70	1.84
	Playing Area	Low-bay (88W)	$158	$52	3.04
	Fitness Area	Indirect pendant - LED Modules	$151	$130	1.16
Gymnasium/ Fitness Center	Locker Room	Linear LED lensed troffer	$915	$200	4.57
Hospital/ Healthcare	Exam/Treatment	Linear LED High Performance lensed troffer	$282	$40	7.05
	Hospital/Medical supplies	Linear LED lensed troffer	$148	$40	3.69
	Hospital - Nursery	Linear LED direct/indirect troffer	$65	$100	0.65
	Nurse station	Linear LED suspended direct/indirect distribution	$176	$170	1.03
	Physical therapy	Linear LED suspended direct/indirect distribution	$272	$52	5.24
	Patient Room	Linear LED direct/indirect troffer	$175	$72	2.43
	Pharmacy	Linear LED lensed troffer	$155	$190	0.81
	Radiology/Imaging	Linear LED direct/indirect troffer	$259	$70	3.71
	Operating Room	Linear LED High Performance lensed troffer	$129	$62	2.08
	Recovery	Linear LED High Performance lensed troffer	$1,051	$270	3.89
	Active storage	Industrial LED channel - surface or suspended	$905	$276	3.28
	Laundry-Washing	Linear LED lensed troffer	$1,291	$358	3.61
Hotel/Conference Center - Conference/Meeting		Indirect pendant - LED Modules	$1,348	$270	4.99
Laundry-Ironing & Sorting		Linear LED lensed troffer	$1,167	$276	4.23
Library	Stacks	Narrow linear LED Bat-Wing distribution	$4,296	$1,120	3.84
Lounge/ Leisure Dining	Dining Area	MR16 downlight flood	$46	$40	1.15
Manufacturing Facility	General Low Bay	Low-bay	$73	$62	1.18
	General Low Bay	Low-bay	$738	$358	2.06
	General High Bay	High-bay	$259	$70	3.71
	Extra High Bay	Industrial super high-bay LED High Output	$259	$70	3.71
Motion Picture Theatre	Audience/Seating Area	Downlight	$259	$70	3.71
	Lobby	Downlight	$175	$72	2.43
Museum	General exhibition	MR16 downlight flood	$274	$52	5.26
	Restoration	Linear LED High Performance lensed troffer	$773	$240	3.22
	Active Storage	Industrial LED channel - surface or suspended	$773	$240	3.22

Building Type	Space Type Description	Luminaire Description	Benefits TDV Energy Cost Savings + Other PV Savings[b] (2020 PV $)	Costs Total Incremental PV Costs[c] (2020 PV $)	Benefit-to-Cost Ratio
Office	Banking Activity Area	Linear LED direct/indirect troffer	$453	$225	2.01
Parking Garage	Parking	Parking structure LED luminaire	$234	$45	5.19
Performing Arts Theatre	Audience/Seating Area	Downlight	$42	$28	1.50
	Lobby	Downlight	$192	$150	1.28
Religious	Audience/Seating Area	Downlight flood	$1,707	$194	8.80
	Worship - Pulpit, Choir	Downlight flood	$313	$240	1.30
Retail	Department Store Sales Area	2X2 Low brightness direct/indirect LED troffer	$1,707	$194	8.80
	Supermarket Sales Area	Narrow linear LED surface/suspended	$1,707	$194	8.80
	Mass Merchandising Sales Area	2X4 LED low-brightness direct/indirect basket	$853	$136	6.27
	Mall Concourse	Downlight flood	$123	$108	1.14
	Dressing/Fitting Room	Downlight	$105	$100	1.05
	Merchandising Sales Area	Downlight	$184	$150	1.23
Sports Arena	Audience/Seating Area	Indirect pendant - LED Modules	$421	$130	3.23
	Class 1 - Court Sports Area	High-bay	$983	$236	4.17
	Class 2 - Court Sports Area	High-bay	$248	$204	1.22
	Class 3 - Court Sports Area	Low-bay (130W)	$391	$100	3.91
	Class 4 - Court Sports Area	Low-bay (236W)	$1,348	$270	4.99
Transportation	Air/Train/Bus - Baggage Area	Narrow linear LED surface/suspended	$272	$52	5.24
	Terminal - Ticket Counter	Narrow linear LED surface/suspended	$282	$134	2.11
Warehouse	Fine Material	Industrial LED channel - surface or suspended	$435	$110	3.96
	Medium/Bulky Material	High-bay	$435	$110	3.96
Workshop	Workshop	Industrial LED channel - surface or suspended	$249	$140	1.78

a. Units are per luminaire for all spaces.

c. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). 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. Includes present value maintenance cost savings if PV of proposed maintenance costs is less than the PV of current maintenance costs.

d. **Costs: Total Incremental PV 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. Includes incremental first cost if proposed first cost is greater than current first cost. Includes PV of maintenance incremental cost if PV of proposed maintenance costs is greater than the 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 B/C ratio is infinite.

6. FIRST-YEAR STATEWIDE IMPACTS

6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings by multiplying the per-unit savings, which are presented in Section 4.3, by the statewide new construction forecast for 2020 or expected alterations in 2020; the methodology is presented in more detail in Appendix A. The first-year energy impacts represent the first-year annual savings from all buildings forecast to be completed in 2020. The lifecycle energy cost savings represents 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. Results are presented in Table 7 and Table 8 for new construction and alterations, respectively.

Given data regarding the new construction forecast and expected alterations in 2020, the Statewide CASE Team estimates that the proposed code change will reduce annual statewide electricity use by 368 GWh with an associated demand reduction of 50.7 MW. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $922.5 million in (discounted) energy costs over the 15-year period of analysis. This analysis does not calculate the interaction effects with heating and air conditioning consumption; smaller electrical loads reduce internal heat generation from lighting, which reduces air conditioning loads but increases heating loads.

Table 7: Statewide Energy and Energy Cost Impacts – New Construction[a]

Building Type	New Construction Building Area (million ft^2)	Electricity Savings (GWh/yr)	Statewide Electrical Peak Reduction (MW)	TDV Savings (Million TDV kBtu)	Statewide Lifecycle Energy Cost Savings[b] (million PV$)
Automotive	3.0	2.7	0.3	72.7	6.5
Convention	3.0	4.6	0.9	137.7	12.3
Courthouse	4.7	4.2	0.8	124.9	11.1
Dining - Family	1.6	2.8	0.5	81.2	7.2
Dining - Bar	1.6	2.3	0.4	67.7	6.0
Dining - Fast	1.6	2.5	0.4	72.2	6.4
Healthcare	22.0	12.4	1.3	335.6	45.3
Hotel	3.1	1.5	0.3	45.3	4.0
Hospital	7.4	5.1	0.5	137.6	12.2
Library	4.7	3.5	0.4	97.9	8.7
Manufacturing	3.0	2.2	0.2	60.8	5.4
Office	19.1	9.7	1.2	269.0	23.9
Parking	3.0	0.8	0.1	23.4	2.1
Retail	37.0	9.27	1.4	265.2	23.6
Religious	3.0	3.3	0.6	98.5	8.8
School	18.1	11.5	1.9	328.4	29.2
Sports	3.0	2.6	0.4	74.3	6.6
Performing Arts	3.0	2.6	0.5	77.9	6.9
Motion Picture	3.0	2.0	0.4	60.5	5.4
Town Hall	1.8	1.3	0.3	39.2	3.5
Warehouse	25.0	7.1	0.3	183.6	16.3
Totals	**171.3**	**94.2**	**13.0**	**2,653.7**	**236.2**

a. First-year savings from all buildings completed statewide in 2020.

b. Discounted present value of energy cost savings from all new buildings completed statewide in the single calendar year of 2020 evaluated over a 15-year period of analysis.

Table 8: Statewide Energy and Energy Cost Impacts – Alterations[a]

Building Type	Statewide Lighting Alteration Area (million ft^2)	Statewide Electricity Savings (GWh/yr)	Statewide Electrical Peak Reduction (MW)	Statewide TDV Savings (Million TDV kBtu)	Statewide Lifecycle Energy Cost Savings[b] (million PV$)
Automotive	8.8	7.9	0.8	216.5	19.3
Convention	8.8	13.8	2.6	409.7	36.5
Courthouse	10.8	9.6	1.8	284.5	25.3
Dining - Family	4.4	7.8	1.4	228.2	20.3
Dining - Bar	4.4	6.5	1.1	190.3	16.9
Dining - Fast	4.4	6.9	1.2	202.8	18.1
Healthcare	29.2	16.5	1.7	444.6	39.6
Hotel	4.8	2.4	0.5	70.4	6.3
Hospital	26.2	18.0	1.8	484.8	43.2
Library	10.8	8.0	1.0	223.0	19.9
Manufacturing	8.8	6.6	0.7	180.7	16.1
Office	92.3	47.1	5.6	1,300.0	115.7
Parking	8.8	2.5	0.4	69.7	6.2
Retail	105.3	26.4	4.0	754.9	67.2
Religious	8.8	9.9	1.9	292.9	26.1
School	61.0	38.8	6.2	1,107.3	98.6
Sports	8.8	7.7	1.2	221.0	19.7
Performing Arts	8.8	7.8	1.5	231.9	20.6
Motion Picture	8.8	6.1	1.2	180.1	16.0
Town Hall	2.0	1.5	0.3	43.9	3.9
Warehouse	78.4	22.2	0.9	575.0	51.2
Totals	**504.0**	**273.8**	**37.7**	**7,711.6**	**686.3**

a. First-year savings from all alterations completed statewide in 2020.

b. Discounted present value of energy cost savings from all building lighting alterations completed statewide in the single calendar year of 2020 evaluated over a 15-year period of analysis.

6.2 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.3 Statewide Material Impacts

The Statewide CASE Team calculated material impacts based on life-cycle assessment of impacts of LED and legacy technology products.[4]

[4] https://energy.gov/sites/prod/files/2015/10/f27/2013_led_lca-pt3.pdf

Table 9: Impacts of Material Use

Element	Impact (I, D, or NC) [a]	Impact on Material Use (lbs/yr)	
		Per-Unit Impacts	First-Year[b] Statewide Impacts
Antimony	D	0.0	1
Arsenic	I	0.0	0.004
Barium	I	0.0	2
Chromium	I	0.0	1
Copper	D	0.0	27
Lead	D	0.0	3
Mercury	D	0.0	0.1
Nickel	D	0.0	11
Silver	I	0.0	0.3
Zinc	D	0.0	17

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

b. First-year savings from all new construction completed statewide in 2020.

6.4 Other Non-Energy Impacts

There are a few non-energy impacts and benefits resulting from this code change. The use of LED luminaires means that areas can be continuously and smoothly dimmed as necessary, versus large increments in dimming levels associated with some legacy technology such as fluorescent and metal halide. LED luminaires can also operate at a much lower rated light source power level than some legacy products and have longer lifetimes. As compared to metal halide sources, LEDs are oftentimes lighter and thus easier to install.

7. PROPOSED REVISIONS TO CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manual are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

7.1 Standards

Tables 140.6-B, 140.6-C, 140.6-D, and 140.6-G will be revised with additions and/or deletions to the building and space types as well as new LPD values based on the calculations.

SECTION 100.1 –DEFINITIONS AND RULES OF CONSTRUCTION

BAR/LOUNGE AND FINE DINING: Bar/lounge serves liquor, cocktails, wine, and beer in a relaxed atmosphere, usually with tables and chairs. **Fine dining** is a restaurant with wait staff and an elegant and formal atmosphere.

CAFETERIA/FAST FOOD is a restaurant with little or no wait staff or table service. Diners pick up their food at a counter and carry their food to their table.

COMMERCIAL/INDUSTRIAL STORAGE: SHIPPING AND HANDLING are open areas in storage spaces for shipping or receiving products.

EXAM/TREATMENT ROOM is a room or area in a building that does not provide overnight patient care and that is used to provide physical and mental care through medical, dental, or psychological examination and treatment, including but not limited to laboratories and treatment spaces.

FAMILY/LEISURE DINING is a restaurant that serves relatively simple and/or moderately priced food, in a casual atmosphere which has wait staff serving food.

HEALTH CARE BUILDING is a building used as diagnostic and treatment facilities for inpatient or outpatient care. This includes hospitals, rehabilitation, clinics, medical offices (if they contain medical equipment), and veterinary hospitals or clinics.

IMAGING ROOM is a diagnostic room for application and review of results from imaging technologies including but not limited to x-ray, ultrasound, computerized tomography (CT), and magnetic resonance imaging (MRI).

LABORATORY is a room that provides controlled conditions in which scientific or technological research, experiments, and measurements may be performed. This includes teaching labs, medical labs, industrial labs, and research labs.

LOUNGE/BREAKROOM/WAITING AREA is an area normally provided with seating and used by people for waiting, other than a hotel or entry lobby. Lounge/breakroom/waiting area is an area not normally open to the public for eating, resting for relatively short duration periods.

MEDICAL SUPPLY ROOM is a room designed for storing medical supplies.

NURSERY ROOM is a room for providing medical care to newly born infants.

NURSE'S STATION is an area in a health care facility where health care staff work when not directly interacting with patients.

OPERATING ROOM is a room in a hospital or clinic where surgical operations are carried out in a sterile environment. This category also applies to veterinary operating rooms.

PATIENT ROOM is a room occupied by one or more patients during a stay in a health facility.

PERFORMING ARTS THEATER BUILDING is an assembly building in which people mainly gather to watch performing arts (plays, music, dance etc.) but not primarily movies (see Public Assembly Buildings).

PHYSICAL THERAPY ROOM is a room for providing physical therapy treatment.

PUBLIC ASSEMBLY BUILDING is a building in which people gather for social or recreational activities, whether in private or non-private meeting halls. These include community centers, convention centers, recreation (e.g., gymnasium, health club, bowling alley) museums, motion picture theaters, convention centers, and auditoriums.

PUBLIC ORDER AND SAFETY BUILDING is a building used for the preservation of law and order or public safety. These include courthouses, police stations, and fire stations.

RECOVERY ROOM is a hospital room which is equipped with apparatus for meeting postoperative emergencies and in which surgical patients are kept during the immediate postoperative period for care and recovery from anesthesia.

RETAIL SALES: FITTING ROOM is an extension of the selling floor that is used by customers to try on clothing for fit and appearance. Also called a retail dressing room.

RETAIL STORE BUILDING is a building used for the sale and display of goods other than food.

SERVICE FACILITY BUILDING is a building in which some type of service is provided, other than food service or retail sales of goods. This includes but is not limited to auto repair, dry cleaner or laundromat, post office, gas station, and beauty parlor.

SOLID STATE LIGHTING (SSL) is a family of light sources that includes: semiconductor light emitting diodes (LEDs); organic light emitting diodes (OLEDs) and polymer light emitting diodes (PLEDs).

SOLID STATE LIGHTING DRIVER is a device that uses semiconductors to control and supply DC power for LED starting and operation. The drivers operate from multiple supply sources of 600V maximum at a frequency of 50 or 60 hertz.

SPORTS ARENA BUILDING is an assembly building where sports are played in front of an audience.

TRANSPORTATION AREA: BAGGAGE is an area in a transportation facility where arriving passengers can identify and claim the luggage that has been carried in the hold of an aircraft, train, or vehicle.

TRANSPORTATION AREA: TICKETING is an area in transportation facility where tickets are sold and baggage is dropped off.

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES AND SYSTEMS, BALLASTS, AND LUMINAIRES

~~(c) **Track Lighting Integral Current Limiter.** An integral current limiter for line-voltage track lighting shall be recognized for compliance with Part 6 only if it meets all of the following requirements:~~

~~1. Shall be certified to the Energy Commission as meeting all of the applicable requirements in Section 110.9(c); and~~

~~2. Shall comply with the Lighting Control Installation requirements in accordance with Section 130.4; and~~

~~3. Shall be manufactured so that the current limiter housing is used exclusively on the same manufacturer's track for which it is designed; and~~

~~4. Shall be designed so that the current limiter housing is permanently attached to the track so that the system will be irreparably damaged if the current limiter housing were to be removed after installation into the track. Methods of attachment may include but are not limited to one-way barbs, rivets, and one-way screws; and~~

~~5. Shall employ tamper resistant fasteners for the cover to the wiring compartment; and~~

~~6. Shall have the identical volt-ampere (VA) rating of the current limiter, as installed and rated for compliance with Part 6 clearly marked as follows; and:~~

~~A. So that it is visible for the enforcement agency's field inspection without opening coverplates, fixtures, or panels; and~~

~~B. Permanently marked on the circuit breaker; and~~

~~C. On a factory-printed label that is permanently affixed to a non-removable base plate inside the wiring compartment.~~

~~7. Shall have a conspicuous factory installed label permanently affixed to the inside of the wiring compartment warning against removing, tampering with, rewiring, or bypassing the device; and~~

~~8. Each electrical panel from which track lighting integral current limiters are energized shall have a factory printed label permanently affixed and prominently located, stating the following: "NOTICE: Current limiting devices installed in track lighting integral current limiters connected to this panel shall only be replaced with the same or lower amperage. Adding track or replacement of existing current limiters with higher continuous ampere rating will void the track lighting integral current limiter certification, and will require re-submittal of compliance documentation to the enforcement agency responsible for compliance with the California Title 24, Part 6 Building Energy Efficiency Standards."~~

~~(d) **Track Lighting Supplementary Overcurrent Protection Panel.** A Track Lighting Supplementary Overcurrent Protection Panel shall be used only for line-voltage track lighting and shall be recognized for compliance with Part 6 only if it meets all of the following requirements:~~

~~1. Shall comply with the Lighting Control Installation requirements in accordance with Section 130.4; and~~

~~2. Shall be listed as defined in Section 100.1; and~~

~~3. Shall be used only for line voltage track lighting. No other lighting or building power shall be used in a Supplementary Overcurrent Protection Panel used to determine input wattage for track lighting; and~~

~~4. Be permanently installed in an electrical equipment room, or permanently installed adjacent to the lighting panel board providing supplementary overcurrent protection for the track lighting circuits served by the supplementary over current protection pane; and~~

~~5. Shall have a permanently installed label that is prominently located stating the following: "NOTICE: This Panel for Track Lighting Energy Code Compliance Only. The overcurrent protection devices in this panel shall only be replaced with the same or lower amperage. No other overcurrent protective device shall be added to this panel. Adding to, or replacement of existing overcurrent protective device(s) with higher continuous ampere rating, will void the panel listing and require re-submittal of compliance documentation to the enforcement agency responsible for compliance with the California Title 24, Part 6 Building Energy Efficiency Standards."~~

SECTION 130.0 – LIGHTING SYSTEMS AND EQUIPMENT, AND ELECTRICAL POWER DISTRIBUTION SYSTEMS —GENERAL

(c) **Luminaire power.** Luminaire~~s shall be classified and~~ wattage shall be determined as follows:

1. The wattage of line-voltage luminaires not containing permanently installed ballasts, transformers, or similar devices shall be the greater of the installed wattage of the light source in the luminaire or the maximum rated wattage of the luminaire as determined under UL 1574, 1598, 2108, or 8750, as applicable. The luminaire rated wattage shall be listed on a permanent, preprinted, factory-installed label, as specified by the applicable UL standard.

Exception to Section 130.0(c)1: Luminaires modified in place and containing light sources with a rated lifespan in excess of 25,000 hours shall be the input wattage of the installed light source and any control equipment required for the operation of the light source.

~~1. Luminaire labeling. Luminaire wattage shall be labeled as follows:~~

~~A. The maximum relamping rated wattage of a luminaire shall be listed on a permanent, preprinted, factory-installed label, as specified by UL 1574, 1598, 2108, or 8750, as applicable; and~~

~~B. The factory-installed maximum relamping rated wattage label shall not consist of peel-off or peel-down layers or other methods that allow the rated wattage to be changed after the luminaire has been shipped from the manufacturer.~~

~~**EXCEPTION** to Section 130.0(c)1B: Peel-down labels may be used only for the following luminaires when they can accommodate a range of lamp wattages without changing the luminaire housing, ballast, transformer or wiring. Qualifying luminaires shall have a single lamp, and shall have integrated ballasts or transformers. Peel-down labels must be layered such that the rated wattage reduces as successive layers are removed.~~

~~i. High intensity discharge luminaires, having an integral electronic ballast, with a maximum relamping rated wattage of 150 watts.~~

~~ii. Low-voltage luminaires (except low voltage track systems), ≤ 24 volts, with a maximum relamping rated wattage of 50 watts.~~

~~iii. Compact fluorescent luminaires, having an integral electronic ballast, with a maximum relamping rated wattage of 42 watts.~~

~~2. For luminaires with line voltage lamp holders not containing permanently installed ballasts or transformers;~~

~~the wattage of such luminaires shall be determined as follows:~~

~~A. The maximum relamping rated wattage of the luminaire; and~~

~~B. For recessed luminaires with line-voltage medium screw base sockets, wattage shall not be less than 50 watts per socket.~~

~~3. Luminaires and luminaire housings designed to accommodate a variety of trims or modular components that allow the conversion between incandescent and any other lighting technology without changing the luminaire housing or wiring shall be classified as incandescent.~~

~~4. Screwbased adaptors shall not be used to convert an incandescent luminaire to any type of nonincandescent technology. Screw-based adaptors, including screw-base adaptors classified as permanent by the manufacturer, shall not be recognized for compliance with Part 6.~~

~~5. Luminaires and luminaire housings with incandescent screw base sockets shall be classified only as incandescent. Field modifications, including but not limited to hard wiring of an LED module, shall not be recognized as converting an incandescent luminaire or luminaire housing to a nonincandescent technology for compliance with Part 6 unless such sockets are removed.~~

~~6~~2. The wattage of ~~L~~luminaires with permanently installed or remotely installed ballasts ~~or drivers. The wattage of such luminaries luminaires shall be determined as follows:~~

~~A. The~~ shall be the operating input wattage of the rated lamp/ballast combination published in ballast manufacturer's catalogs based on independent testing lab reports as specified by UL 1598.

~~B.~~ 3. For line voltage solid state lighting (SSL) luminaires or SSLs not enclosed in a luminaire (e.g., tape lights) which are incapable of adding load unless wiring is altered, the wattage shall be the maximum input ~~wattage~~ watts or the maximum input volt-ampere rating of the luminaire or SSL device ~~of the rated driver published in driver's manufacturer catalogs based on independent testing lab reports~~ as specified by UL 1598, UL 2108, UL 8750, or LM-79.

4. For line voltage solid state lighting (SSL) luminaires or SSLs not enclosed in a luminaire (e.g., tape lights) which can accept additional LED load without altering wiring (e.g., snap-on or pre-wired connectors that allow for additional load without the use of any tools), the wattage shall be the maximum input watts or the maximum input volt-ampere rating of the LED driver as specified by UL 2108 or UL 8750.

<OPTION 1 Power over Ethernet and other Plug-in Low Voltage Technologies Served by Multi-port Power Supply>

~~9. Light emitting diode (LED) Luminaires, and LED Light Engine….~~

~~E~~ 5 For ~~LED~~ solid state lighting (SSL) and other low voltage lighting systems that allow the addition of luminaires or light engines without rewiring (e.g., snap-on or pre-wired connectors that allow for additional load without the use of any tools) , the wattage of such luminaires shall be either :

i the maximum rated input wattage of the power supply, labeled in accordance with applicable rating standard ~~Section 130.0(c)1~~ or published in the power supply manufacturer's catalog, or

ii. the volt-ampere rating of current limiting devices as specified by UL 1077, or

iii. the volt-ampere rating of over-current protection devices as specified by UL 489

<OPTION 2 Power over Ethernet and other Plug-in Low Voltage Technologies Served by Multi-port Power Supply>

5 ~~For LED~~ Solid state lighting (SSL) and other low voltage lighting systems that allow the addition of luminaires or light engines without rewiring (e.g., snap-on or pre-wired connectors that allow for additional load without the use of any tools) shall be connected by low voltage wiring compliant with ANSI 137.3 where the length of low voltage wiring between the power supply and the most distant luminaire shall be no longer than 165 feet (50 meters). ~~the~~ The wattage of such luminaires shall be the product of:

i. the wattage of the luminaire ~~maximum rated input wattage of the power supply,~~ labeled in accordance with Section 130.0(c)1 ~~or published in the power supply manufacturer's catalog.~~,

ii 1.05 reflecting cable losses

iii. 1/(average active mode power supply efficiency) as rated in accordance with 10 CFR 430, Subpart B, Appendix Z for external power supplies and as rated in accordance with Generalized Internal Power Supply Efficiency Test Protocol, Rev. 6.7 for internal power supplies.

~~7~~ 6. The wattage of ~~Line voltage~~ lighting track, ~~and~~ plug-in busway or other lighting systems that allow~~s~~ the addition or relocation of luminaires without altering the wiring of the system~~. The wattage of such luminaires~~ shall be determined by ~~one of the following methods~~ either Item A or Item B~~.~~:

~~A. The wattage of line voltage busway and track rated for more than 20 amperes shall be the total volt-ampere rating of the branch circuit feeding the busway and track.~~

~~B. The wattage of line voltage busway and track rated for 20 amperes or less shall be determined by one of the following methods:~~

~~i. The volt-ampere rating of the branch circuit feeding the track or busway; or~~

~~ii.~~ A. The wattage shall be the greater ~~higher~~ of:

i. 30 watts per linear foot of track or plug-in busway or

ii. the ~~higher of the~~ rated wattage of all of the luminaires included in the system, where luminaire ~~classification and~~ wattage is determined according to the applicable provisions in Section 130.0(c)~~, or 45 watts per linear foot;~~ or

B. The wattage shall be equal to:

i. the volt-ampere rating of current limiting devices as specified by UL 1077, or

ii. the volt-ampere rating of over-current protection devices as specified by UL 489, or

iii. the maximum rated input wattage of the transformer as specified by UL 2108, serving the lighting system.

~~iii When using a line-voltage track lighting integral current limiter, the higher of the volt-ampere rating of an integral current limiter controlling the track or busway, or 12.5 xx watts per linear foot of track or busway. An Integral current limiter shall be certified to the Energy Commission in accordance with Section 110.9, and shall comply with the Lighting Control Installation Requirements in accordance with Section 130.4, to qualify to use Subsection Biii to determine luminaire power; or~~

~~iv When using a dedicated track lighting supplementary overcurrent protection panel, the sum of the ampere (A) rating of all of the overcurrent protection devices times the branch circuit voltages. Track lighting supplementary overcurrent protection panels shall comply with the applicable requirements in Section 110.9, and shall comply with the Lighting Control Installation Requirements in accordance with Section 130.4, to qualify to use Subsection Biv to determine luminaire power.~~

~~8 Luminaires and lighting systems with permanently installed or remotely installed transformers. The wattage of such luminaires shall be determined as follows:~~

~~A.~~ 7. The wattage of ~~For~~ low-voltage luminaires that do not allow the addition of lamps, lamp holders, or luminaires without rewiring~~, the wattage~~ shall be the rated wattage of the lamp/transformer combination.

8. The wattage of low-voltage luminaires that allow the addition of lamps or lamp holders or luminaires without rewiring shall be the maximum rated input wattage of the transformer as specified by UL 2108.

~~B. For low-voltage lighting systems, including low-voltage tracks and other low-voltage lighting systems that allow the addition of lamps, lamp holders, or luminaires without rewiring, the wattage shall be the maximum rated input wattage of the transformer, labeled in accordance with Item 1, or the maximum rated wattage published in transformer manufacturer's catalogs, as specified by UL 2108.~~

~~9. Light emitting diode (LED) Luminaires, and LED Light Engine.~~

~~A. The wattage of such luminaires shall be the maximum rated input wattage of the system when tested in accordance with IES LM-79-08.~~

~~B. The maximum rated input wattage shall be labeled in accordance with Section 130.0(c)1.~~

~~C. An LED lamp, integrated or nonintegrated type in accordance with the definition in ANSI/IES RP-16-~~

~~2010, shall not be classified as a LED lighting system for compliance with Part 6. LED modules having screw bases, including but not limited to screw based pig-tails, screw-based sockets, or screw-based adaptors, shall not be recognized as a LED lighting system for compliance with Part 6.~~

~~D. Luminaires manufactured or rated for use with low-voltage incandescent lamps, into which have been installed LED modules or LED lamps, shall not be recognized as a LED lighting system for compliance with Part 6.~~

~~E. For LED lighting systems that allow the addition of luminaires or light engines without rewiring, the wattage of such luminaires shall be the maximum rated input wattage of the power supply, labeled in accordance with Section 130.0(c)1 or published in the power supply manufacturer's catalog.~~

~~EXCEPTION to Section 130.0(c)9: Luminaires in areas that must comply with Section 150.0(k), as specified by Section 130.0(b).~~

~~10.~~ 9. The wattage of all other miscellaneous lighting equipment shall be the maximum rated wattage of the lighting equipment, or operating input wattage of the system, labeled in accordance with Section 130.0(c)1, or published in manufacturer's catalogs, based on independent testing lab reports as specified

by UL 1574 or UL 1598. ~~Lighting technologies listed in Subsections 2 through 9 shall be determined in accordance with the applicable requirements in Subsections 1 through 9.~~

SECTION 130.4 – LIGHTING CONTROL ACCEPTANCE AND INSTALLATION CERTIFICATION REQUIREMENTS

Nonresidential, high-rise residential, and hotel/motel buildings shall comply with the applicable requirements of Sections 130.4(a) through 130.4(c).

…

(b) Lighting Control Installation Certificate Requirements. To be recognized for compliance with Part 6 an Installation Certificate shall be submitted in accordance with Section 10-103(a) for any lighting control system, Energy Management Control System, track lighting integral current limiter, track lighting supplementary overcurrent protection panel, interlocked lighting system, lighting Power Adjustment Factor, or additional wattage available for a videoconference studio, in accordance with the following requirements, as applicable:

…

~~3. Certification that line-voltage track lighting integral current limiters comply with the applicable requirements of Section 110.9 and installed wattage has been determined in accordance with Section 130.0(c); and comply with Reference Nonresidential Appendix NA7.7.3.~~

~~4. Certification that line-voltage track lighting supplementary overcurrent protection panels comply with the applicable requirements of Section 110.9 and installed wattage has been determined in accordance with Section 130.0(c); and comply with Reference Nonresidential Appendix NA7.7.4~~

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

A building complies with this section if:

i. The Calculation of ~~Actual~~ Adjusted Indoor Lighting Power of all proposed building areas combined, calculated under Subsection (a) is no greater than the Calculation of Allowed Indoor Lighting Power, Specific Methodologies calculated under Subsection (c); and

ii. The Calculation of Allowed Indoor Lighting Power, General Rules comply with Subsection (b); and

iii. General lighting complies with the Automatic Daylighting Controls in Secondary Daylit Zone requirements in Subsection (d).

…

(a) Calculation of ~~Actual~~ Adjusted Indoor Lighting Power. The ~~actual indoor~~ Adjusted Indoor Lighting Power of all proposed building areas is the total watts of all planned permanent and portable lighting systems in all areas of the proposed building; subject to the applicable adjustments under Subdivisions 1 through ~~3~~ 5 of this subsection and the requirements of Subdivision ~~4~~ 6 of this subsection.

~~**EXCEPTION to Section 140.6(a):** Up to 0.3 watts per square foot of portable lighting for office areas shall not be required to be included in the calculation of actual indoor Lighting Power.~~

1. Two interlocked lighting systems: No more than two lighting systems may be used for an area, and if there are two they must be interlocked. Where there are two interlocked lighting systems, the watts of the lower wattage system may be excluded from the ~~actual indoor~~ Adjusted Indoor Lighting Power if:

…

2. Reduction of wattage through controls. In calculating ~~actual indoor~~ Adjusted Indoor Lighting Power, the installed watts of a luminaire providing general lighting in an area listed in TABLE 140.6-A may be reduced by the product of (i) the number of watts controlled as described in TABLE 140.6-A, times (ii) the applicable Power Adjustment Factor (PAF), if all of the following conditions are met:

…

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

…

3. Lighting wattage excluded. The watts of the following indoor lighting applications may be excluded from ~~actual indoor~~ Adjusted Indoor Lighting Power Density. (Indoor lighting not listed below shall comply with all applicable nonresidential indoor lighting requirements in Part 6.):

F. In medical, veterinary, and clinical buildings: Examination and surgical lights, low-ambient night-lights, and lighting integral to medical equipment, provided that these lighting systems are additions to and separately switched from a general lighting system.

…

4. Small aperture tunable white and dim-to-warm luminaire Lighting Power adjustment. For qualifying small aperture tunable white or dim-to-warm luminaires, the Adjusted Indoor Lighting Power of these luminaires shall be reduced by multiplying the installed watts by 0.75 to calculate their Adjusted Indoor Lighting Power. Qualifying luminaires shall comply with Items A though C:

A. Small aperture. Qualifying luminaires longer than 18 inches shall be no wider than four inches. Qualifying luminaires with a length of 18 inches or less shall be no wider than eight inches.

B. Color changing. Qualifying tunable white luminaires shall be capable of a color change greater than or equal to 2,000 Kelvin correlated color temperature (CCT). Qualifying dim-to-warm luminaires shall be capable of color change greater than or equal to 500 Kelvin CCT.

C. Controls. Qualifying luminaires shall be connected to controls that enable color changing.

5. Tailored Method display lighting mounting height power adjustment. For areas using the Tailored Method, where the bottom of luminaires providing wall display or floor display are greater than 11 feet above the finished floor, the Adjusted Indoor Lighting Power of these luminaires shall be reduced by multiplying the installed watts by the appropriate mounting height adjustment factor from TABLE 140.6-E. General lighting shall not qualify for a mounting height multiplier.

~~4~~ 6. Luminaire Classification and Power. Luminaire Classification and Power shall be determined in accordance with Section 130.0(c).

…

(c) **Calculation of Allowed Indoor Lighting Power: Specific Methodologies.** The allowed indoor Lighting Power for each building type, or each primary function area shall be calculated using only one of the methods in Subsection 1, 2 or 3 below as applicable.

1. Complete Building Method. Requirements for using the Complete Building Method include all of the following:

…

2. Area Category Method. Requirements for using the Area Category Method include all of the following:

A. The Area Category Method shall be used ~~only~~ for primary function areas, as defined in Section 100.1, that are listed in TABLE 140.6-C. For primary function areas not listed, selection of a reasonably equivalent type shall be permitted.

…

E. If, at the time of permitting for a newly constructed building, a tenant is not identified for a multi-tenant area, a maximum of ~~0.6~~ 0.4 ~~watts~~ watts per square foot shall be allowed for the lighting in each area in which a tenant has not been identified. The area shall be classified as Unleased Tenant Area.

…

G. In addition to the allowed indoor Lighting Power calculated according to Sections 140.6(c)2 Items A through F, the building may add additional lighting power allowances for specialized task work, ornamental, precision, accent, display, decorative, and white boards and chalk boards, in accordance with the "Allowed Additional Lighting LPD" column ~~footnotes~~ in TABLE 140.6-C under the following conditions:

i. Only primary function areas ~~having a footnote next to the allowed Lighting Power Density allotments~~ a lighting power density listed in the "Allowed Additional Lighting LPD" column in TABLE 140.6-C shall qualify for the added lighting power allowances, for the type of lighting described in the "Qualifying Lighting Systems" column, and in accordance with the correlated footnote listed at the bottom of the table; and

ii. The additional lighting power allowances shall be used only if the plans clearly identify all applicable task areas and the lighting equipment designed to illuminate these tasks; and

iii. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for the additional lighting power allowances; and

iv. The additional lighting power allowances shall not utilize any type of luminaires that are used for general lighting in the building; and

v. The additional lighting power allowances shall not be used when using the Complete Building Method, or when the Tailored Method is used for any area in the building; and

vi. The additional lighting power allowed is the smaller of:

a. the lighting power density listed in the ~~applicable footnote~~ "Allowed Additional Lighting LPD" column in TABLE 140.6-C, times the square feet of the primary function or;

b. the ~~actual design wattage~~ Adjusted Indoor Lighting Power of the applicable lighting ~~may be added to the allowed lighting power;~~ and

vii. In addition to all other additional lighting power allowed under Sections 140.6(c)2Gi through vi, up to ~~1.5 watts~~ 1.0 watts per square foot of additional lighting power shall be allowed in a videoconferencing studio, as defined in Section 100.1, provided the following conditions are met:

…

3. **Tailored Method.** Requirements for using the Tailored Method include all of the following:

A. The Tailored Method shall be used only for primary function areas listed in TABLE 140.6-D, as they are defined in Section 100.1~~, and for IES allowances listed in Section 140.6(c)3H~~.

B. Allowed Indoor Lighting Power ~~allotments~~ for general lighting shall be determined according to Section 140.6(c)3G ~~or H, as applicable~~. ~~General lighting shall not qualify for a mounting height multiplier.~~

C. For compliance with this Item, an "area" shall be defined as all contiguous areas that accommodate or are associated with a single primary function area listed in TABLE 140.6-D.

D. Where areas are bounded or separated by interior partitions, the floor area occupied by those interior partitions may be included in a Primary Function Area.

E. In addition to the allowed indoor Lighting Power ~~allotments~~ for general lighting calculated according to Sections 140.6(c)3G ~~or H, as applicable~~, the building may add additional lighting power allowances for wall display, floor display and task lighting, ornamental/special effects, and very valuable display cases according to Section 140.6(c)3~~I~~G through ~~L~~J.

~~F. The general lighting system shall not use narrow beam direction lamps, wall-washer, valance, direct cove, or perimeter linear slot types of lighting systems.~~

F ~~G~~. Determine allowed indoor Lighting Power ~~allotments~~ for general lighting for primary function areas listed in TABLE 140.6-D as follows:

i. Use the ~~IES~~ Illuminance ~~values~~ Level (Lux) listed in Column 2 to determine the Allowed General Lighting Power Density ~~allotments~~ for the area.

ii. Determine the room cavity ratio (RCR) for the area. The RCR shall be calculated according to the applicable equation in TABLE 140.6-F.

iii. Find the allowed General Lighting Power Density ~~allotments~~ in TABLE 140.6-G that is applicable to the ~~IES~~ General Illuminance ~~value~~ Level (Lux) from Column 2 of Table 140.6-D (as described in Item i.) and the RCR determined in accordance with TABLE 140.6-F (as described in Item ii).

iv. Determine the square feet of the area in accordance with Section 140.6(c)3C and D.

v. Multiply the allowed Lighting Power Density ~~allotment~~, as determined in accordance with Item iii, by the square feet of each primary function area, as determined in accordance with Item iv. The product is the Allowed Indoor Lighting Power ~~allotment~~ for general lighting for the area.

~~H. Determine allowed indoor Lighting Power allotments for general lighting for only specific primary function areas NOT listed in TABLE 140.6-D as follows:~~

~~i. Use this Section only to calculate allowed indoor lighting power for general lighting in the following primary function areas. Do not use Section 140.6(c)3H for any primary function areas NOT listed below:~~

~~a. Exercise Center, Gymnasium~~

~~b. Medical and Clinical Care~~

~~c. Police Stations and Fire Stations~~

~~d. Public rest areas along state and federal roadways~~

~~e. Other primary function areas that are listed in neither TABLE 140.6-C nor TABLE140.6-D.~~

~~ii. When calculating allowed indoor Lighting Power allotments for general lighting using Section 140.6(c)3H, the building shall not add additional lighting power allowances for any other use, including but not limited to wall display, floor display and task, ornamental/special effects, and very valuable display case lighting.~~

~~iii. Calculate the allowed indoor Lighting Power for each primary function area in the building as follows:~~

~~a. Determine the illuminance values (Lux) according to the Tenth Edition IES Lighting Handbook (IES HB), using the Recommended Horizontal Maintained Illuminance Targets for Observers 25-65 years old for illuminance.~~

~~b. Determine the room cavity ratio (RCR) for area. The RCR shall be calculated according to the applicable equation in TABLE 140.6-F.~~

~~c. Find the allowed lighting power density in TABLE 140.6-G that is applicable to the illuminance value (Lux) determined in accordance with Item (a) and the RCR determined in accordance with Item (b).~~

~~d. Determine the square feet of the area. For compliance with this item, an "area" shall be defined as all contiguous areas that accommodate or are associated with a single primary function area listed in Item (i). Where areas are bounded or separated by interior partitions, the floor area occupied by those interior partitions may be included in a Primary Function Area.~~

~~e. Multiply the square feet determined in accordance with Item (d), by the allowed lighting power density determined in accordance with item (c). The product is the Allowed Indoor Lighting Power allotment for general lighting for the area.~~

G ~~I~~. Determine additional allowed power for wall display lighting according to column 3 of Table 140.6-D for each primary function area as follows:

~~i. Additional wall display lighting power shall not be available when using Section 140.6(c)3H for determining the Allowed Indoor Lighting Power allotment for general lighting for the area.~~

i~~i~~. Floor displays shall not qualify for wall display allowances.

ii~~i~~. Qualifying wall lighting shall:

a. Be mounted within 10 feet of the wall having the wall display. When track lighting is used for wall display, and where portions of that lighting track are more than 10 feet from the wall and other portions are within 10 feet of the wall, portions of track more than 10 feet from the wall shall not be used for the wall display allowance.

b. Be a lighting system type appropriate for wall lighting. Lighting systems appropriate for wall lighting are lighting track adjacent to the wall, wall-washer luminaires, luminaires behind a wall valance or wall cove, or accent light. (Accent luminaires are adjustable or fixed luminaires with PAR, R, MR, AR, or other directional lamp types or luminaires providing directional display light.)

iii-~~iv~~. Additional allowed power for wall display lighting is available only for lighting that illuminates walls having wall displays. The length of display walls shall include the length of the perimeter walls, including but not limited to closable openings and permanent full height interior partitions. Permanent full height interior partitions are those that (I) extend from the floor to ~~no more than~~ within two feet of the ceiling or are taller than ten feet, and (II) are permanently anchored to the floor~~, provided, however, that neither commercial industrial stacks nor industrial storage stacks are permanent full height interior partitions~~.

~~v. The wall display mounting height multiplier is the applicable factor from TABLE 140.6-E. Mounting height is the distance from the finished floor to the bottom of the luminaire. The wall display mounting height multipliers shall be used to reduce the design watts of the space.~~

iv~~i~~. The additional allowed power for wall display lighting shall be the smaller of:

a. The ~~product of wall display power~~ Allowed Additional Wall Display Lighting Power Density determined in accordance with Column 3 of TABLE 140.6-D, ~~times~~ multiplied by the wall display lengths determined in accordance with Item ~~iv~~iii; or

b. The ~~actual power~~ Adjusted Indoor Lighting Power used for the wall display lighting systems.

v. Lighting internal to display cases that are attached to a wall or directly adjacent to a wall is counted as wall display lighting in accordance with Section 140.6(c)3G. All other lighting internal to display cases are counted as floor display lighting in accordance with Section 140.6(c)3H, or as very valuable display case lighting in accordance with Section 140.6(c)3J.

H ~~J~~. Determine additional allowed power for floor display lighting and task lighting as follows:

~~i. Neither additional allowed power for floor display lighting nor additional allowed power for task lighting shall be available when using Section 140.6(c)3H for determining allowed indoor Lighting Power allotment for general lighting.~~

i~~i~~. Displays that are installed against a wall shall not qualify for the floor display lighting power allowances.

ii~~i~~. Lighting internal to display cases that are not attached to a wall and not directly adjacent to a wall shall be counted as floor display lighting in accordance with Section 140.6(c)3H~~J~~;, or as very valuable display case lighting in accordance with Section 140.6(c)3J ~~Liii and iv~~.

iii ~~iv~~. Additional allowed power for floor display lighting, and additional allowed power for task lighting, may be used by qualifying floor display lighting systems, qualifying task lighting systems, or a combination of both. For floor areas qualifying for both floor display and task lighting power allowances, the additional allowed power shall be used only once for the same floor area, so that the allowance shall not be additive.

iv. Qualifying floor display lighting shall:

a. Be mounted no closer than 2 feet to a wall.

b. Consist of only (I) directional lighting types, such as PAR, R, MR, AR; or (II) lighting employing optics providing directional display light ~~from nondirectional lamps~~.

c. If track lighting is used, shall be only track heads that are classified as directional lighting types.

v~~i~~. Qualifying task lighting shall:

a. Be located immediately adjacent to and capable of illuminating the task for which it is installed.

b. Be of a type different from the general lighting system.

c. Be separately switched from the general lighting system.

vi~~i~~. If there are illuminated floor displays, floor display lighting power shall be used only if allowed by column 4 of TABLE 140.6-D.

vii~~i~~. ~~Additional allowed power for a combination of floor display lighting and task lighting shall be available only for (I) floors having floor displays; or (II) floors not having floor displays but having tasks having illuminance recommendations that appear in the Tenth Edition of the IES Lighting Handbook and that are higher than the general lighting level in column 2 of TABLE 140.6-D.~~ The square footage of floor display or the square footage of task areas shall be determined in accordance with Section 140.6(c)3C and D, except that any floor area designed to not have floor displays or tasks, such as floor areas designated as a path of egress, shall not be included for the floor display allowance.

~~ix~~. ~~For floor display lighting where the bottom of the luminaire is 12 feet or higher above the finished floor, the wattage allowed in column 4 of TABLE 140.6-D may be increased by multiplying the floor display lighting power allowance by the appropriate factor from TABLE 140.6-E~~

viii~~x~~. The additional allowed power for floor display lighting for each applicable area shall be the smaller of:

a. The ~~product of allowed floor display and task lighting power "~~allowed combined floor display combined Floor Display Power and Task Lighting Power Density" in column 4 of TABLE 140.6-D determined in accordance with Section 140.6(c)3Hvii ~~Jvii~~ ~~times~~ multiplied by the floor square footage determined in accordance with Section 140.6(c)3Hviii ~~Jviii~~; or

b. The ~~actual power~~ Adjusted Indoor Lighting Power used for the floor display lighting systems.

I ~~K~~. Determine additional allowed power for ornamental/special effects lighting as follows:

~~i. Additional allowed power for ornamental/special effects lighting shall not be available when using Section 140.6(c)3H for determining general Lighting Power allowances.~~

ii. Qualifying ornamental lighting includes luminaires such as chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes, theatrical projectors, moving lights and light color panels when any of those lights are used in a decorative manner that does not serve as display lighting or general lighting.

iii. Additional lighting power for ornamental/special effects lighting shall be used only if allowed by Column 5 of TABLE 140.6-D.

iii~~v~~. Additional lighting power for ornamental/special effects lighting shall be used only in areas having ornamental/special effects lighting. The square footage of the floor area shall be determined in accordance with Section 140.6(c)3C and D, and it shall not include floor areas not having ornamental/special effects lighting.

iv. The additional allowed power for ornamental/special effects lighting for each applicable area shall be the smaller of:

a. The ~~product of the allowed ornamental/special effects lighting power~~ "Allowed Additional Ornamental/Special Effect Lighting Power Density" in Column 5 of TABLE 140.6 -D determined in accordance with Section 140.6(c)3Iii ~~Kiii~~, ~~times~~ multiplied by the floor square footage determined in accordance with Section 140.6(c)3Iiii ~~Kiv~~; or

b. The ~~actual power~~ Adjusted Indoor Lighting Power of allowed ornamental/special effects lighting.

J ~~L~~. Determine additional allowed power for very valuable display case lighting as follows:

~~i. Additional allowed power for very valuable display case lighting shall not be available when using Section 140.6(c)3H for determining general Lighting Power allowances.~~

ii. Additional allowed power for very valuable display case lighting shall be available only for display cases in appropriate function areas in retail merchandise sales, museum and religious worship.

iii. To qualify for additional allowed power for very valuable display case lighting, a case shall contain jewelry, coins, fine china, fine crystal, precious stones, silver, small art objects and artifacts, and/or valuable collections the display of which involves customer inspection of very fine detail from outside of a locked case.

iii ~~iv~~. Qualifying lighting includes internal display case lighting or external lighting employing highly directional luminaires specifically designed to illuminate the case or inspection area without spill light, and shall not be fluorescent lighting unless installed inside of a display case.

iv. If there is qualifying very valuable display case lighting, in accordance with Section 140.6(c)3Jii ~~Liii~~, the smallest of the following separate lighting power for display cases presenting very valuable display items is permitted:

a. The product of the area of the primary function and ~~0.8 watt~~ 0.55 watts per square foot; or

b. The product of the area of the display case and ~~12 watts~~ 8 watts per square foot; or

c. The ~~actual power~~ Adjusted Indoor Lighting Power of lighting for very valuable displays.

Table 10: Existing Table 140.6-B Complete Building Method Lighting Power Density Values

~~TYPE OF BUILDING~~	~~ALLOWED LIGHTING POWER DENSITY (WATTS PER~~
~~Auditorium Building~~	~~1.4~~
~~Classroom Building~~	~~1.1~~
~~Commercial and Industrial Storage Building~~	~~0.6~~
~~Convention Center Building~~	~~1.0~~
~~Financial Institution Building~~	~~1.0~~
~~General Commercial Building/Industrial Work~~	~~1.0~~
~~Grocery Store Building~~	~~1.5~~
~~Library Building~~	~~1.2~~
~~Medical Building/Clinic Building~~	~~1.0~~
~~Office Building~~	~~0.8~~
~~Parking Garage Building~~	~~0.2~~
~~Religious Facility Building~~	~~1.5~~
~~Restaurant Building~~	~~1.1~~
~~School Building~~	~~0.9~~
~~Theater Building~~	~~1.3~~
~~All others buildings~~	~~0.5~~

Table 11: Proposed Table 140.6-B Complete Building Method Allowed Lighting Power Density ~~Values~~

TYPE OF BUILDING	ALLOWED LIGHTING POWER DENSITY (WATTS PER SQUARE FOOT)
Public Assembly	0.70
Public Order and Safety	0.70
Financial Institution	0.65
Grocery Store	0.95
Hospital	0.90
Industrial/ Manufacturing facility	0.60
Library	0.70
Medical/Healthcare Clinic	0.70
Office	0.65
Parking Garage	0.13
Performing arts theater	0.80
Religious Facility	0.70
Restaurant	0.70
Retail Store	0.90
School and/or university	0.65
Service facility	0.60
Sports arena	0.75
Warehouse	0.45
All other buildings	0.40

Table 12: Existing Table 140.6-C Area Category Method – Lighting Power Density Values (Watts/Square Foot)

PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER DENSITY (W/ft²)	PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER DENSITY (W/ft²)
Auditorium Area		1.40 [3]	Library Area	Reading areas	1.1 [3]
Auto Repair Area		0.90 [2]		Stack areas	1.5 [3]
Beauty Salon Area		1.7	Lobby Area	Hotel lobby	0.95 [3]
Civic Meeting Place Area		1.3 [3]		Main entry lobby	0.95 [3]
Classroom, Lecture, Training, Vocational Areas		[5] 1.2	Locker/Dressing Room		0.70
Commercial and Industrial Storage Areas (conditioned and unconditioned)		0.60	Lounge Area		0.90 [3]
Commercial and Industrial Storage Areas (refrigerated)		0.7	Malls and Atria		0.95 [3]
Convention, Conference, Multipurpose and Meeting Center Areas		1.2 [3]	Medical and Clinical Care Area		1.2
Corridor, Restroom, Stair, and Support Areas		0.60	Office Area	> 250 square feet	0.75
Dining Area		1.0 [3]		≤ 250 square feet	1.0
Electrical, Mechanical, Telephone Rooms		[2] 0.55	Parking Garage Area	Parking Area [10]	0.14
Exercise Center, Gymnasium Areas		1.0		Dedicated Ramps	0.30
Exhibit, Museum Areas		1.8		Daylight Adaptation Zones [9]	0.60
Financial Transaction Area		1.0 [3]	Religious Worship Area		1.5 [3]
General Commercial and Industrial Work Areas	Low bay	0.9 [2]	Retail Merchandise Sales, Wholesale Showroom Areas		1.2 7and 7
	High bay	1.0 [2]			
	Precision	1.2 [4]	Theater Area	Motion picture	0.90 [3]
Grocery Sales Area		1.2 6 and 7		Performance	1.4 [3]

Table 13: Continued: Existing Table 140.6-C Area Category Method – Lighting Power Density ~~Values~~ (Watts/Square Foot)

~~Hotel Function Area~~	~~1.4[3]~~	~~Transportation Function Area~~	~~Concourse & Baggage~~	~~0.50~~
			~~Ticketing~~	~~1.0~~
~~Kitchen, Food Preparation Areas~~	~~1.2~~	~~Videoconferencing Studio~~		~~1.2[8]~~
~~Laboratory Area, Scientific~~	~~1.4[4]~~	~~Waiting Area~~		~~0.80[3]~~
~~Laundry Area~~	~~0.70~~	~~All other areas~~		~~0.50~~

~~Footnotes for this table are listed below.~~

~~FOOTNOTES FOR TABLE 140.6-C:~~

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

~~Footnote number~~	~~Type of lighting system allowed~~	~~Allowed lighting power density. (W/ft^2 of task area unless otherwise noted)~~
~~1~~	~~Specialized task work~~	~~0.20 W/ft^2~~
~~2~~	~~Specialized task work~~	~~0.50 W/ft^2~~
~~3~~	~~Ornamental lighting as defined in Section 100.1 and in accordance with Section 140.6.(c)2.~~	~~0.50 W/ft^2~~
~~4~~	~~Precision commercial and industrial work~~	~~1.0 W/ft^2~~
~~5~~	~~Per linear foot of white board or chalk board.~~	~~5.5 W per linear foot~~
~~6~~	~~Accent, display and feature lighting - luminaires shall be adjustable or directional~~	~~0.30 W/ft^2~~
~~7~~	~~Decorative lighting - primary function shall be decorative and shall be in addition to general illumination.~~	~~0.20 W/ft^2~~
~~8~~	~~Additional Videoconferencing Studio lighting complying with all of the requirements in Section 140.6(c)2Gvii.~~	~~1.5 W/ft^2~~
~~9~~	~~Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage~~	
~~10~~	~~Additional allowance for ATM locations in Parking Garages. Allowance per ATM.~~	~~200 watts for first ATM location. 50 watt for each additional ATM location in a group.~~

Table 14: Proposed Table 140.6-C Area Category Method – Allowed Lighting Power Density ~~Values~~ (watts/square foot)

PRIMARY FUNCTION AREA	**ALLOWED LIGHTING POWER DENSITY (W/ft^2)**	**ADDITIONAL LIGHTING POWER[1]**	
		QUALIFYING LIGHTING SYSTEMS	**ALLOWED ADDITIONAL LPD^2 W/ft^2)**
Auditorium	0.70	Ornamental lighting[3]	0.30
		Accent & feature lighting[10]	0.20
Auto Repair & Maintenance	0.55	Detailed task work[4]	0.20
Audience Seating	0.60	Ornamental lighting[3]	0.30
Beauty Salon	0.80	Detailed task work[4]	0.20
		Ornamental lighting[3]	0.30
Civic Meeting Place	1.00	Ornamental lighting[3]	0.30

PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER DENSITY (W/ft²)	ADDITIONAL LIGHTING POWER[1]	
			QUALIFYING LIGHTING SYSTEMS	ALLOWED ADDITIONAL LPD[2] W/ft²)
Classroom, Lecture, Training		0.70	White or chalkboard[6]	4.50 W/linear foot
Commercial/Industrial Storage (Warehouse)	Warehouse	0.45		
	Shipping & Handling	0.60		
Convention, Conference, Multipurpose and Meeting Center		0.85	Ornamental lighting[3]	0.30
Copy/Print Room		0.50		
Corridors		0.60		
Dining	Bar/Lounge and Fine Dining	0.55	Ornamental lighting[3]	0.30
	Cafeteria/Fast Food	0.40		
	Family and Leisure	0.50		
Electrical, Mechanical, Telephone Rooms		0.40	Detailed task work[4]	0.20
Exercise /Fitness Center & Gymnasium		0.50		
Hotel Function		0.85	Ornamental lighting[3]	0.30
Museum	Exhibition/Display	0.60	Accent, display and feature lighting[10]	0.50
	Restoration Room	0.75	Detailed task work[4]	0.20
Financial Transaction		0.80	Ornamental lighting[3]	0.30
General/Commercial & Industrial Work	Low Bay	0.60	Detailed task work[4]	0.20
	High Bay	0.65	Detailed task work[4]	0.20
	Precision	0.85	Precision specialized task work[7]	0.70
Library	Reading	0.80	Ornamental lighting[3]	0.30
	Stacks	1.10		
Main Entry Lobby		0.85	Ornamental lighting[3]	0.30
Locker Room		0.45		
Lounge, Breakroom, or Waiting		0.65	Ornamental lighting[3]	0.30
Concourse and Atria		0.90	Ornamental lighting[3]	0.30
Office	> 250 square feet	0.65	Portable lighting for office areas with time clock or occupancy controls[13]	0.20
	≤ 250 square feet	0.70		
	Open Plan	0.60		
Parking Structure	Parking Zone	0.10	First ATM[8]	100 W
			Additional ATM	50 W/ea

PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER DENSITY (W/ft²)	ADDITIONAL LIGHTING POWER[1]	
			QUALIFYING LIGHTING SYSTEMS	ALLOWED ADDITIONAL LPD[2] W/ft²)
	Dedicated Ramps	0.25		
	Daylight Adaptation Zones [9]	0.50		
Pharmacy		1.10	Specialized task work[5]	0.35
Merchandise Sales	Grocery Sales	1.05	Accent, display and feature lighting[10]	0.20
			Decorative lighting[11]	0.15
	Retail Merchandise	1.00	Accent, display and feature lighting[10]	0.20
			Decorative lighting[11]	0.15
	Fitting Room	0.60	External illuminated mirror[12]	40 W/ea
			Internal illuminated mirror[12]	120 W/ea
Theater	Motion Picture	0.60	Ornamental lighting[3]	0.30
	Performance	1.00		
Kitchen and/or Food Preparation		0.95		
Laboratory		1.00	Specialized task work[5]	0.35
Healthcare Facility (Hospital) (See exception for specialized medical lighting[15])	Exam/Treatment Room	1.15		
	Imaging Room	1.00		
	Medical Supply Room	0.55		
	Nursery	0.95	Tunable white or dim-to-warm[14]	0.10
	Nurses' Station	0.75	Tunable white or dim-to-warm[14]	0.10
	Operating Room	1.90		
	Patient Room	0.55	Decorative lighting[11]	0.15
			Tunable white or dim-to-warm[14]	0.10
	Physical Therapy Room	0.85	Tunable white or dim-to-warm[14]	0.10
	Recovery Room	0.90	Tunable white or dim-to-warm[14]	0.10
Laundry		0.45		
Religious Worship		0.95	Ornamental lighting[3]	0.30
Restrooms		0.65	Accent/feature lighting[10]	0.20
			Decorative lighting[11]	0.15
Transportation Functions	Transportation: Baggage	0.40		

PRIMARY FUNCTION AREA		ALLOWED LIGHTING POWER DENSITY (W/ft²)	ADDITIONAL LIGHTING POWER[1]	
			QUALIFYING LIGHTING SYSTEMS	ALLOWED ADDITIONAL LPD[2] W/ft²)
	Transportation: Ticketing	0.45	Accent/feature lighting[10]	0.20
Sports Arena—Playing Area	Class I Facility	2.25		
	Class II Facility	1.45		
	Class III Facility	1.10		
	Class IV Facility	0.75		
Stairwell		0.50	Accent/feature lighting[10]	0.20
			Decorative lighting[11]	0.15
Videoconferencing Studio		0.90	Videoconferencing lighting[16]	1.00
All other		0.40		
Aging Eye/Low-vision[17]	Entry or Main Entry Lobby	0.85	Ornamental lighting[3]	0.30
			Transition lighting OFF at night[18]	0.95
	Stairwell	0.80		
	Corridors/Hallways	0.80	Decorative lighting[11]	0.15
	Lounge/Waiting Rooms	0.75	Ornamental lighting[3]	0.30
	Activity/Meeting/Common Room	0.95	Ornamental lighting[3]	0.30
	Religious Worship	1.00	Ornamental lighting[3]	0.30
	Dining	0.80	Ornamental lighting[3]	0.30
	Restroom	0.80	Accent/feature lighting[10]	0.20

1. Additional lighting power in accordance with 140.6(c)2G.

2. Watts per square foot unless otherwise noted.

3. Ornamental lighting as defined in Section 100.1 and in accordance with Section 140.6(c)2.

4. Detailed task work - Lighting provides high level of visual acuity required for activities with close attention to small elements and/or extreme close up work .

5. Specialized task work - Lighting provides level of visual acuity and or luminaires for work requiring specialized equipment and/or engaging in a specialized activity or task.

6. Whiteboard or chalkboard - Directional lighting dedicated to illumination of a white board or chalkboard.

7. Precision specialized work - Lighting for work performed within a commercial or industrial environment that entails working with low contrast, finely detailed, or fast moving objects. .

8. Automated teller machines in parking garages: 100 watts for first ATM, 50 watts each for additional ATM.

9. Daylight adaptation zones shall be no longer than 66 feet from the entrance to the parking garage.

10. Accent, display and feature lighting - luminaires shall be adjustable or directional.

11. Decorative lighting - primary function shall be decorative and shall be in addition to general illumination.

12. Illuminated mirrors. Lighting shall be dedicated to mirror.

13. Portable lighting in office areas including under shelf or furniture-mounted supplemental task lighting qualifies when controlled by a time clock or an occupancy sensor.

14. Tunable white or dim-to-warm luminaire as specified in Section 140.6(a)4B.

PRIMARY FUNCTION AREA	ALLOWED LIGHTING POWER DENSITY (W/ft²)	ADDITIONAL LIGHTING POWER[1]	
		QUALIFYING LIGHTING SYSTEMS	ALLOWED ADDITIONAL LPD[2] W/ft²)
15. Lighting wattage exempted for: examination and surgical lights, low-ambient night lights, and lighting integral to medical equipment, provided that these lighting systems are additions to and separately switched from a general lighting system. See Section 140.6 (a)3F. 16. Additional videoconferencing studio lighting complying with all of the requirements in Section 140.6(c)2Gvii. 17. Aging eye/low-vision areas can be documented as being designed to comply with the light levels in ANSI/IES RP-28 and are or will be licensed by local/state authorities for either senior long-term care, adult day care, senior support, and/or people with special visual needs. 18. Transition lighting OFF at night. Lighting power controlled by astronomical time clock or other control to shut lighting off at night. Additional LPD only applies to area within 30 feet of an exit. Not applicable to lighting in daylit zones.			

Table 15: Existing Table 140.6-D Tailored Lighting Power Allowances

1	2	3	4	5
~~Primary Function Area~~	~~General Illumination Level (Lux)~~	~~Wall Display Lighting Power Density (W/ft)~~	~~Allowed Combined Floor Display Power and Task Lighting Power Density (W/ft^2)~~	~~Allowed Ornamental/ Special Effect Lighting Power Density (W/ft^2)~~
~~Auditorium Area~~	~~300~~	~~2.25~~	~~0.3~~	~~0.5~~
~~Civic Meeting Place~~	~~300~~	~~3.15~~	~~0.2~~	~~0.5~~
~~Convention, Conference, Multipurpose, and Meeting Center Areas~~	~~300~~	~~2.50~~	~~0.4~~	~~0.5~~
~~Dining Areas~~	~~200~~	~~1.50~~	~~0.6~~	~~0.5~~
~~Exhibit, Museum Areas~~	~~150~~	~~15.0~~	~~1.2~~	~~0.5~~
~~Financial Transaction Area~~	~~300~~	~~3.15~~	~~0.2~~	~~0.5~~
~~Grocery Store Area~~	~~500~~	~~8.00~~	~~0.9~~	~~0.5~~
~~Hotel Function Area~~	~~400~~	~~2.25~~	~~0.2~~	~~0.5~~
~~Lobby Area:~~				
~~Hotel lobby~~	~~200~~	~~3.15~~	~~0.2~~	~~0.5~~
~~Main entry lobby~~	~~200~~	~~0~~	~~0.2~~	~~0~~
~~Lounge Area~~	~~200~~	~~7.00~~	~~0~~	~~0.5~~
~~Malls and Atria~~	~~300~~	~~3.50~~	~~0.5~~	~~0.5~~
~~Religious Worship Area~~	~~300~~	~~1.50~~	~~0.5~~	~~0.5~~
~~Retail Merchandise Sales, and Showroom Areas~~	~~400~~	~~14.00~~	~~1.0~~	~~0.5~~
~~Theater Area:~~				
~~Motion picture~~	~~200~~	~~3.00~~	~~0~~	~~0.5~~
~~Performance~~	~~200~~	~~6.00~~	~~0~~	~~0.5~~
~~Transportation Function Area~~	~~300~~	~~3.15~~	~~0.3~~	~~0.5~~
~~Waiting Area~~	~~300~~	~~3.15~~	~~0.2~~	~~0.5~~

Table 16: Proposed Table 140.6-D Tailored Lighting Power Allowances

1		2	3	4	5
Primary Function Area		**General Illumination Level (Lux)**	**Allowed Additional Wall Display Lighting Power Density (W/ft)**	**Allowed Additional Combined Floor Display Power and Task Lighting Power Density (W/ft²)**	**Allowed Additional Ornamental/Special Effect Lighting Power Density (W/ft²)**
Auditorium		300	3.00	0.20	0.40
Convention, Conference, Multipurpose, and Meeting Center		300	2.00	0.35	0.40
Dining Room/Foodservice		200	1.25	0.50	0.40
Museum and Exhibit Presentation,		150	11.50	0.80	0.40
Hotel	Lobby	200	3.50	0.20	0.40
	Ballroom/Events	400	1.80	0.120	0.40
Main Entry Lobby		200	3.50	0.20	0.40
Religious Worship		300	1.30	0.40	0.40
Retail Sales	Grocery & Food Market	600	6.80	0.70	0.40
	Merchandise & Showrooms	500	11.80	0.80	
Theater	Motion Picture	200	2.00	0.20	0.40
	Performing Arts	200	7.50	0.20	

Table 17: Edited Table 140.6-E ~~Adjustment for~~ Tailored Wall and Floor Display Mounting Height Adjustment Factors ~~Above Floor~~

Height in feet above finished floor and bottom of luminaire(s)	Floor Display or Wall Display Mounting Height Adjustment Factors: Multiply by Display Installed Watts.
~~< 12'~~ < 10′7″	~~1.00~~ 1.00
~~12' to 16'~~ 10′7″ to 14′0″	~~0.87~~ 0.85
~~> 16'~~ >14′0″ to 18′0″	~~0.77~~ 0.75
> 18′0″	~~0.77~~ 0.70

Table 18: Existing (Unchanged) Table 140.6-F Room Cavity Ratio (RCR) Equations

TABLE 140.6-F ROOM CAVITY RATIO (RCR) EQUATIONS

Determine the Room Cavity Ratio for TABLE 140.6-G using one of the following equations.
Room cavity ratio for rectangular rooms $$RCR = \frac{5 \times H \times (L + W)}{L \times W}$$
Room cavity ratio for irregular-shaped rooms $$RCR = \frac{2.5 \times H \times P}{A}$$
Where: L =Length of room; W = Width of room; H =Vertical distance from the work plane to the centerline of the lighting fixture; P = Perimeter of room, and A = Area of room

Table 19: Current Table 140.6-G Tailored Method General Lighting Allowed Power Density Values (Watts/Square Feet)

Illuminance Level (Lux)	RCR ≤ 2.0	RCR > 2.0 and ≤ 3.5	RCR > 3.5 and ≤ 7.0	RCR > 7.0
~~50~~	~~0.18~~	~~0.22~~	~~0.32~~	~~0.46~~
~~100~~	~~0.30~~	~~0.38~~	~~0.56~~	~~0.84~~
~~200~~	~~0.48~~	~~0.64~~	~~0.88~~	~~1.34~~
~~300~~	~~0.64~~	~~0.82~~	~~1.12~~	~~1.76~~
~~400~~	~~0.78~~	~~0.98~~	~~1.34~~	~~2.08~~
~~500~~	~~0.90~~	~~1.10~~	~~1.52~~	~~2.32~~
~~600~~	~~1.06~~	~~1.26~~	~~1.74~~	~~2.60~~
~~700~~	~~1.24~~	~~1.46~~	~~1.82~~	~~2.96~~
~~800~~	~~1.44~~	~~1.70~~	~~2.28~~	~~3.30~~
~~900~~	~~1.66~~	~~2.00~~	~~2.64~~	~~3.74~~
~~1000~~	~~1.84~~	~~2.20~~	~~2.90~~	~~4.06~~

Table 20: Proposed Table 140.6-G Tailored Method - ~~Illuminance Level (Lux)~~ General Lighting Allowed Power Density ~~Values~~ (Watts/Square Feet) by Illuminance and Room Cavity Ratio

General Illuminance Level (Lux)[a]	**Room Cavity Ratio (RCR)**[b]			
	RCR ≤ 2.0	**RCR > 2.0 and ≤ 3.5**	**RCR > 3.5 and ≤ 7.0**	**RCR > 7.0**
150	0.40	0.45	0.60	0.75
200	0.45	0.55	0.75	1.00
300	0.65	0.80	1.00	1.40
400	0.75	0.95	1.25	1.50
500	0.90	1.05	1.45	1.85
600	1.08	1.24	1.64	2.38

[a] Illuminance values from Column 2 of Table 140.6-D
[b] RCR calculated in accordance with equations in table 140.6-F

APPENDIX 1-A

STANDARDS AND DOCUMENTS REFERENCED IN THE ENERGY EFFICIENCY REGULATIONS

UNDERWRITERS LABORATORIES

UL 181 Standard for Safety for Factory-made Air Ducts and Connectors (1996)

UL 181A Standard for Safety for Closure Systems for Use with Rigid Air Ducts and Air Connectors (1994)

UL 181B Standard for Safety for Closure Systems for Use with Flexible Air Ducts and Air Connectors

(1995)

UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures (2016)

UL 723 Standard for Test for Surface Burning Characteristics of Building Materials (1996)

UL 727 Standard for Oil-Fired Central Furnaces (1994)

UL 731 Standard for Oil-Fired Unit Heaters (1995)

UL 1077 Standard for Supplementary Protectors for Use in Electrical Equipment (2015)

UL 1574 Track Lighting Systems (2000)

UL 1598 Standard for Luminaires (2000)

UL 2108 Low Voltage Lighting Systems (2008)

Available from: Underwriters Laboratories

333 Pfingsten Road

Northbrook, Illinois 60062-2096

(847) 272-8800

7.2 Reference Appendices

Eliminate NA7.7.3 Track Lighting Integral Current Limiter. The primary data to be collected is whether claimed wattages listed in NRCC-LTI-01 are installed. A separate inspection and form for current limiters is not required.

7.3 ACM Reference Manual

The ACM Reference Manual and compliance software will need to be updated to reflect the new LPD values. The LPD values appear in Appendix 5.4A of the ACM Reference Manual.

7.4 Compliance Manuals

Chapter 5 of the Nonresidential Compliance Manual will need to be revised.

7.5 Compliance Documents

Document NRCC-LTI-01 "Indoor Lighting" Section C. "Summary of Allowed Lighting Power" will need to be revised to reflect that office task lighting no longer subtracted off of installed watts but now an additional allowed lighting allowance. Section H. "Indoor Lighting Schedule and Field Inspection Energy Checklist," will need to be modified to account for adjustment factors for Tailored display lighting height adjustment and for small aperture color changing lighting.

Document NRCC-LTI-03 "Indoor Lighting Power Allowance" will need to be revised to include additional criteria for additional lighting power allowances in C-3 Area Category Method Additional Lighting Wattage Allowance (from Table 140.6-C ~~Footnotes~~ Additional Lighting Power Columns)

Document NRCC-LTI-05 "Line-Voltage Track Lighting Worksheet" will need to be revised to include new instructions and wattages. Document NRCC-LTI-01 "Indoor Lighting" will need to be modified to account for track lighting in the total installed lighting wattage.

The Installation Certificate NRCI-LTI-03-E "Track Lighting Integral Current Limiter or Supplementary Overcurrent Protection Panel," should be eliminated to match the elimination of Nonresidential Appendix NA7.7.3 Track Lighting Integral Current Limiter.

The Installation Certificate NRCI-LTI-01 "Indoor Lighting" can be modified to provide more clarity on the total installed wattage, where to find it on the plans, and how to sum up the different methods of calculating adjusted indoor lighting power.

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Appendix A: STATEWIDE SAVINGS METHODOLOGY

The projected nonresidential new construction forecast that will be impacted by the proposed code change in 2020 is presented in Table 21. The projected nonresidential existing statewide building stock that will be impacted by the proposed code change as a result of additions and alterations in 2020 is presented in Table 22.

To calculate first-year statewide savings, the Statewide CASE Team multiplied the per-unit savings by statewide new construction estimates for the first year the standards will be in effect (2020). The Energy Commission Demand Analysis Office provided the Statewide CASE Team with the nonresidential new construction forecast. The raw data presented annual total building stock and new construction estimates for twelve building types by forecast climate zones (FCZ).

The Statewide CASE Team completed the following steps to refine the data and develop estimates of statewide floor space that will be impacted by the proposed code changes:

1. Translated data from FCZ data into building standards climate zones (BSCZ). This was completed using the FCZ to BSCZ conversion factors provided by the Energy Commission (see). Translated data from FCZ data into building standards climate zones (BSCZ). Since Title 24, Part 6 uses BSCZ, the Statewide CASE Team converted the construction forecast from FCZ to BSCZ using conversion factors supplied by the Energy Commission. The conversion factors, which are presented in Table 23 represent the percentage of building square footage in FCZ that is also in BSCZ. For example, looking at the first column of conversion factors in Table 23, 22.5 percent of the building square footage in FCZ 1 is also in BSCZ 1 and 0.1 percent of building square footage in FCZ 4 is in BSCZ 1. To convert from FCZ to BSCZ, the total forecasted construction for a specific building type in each FCZ was multiplied by the conversion factors for BSCZ 1, then all square footage from all FCZs that are found to be in BSCZ 1 are summed to arrive at the total construction for that building type in BSCZ 1. This process was repeated for every climate zone and every building type. See Table 25 for an example calculation to convert from FCZ to BSCZ. In this example, construction BSCZ 1 is made up of building floorspace from FCZs 1, 4, and 14.
2. Made assumptions about the percentage of nonresidential new construction in 2020 that will be impacted by the proposed code change by building type and climate zone. The Statewide CASE Team's assumptions are presented in Table 26 and Table 27 and discussed further below.
3. Made assumptions about the percentage of the total nonresidential building stock in 2020 that will be impacted by the proposed code change (additions and alterations) by building type and climate zone. The Statewide CASE Team's assumptions are presented in Table 26 and Table 27 and discussed further below.
4. Calculated nonresidential floor space that will be impacted by the proposed code change in 2020 by building type and climate zone for both new construction and alterations. Results are presented in Table 21 and Table 22.

Table 21: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2020, by Climate Zone and Building Type (Million Square Feet)

Climate Zone	New Construction in 2020 (Million Square Feet)												
	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel	Miscellaneous	Large Office	TOTAL
1	0.0494	0.0163	0.0853	0.0287	0.0368	0.0024	0.0656	0.0280	0.0307	0.0252	0.1115	0.0546	**0.5344**
2	0.2094	0.0921	0.7071	0.1856	0.4734	0.0379	0.3277	0.1629	0.2106	0.2354	0.8961	0.8296	**4.3678**
3	0.6925	0.3910	3.1839	0.7394	2.8795	0.1861	1.2192	0.7361	0.8441	1.3410	4.2876	5.5830	**22.0835**
4	0.4642	0.2089	1.6923	0.4394	1.0709	0.0942	0.7371	0.3647	0.5034	0.5232	2.0944	1.8543	**10.0470**
5	0.0901	0.0406	0.3286	0.0853	0.2079	0.0183	0.1431	0.0708	0.0977	0.1016	0.4066	0.3600	**1.9508**
6	0.6562	0.4806	2.7570	0.6896	2.2619	0.0986	0.8324	0.4764	0.5260	0.6422	2.6255	3.6351	**15.6814**
7	0.8790	0.2643	1.7010	0.5230	0.9519	0.0093	0.8959	0.3922	0.5561	0.5616	1.7181	1.8328	**10.2854**
8	0.9103	0.6887	3.9674	0.9869	3.2044	0.1363	1.2113	0.6661	0.7993	0.9200	3.8447	5.3065	**22.6420**
9	0.8937	0.7622	4.1915	1.0172	3.4313	0.1143	1.2286	0.7831	1.1364	1.0587	4.4500	7.1600	**26.2269**
10	0.9833	0.6400	3.0564	0.8578	2.6193	0.0595	1.6484	0.5499	0.6499	0.5891	3.3939	1.7311	**16.7786**
11	0.2830	0.0875	0.6543	0.2231	0.6491	0.0768	0.4366	0.1406	0.2110	0.1448	0.7554	0.3341	**3.9962**
12	1.5316	0.4403	3.5976	0.9482	3.0782	0.2282	1.7985	0.6916	1.0131	0.9038	3.9658	3.6878	**21.8846**
13	0.6028	0.1986	1.4244	0.4797	1.2207	0.1958	0.9484	0.2751	0.4488	0.3201	1.7269	0.6287	**8.4700**
14	0.1598	0.1219	0.6017	0.1621	0.5098	0.0187	0.2989	0.0969	0.1279	0.1102	0.6806	0.4322	**3.3207**
15	0.2172	0.0853	0.5340	0.1817	0.5765	0.0167	0.3049	0.0737	0.0905	0.1339	0.5966	0.2185	**3.0295**
16	0.2220	0.1358	0.7642	0.2060	0.5350	0.0332	0.3240	0.1666	0.1893	0.1510	0.9377	0.9963	**4.6611**
TOTAL	**8.8443**	**4.6542**	**29.2467**	**7.7536**	**23.7066**	**1.3263**	**12.4207**	**5.6748**	**7.4348**	**7.7617**	**32.4914**	**34.6448**	**175.9598**

Table 22: Estimated Existing Nonresidential Floor Space Impacted by Proposed Code Change in 2020 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Climate Zone	Alterations in 2020 (Million Square Feet)												
	Small Office	**Restaurant**	**Retail**	**Food**	**Non-Refrigerated Warehouse**	**Refrigerated Warehouse**	**School**	**College**	**Hospital**	**Hotel**	**Miscellaneous**	**Large Office**	**TOTAL**
1	0.1471	0.0475	0.2577	0.0874	0.1283	0.0073	0.1902	0.0981	0.1119	0.0902	0.3107	0.1532	**1.6296**
2	0.6551	0.2442	1.9541	0.5166	1.3669	0.1081	1.0646	0.5800	0.7262	0.6878	2.4262	2.2715	**12.6014**
3	2.0934	0.9847	8.1846	1.9039	7.1501	0.4943	4.1610	2.4477	2.8807	3.2837	10.8984	13.7501	**58.2327**
4	1.4864	0.5487	4.7111	1.2252	3.2142	0.2729	2.4328	1.3312	1.7208	1.5808	5.7553	5.2988	**29.5781**
5	0.2886	0.1065	0.9147	0.2379	0.6241	0.0530	0.4724	0.2585	0.3341	0.3069	1.1175	1.0288	**5.7430**
6	2.0920	1.3923	8.2196	2.0578	7.6495	0.3102	3.6382	2.0389	2.1685	2.2835	9.5940	10.0748	**51.5193**
7	2.5404	0.7374	5.1268	1.5550	3.4287	0.0315	2.4626	1.3414	1.8381	2.1824	5.1626	5.6371	**32.0440**
8	2.8855	1.9848	11.7115	2.9199	10.7365	0.4281	5.1045	2.7994	3.1900	3.2311	13.8259	14.5972	**73.4144**
9	2.6479	2.1239	11.4846	2.8097	10.3170	0.3507	4.6013	3.0294	3.9106	3.2276	13.2542	17.8912	**75.6480**
10	3.0563	1.9712	9.6954	2.6919	10.3684	0.1987	4.6292	1.9062	2.2675	2.2077	10.9100	5.2016	**55.1041**
11	0.8060	0.2335	1.7677	0.6039	1.9178	0.2230	1.1901	0.4882	0.7102	0.3968	1.9943	0.8518	**11.1833**
12	4.1402	1.1836	9.8761	2.6078	8.8320	0.6819	5.1107	2.3287	3.4676	2.5740	10.4168	9.7204	**60.9400**
13	1.7153	0.5161	3.7249	1.2534	3.1859	0.5435	2.6320	0.9747	1.4680	0.8125	4.4551	1.4942	**22.7757**
14	0.4987	0.3691	1.8405	0.4943	1.9145	0.0580	0.8624	0.3375	0.4464	0.3832	2.1845	1.1972	**10.5861**
15	0.6470	0.2521	1.5392	0.5116	1.8970	0.0495	0.7499	0.2204	0.3057	0.3856	1.6352	0.5870	**8.7804**
16	0.6559	0.3819	2.2184	0.5964	1.7429	0.0967	0.9457	0.5797	0.6577	0.4706	2.7056	2.4926	**13.5441**
TOTAL	**26.3558**	**13.0776**	**83.2270**	**22.0728**	**74.4740**	**3.9074**	**40.2476**	**20.7599**	**26.2039**	**24.1045**	**96.6463**	**92.2475**	**523.3243**

Table 23: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ)

		Building Standards Climate Zone (BSCZ)																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Forecast Climate Zone (FCZ)	**1**	22.5%	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	33.1%	0.2%	0.0%	0.0%	13.8%	**100%**
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.0%	75.7%	0.0%	0.0%	0.0%	2.3%	**100%**
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.9%	22.8%	54.5%	0.0%	0.0%	1.8%	**100%**
	4	0.1%	13.7%	8.4%	46.0%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	**100%**
	5	0.0%	4.2%	89.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	0.0%	**100%**
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	**100%**
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	75.8%	7.1%	0.0%	17.1%	**100%**
	8	0.0%	0.0%	0.0%	0.0%	0.0%	40.1%	0.0%	50.8%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	**100%**
	9	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	0.0%	26.9%	54.8%	0.0%	0.0%	0.0%	0.0%	6.1%	0.0%	5.8%	**100%**
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.9%	0.0%	0.0%	0.0%	12.3%	7.9%	4.9%	**100%**
	11	0.0%	0.0%	0.0%	0.0%	0.0%	27.0%	0.0%	30.6%	42.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100%**
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	4.2%	95.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	**100%**
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	69.6%	0.0%	0.0%	28.8%	0.0%	0.0%	0.0%	1.6%	0.1%	0.0%	**100%**
	14	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	**100%**
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	**100%**
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100%**

Table 24: Description of Building Types and Sub-types (Prototypes) in Statewide Construction Forecast

Energy Commission Building Type ID	Energy Commission Description	Prototype Description			
		Prototype ID	Floor Area (ft^2)	Stories	Notes
OFF-SMALL	Offices less than 30,000 square feet	Small Office	5,502	1	Five zone office model with unconditioned attic and pitched roof.
REST	Any facility that serves food	Small Restaurant	2,501	1	Similar to a fast food joint with a small kitchen and dining areas.
RETAIL	Retail stores and shopping centers	Stand-Alone Retail	24,563	1	Stand-alone store similar to Walgreens or Banana Republic.
		Large Retail	240,000	1	Big box retail building, similar to a Target or Best Buy store.
		Strip Mall	9,375	1	Four-unit strip mall retail building. West end unit is twice as large as other three.
		Mixed-Use Retail	9,375	1	Four-unit retail representing the ground floor units in a mixed use building. Same as the strip mall with adiabatic ceilings.
FOOD	Any service facility that sells food and or liquor	N/A	N/A	N/A	N/A
NWHSE	Non-refrigerated warehouses	Warehouse	49,495	1	High ceiling warehouse space with small office area.
RWHSE	Refrigerated warehouses	N/A	N/A	N/A	N/A
SCHOOL	Schools K-12, not including colleges	Small School	24,413	1	Similar to an elementary school with classrooms, support spaces and small dining area.
		Large School	210,886	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
COLLEGE	Colleges, universities, community colleges	Small Office	5,502	1	Five zone office model with unconditioned attic and pitched roof.
		Medium Office	53,628	3	Five zones per floor office building with plenums on each floor.
		Medium Office/Lab		3	Five zones per floor building with a combination of office and lab spaces.
		Public Assembly		2	TBD
		Large School	210,886	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
		High Rise Apartment	93,632	10	75 residential units along with common spaces and a penthouse. Multipliers are used to represent typical floors.
HOSP	Hospitals and other health-related facilities	N/A	N/A	N/A	N/A
HOTEL	Hotels and motels	Hotel	42,554	4	Hotel building with common spaces and 77 guest rooms.
MISC	All other space types that do not fit another category	N/A	N/A	N/A	N/A
OFF-LRG	Offices larger than 30,000 square feet	Medium Office	53,628	3	Five zones per floor office building with plenums on each floor.
		Large Office	498,589	12	Five zones per floor office building with plenums on each floor. Middle floors represented using multipliers.

Table 25: Converting from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ) – Example Calculation

Climate Zone	**Total Statewide Small Office Square Footage in 2020 by FCZ** (Million Square Feet) **[A]**	**Conversion Factor FCZ to BSCZ 1 [B]**	**Small Office Square Footage in BSCZ 1** (Million Square Feet) **[C] = A x B**
1	0.204	22.5%	0.046
2	0.379	0.0%	0.000
3	0.857	0.0%	0.000
4	1.009	0.1%	0.001
5	0.682	0.0%	0.000
6	0.707	0.0%	0.000
7	0.179	0.0%	0.000
8	1.276	0.0%	0.000
9	0.421	0.0%	0.000
10	0.827	0.0%	0.000
11	0.437	0.0%	0.000
12	0.347	0.0%	0.000
13	1.264	0.0%	0.000
14	0.070	2.9%	0.002
15	0.151	0.0%	0.000
16	0.035	0.0%	0.000
Total	**8.844**		**0.049**

Table 26: Percent of Floor Space Impacted by Proposed Measure, by Building Type

Building Type *Building sub-type*	Composition of Building Type by Sub-types[a]	Percent of Square Footage Impacted[b]	
		New Construction	Existing Building Stock (Alterations)[c]
Small Office		100%	7%
Restaurant		100%	7%
Retail		100%	7%
Stand-Alone Retail	*10%*	*100%*	*7%*
Large Retail	*75%*	*100%*	*7%*
Strip Mall	*5%*	*100%*	*7%*
Mixed-Use Retail	*10%*	*100%*	*7%*
Food		100%	7%
Non-Refrigerated Warehouse		100%	7%
Refrigerated Warehouse		100%	7%
Schools		100%	7%
Small School	*60%*	*100%*	*7%*
Large School	*40%*	*100%*	*7%*
College		100%	7%
Small Office	*5%*	*100%*	*7%*
Medium Office	*15%*	*100%*	*7%*
Medium Office/Lab	*20%*	*100%*	*7%*
Public Assembly	*5%*	*100%*	*7%*
Large School	*30%*	*100%*	*7%*
High Rise Apartment	*25%*	*100%*	*7%*
Hospital		100%	7%
Hotel/Motel		100%	7%
Large Offices		100%	7%
Medium Office	*50%*	*100%*	7%
Large Office	*50%*	*100%*	7%
Miscellaneous		100%	7%

a. Presents the assumed composition of the main building type category by the building sub-types. All 2019 CASE Reports assumed the same percentages of building sub-types.

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

c. Percent of existing floor space that will be altered during the first year the 2019 Standards are in effect.

Table 27: Percent of Floor Space 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 floor space that will be altered during the first year the 2019 Standards are in effect.

Appendix B: Discussion of Impacts of Compliance Process on Market Actors

This section discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. The Statewide CASE Team asked stakeholders for feedback on how the measure will impact various market actors during public stakeholder meetings that were held on September 8, 2016, and March 22, 2017 (Statewide CASE Team 2016). The Statewide CASE Team also held several meetings with NEMA members and conducted an online survey. The key results from feedback received during stakeholder meetings and other target outreach efforts are detailed below.

Table 28 identifies the market actors who will play a role in complying with the proposed change, the tasks for which they will 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.

Table 28: Roles of Market Actors in The Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Lighting designer	• Identify relevant requirements and/ or compliance path and ensure their design complies with and meets building owner's needs. • Perform required calculations by space to confirm compliance. • Coordinate design with other team members (HVAC & modeler). • Complete compliance document for permit application. • Review submittals during construction. • Coordinate with commissioning agent/Acceptance Test Technician (ATT) as necessary.	• Quickly and easily determine requirements based on scope. • Demonstrate compliance with calculations required for other design tasks. • Streamlined coordination with other team members. • Clearly communicate system requirements to constructors. • Quickly complete compliance documents. • Easily identify noncompliant substitutions. • Coordinate with manufacturers/dealers to know which products are available and meet compliance. • Coordinate with building owner to determine what their needs/wants are early in design phase. • Interaction with contractors is around submittal reviews, so not much coordination (RFI or submittal reviews). Subcontractors sends specs through submittal process to designer to ensure compliance with codes. Lighting designer is supposed to catch if lights don't meet code. • Coordinate with the building department for a plan check	• Will need to learn new, more stringent LPDs. • Will need to apply new track lighting wattages (with and without current limiters).	• Revise compliance document to automate compliance calculations. • Existing conditions could be documented via as-builts or photographs. Some market actors are supportive of ATT verification. • Modeling software will 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 aren't. • Documents showing exactly what their role in Title 24 compliance is/how to complete compliance tasks. • Documents explaining who

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
		by the plans examiner.		they can speak with for help on code compliance.
Contractor/Builder	• Follow the lighting design and specifications provided by the lighting designer. • They should only need to follow the design, but it's helpful for them to understand the code in case they need to make substitutions in products. • Complete installation compliance documents.	• They are responsible for following what's in the design – if they don't, the system can end up not being in compliance. • Coordinate with lighting designer in case issues with installation arise. • They purchase/install products specified by design. It's helpful for them to know what products meet compliance in case they need to substitute products.	• Will need to learn new, more stringent LPDs. • Will need to know revised current limiter requirements – no longer need to use Energy Commission certified current limiters.	• Clear documentation of Title 24, Part 6 compliant products. • Clear documentation illustrating difference between old standard 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 aren't.
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. • Complete design and/or installation compliance documents.	• 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's in the design – if they don't, the system can end up not being in compliance. They would complete installation compliance documents. • Coordinate with lighting designer in case issues with installation arise.	• If designing a system, will need to learn new, more stringent LPDs. • Will need to know revised current limiter requirements – no longer need to use Energy Commission certified current limiters.	• 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 aren't.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
		• Purchase/install products specified by design that are compliant.		
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 provide assistance in code interpretation.	• Will need to know the new, more stringent LPDs. • Will need to know new current limiter requirements.	• Document explaining Title 24 process and where documents go/who needs to sign what. • Modeling software will 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 aren't. • Documents explaining who they can speak with for help on code compliance.
Building Owners	• Coordinate with designers/contractors and fill out appropriate paperwork. They must also ensure	• Need to ensure paperwork is sent to proper places and their system is up to code. • Coordinate with contractors,	• Will need to know new standards.	• Clear documentation of code requirements. • Clear documentation of everything that needs to be

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
	proper compliance paperwork is filled out/signed/submitted to appropriate entities.	designers, and compliance enforcement agencies.		completed for code requirements. • Clear documentation of what compliance paperwork goes where, and the steps of the process. • Documents explaining who they can speak with for help on code compliance.
Plan Checker	• 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. • Quickly and easily provide correction comments that will resolve issues. • Coordinate with building owners/designers/inspectors.	• Will need to verify calculations are compliant with new standards. • Will need to verify existing conditions baseline.	• Clear code language that's 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 documents could auto-verify data is compliant with standards. • Existing conditions documented via as-builts or photos or ATT. Do not require additional field visit by Authority Having Jurisdiction. • Provide documentation of compliance in a way easily compared to plans. • Examples of plans that are in compliance. • Examples of plans that aren't in compliance and

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
				reasons why they aren't.
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 will resolve issue. • Coordinate with building owners/designers/plan checkers.	• Will need to verify installations are compliant with new standards. • Will need to know easier compliance requirements for current limiters and LED screw-base lamps.	• 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, 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 C: MARKET SURVEY SUMMARY

Interviews and Field Surveys

Results of interviews and surveys indicated that there is substantial voluntary penetration of LED products in the market. Interviews conducted with manufacturers of commercial lighting equipment revealed that sales of LED luminaires dominate the market. Furthermore, observation through site surveys of existing, remodeled, and new construction spaces provided visual evidence of substantial voluntary use of LED product.

Manufacturer Interviews

Interviews with manufacturers included collecting data from manufacturers that produce products for a wide range of the commercial market as well as manufacturers who focus on retail and hospitality market segments. Five wide-range commercial market luminaire manufacturers and four retail and hospitality-focused manufacturers were interviewed. Manufacturers were asked the following with reference to production and sales of LED products:

1. What percentage of your total manufacturing and sale of commercial luminaires is LED product?
2. What is the role of legacy and incumbent luminaire manufacturing and sales within your company?
3. Please share any other thoughts/comments with reference to LED lighting in the market place.

The interviews yielded the following results:

1. What percentage of your total manufacturing and sale of commercial luminaires is LED product?
    a. General commercial lighting manufacturers reported that LEDs represent 64 percent to 74 percent of manufacturing and sales. Figure 1 shows the percentage of LED manufacturing and sales against total manufacturing and sales for each of the five general commercial lighting manufacturers.
    b. Manufacturers that focus on hospitality and retail lighting applications reported that their LEDs represent 80 percent to 99 percent of manufacturing and sales. Figure 2 shows the percentage of LED manufacturing and sales against the total manufacturing and sales for each of the four manufacturers that focus on hospitality and retail lighting.
2. What is the role of legacy and incumbent luminaire manufacturing and sales within your company?
    a. Many of the manufacturers reported that most legacy and incumbent lighting sales are for replacement of failed products, additional legacy/incumbent luminaires for existing spaces with maintenance needs, or minor (non-permitted) retrofits.
    b. Manufacturers also reported that legacy and incumbent lighting sales are typically more prevalent in areas outside of California. Several manufacturers indicated that California sales of LEDs are well above LED sales in other areas of the country.
3. Please share any other thoughts/comments with reference to LED lighting in the marketplace.
    a. One manufacturer indicated that its fluorescent products now have a surcharge versus the LED counterpart.
    b. Two of the four hospitality/retail-focused manufacturers indicated they are in the process of discontinuing, or have already discontinued, non-LED products.

c. All manufacturers indicated that they anticipate additional improvements in LED performance as well as a greater variety of products, including dim-to-warm and color-tuning LEDs.

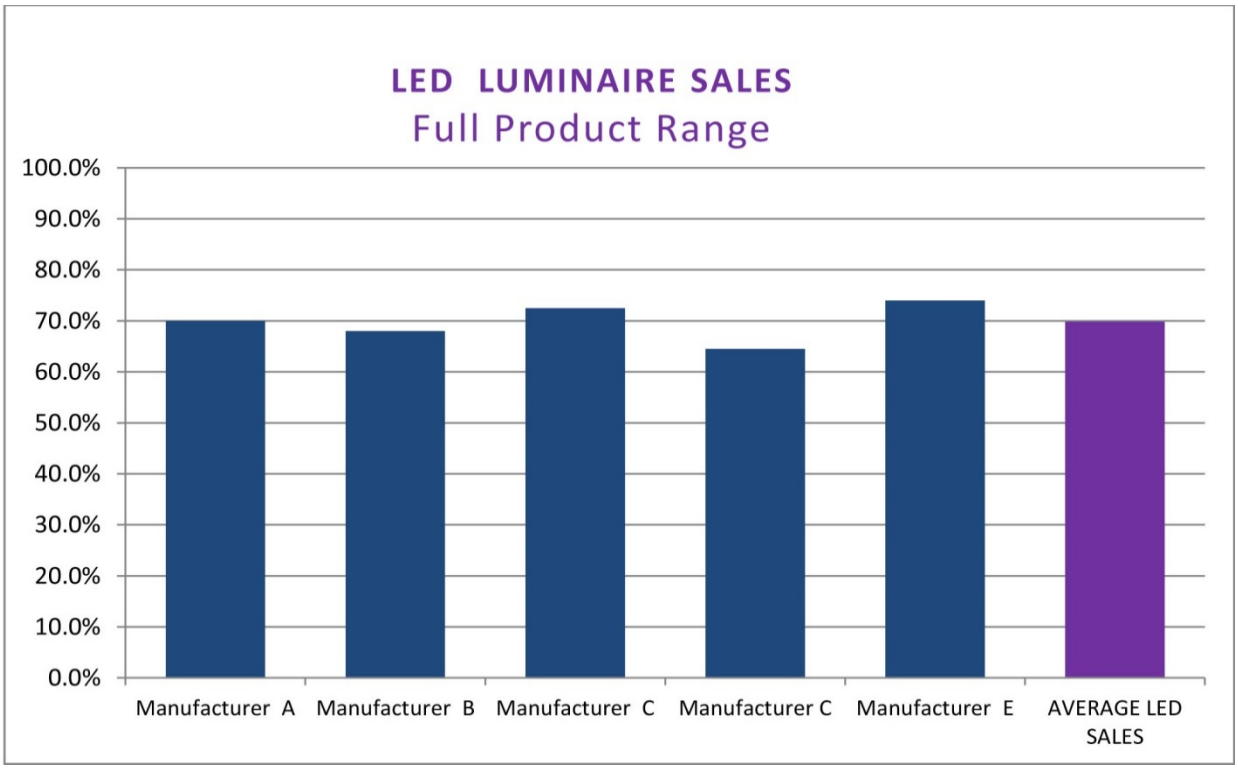

Figure 1: Percentage of LED luminaire manufacturing and sales for five manufacturers of general commercial lighting equipment.

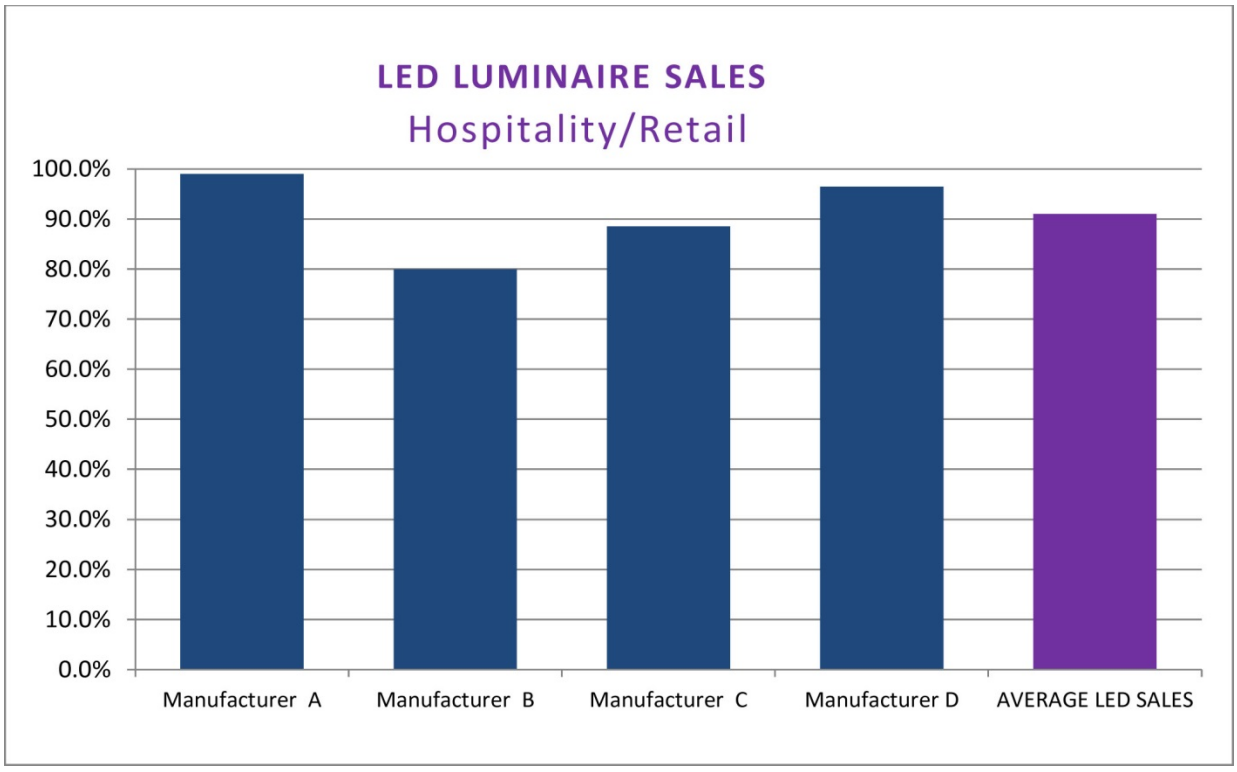

Figure 2: Percentage of LED luminaire manufacturing and sales for four manufacturers that focus on hospitality and retail commercial lighting equipment.

Field (Site) Surveys

The Statewide CASE Team conducted informal field surveys between January 2016 and April 2017. These surveys consisted of observing various spaces and documenting the percentage of lighting that employed LED luminaires and/or lamps versus legacy luminaires. The Statewide CASE Team observed retail stores, hospitality (hotels and restaurants), two international airports, and several banks and museums.

Retail and hospitality observations included approximately 250 stores, 45 restaurants, and 15 hotels at random locations throughout California and other states. The following outlines the retail and hospitality observations:

1. Nearly 70 percent of re-lamp or minor retrofit applications (typically non-permitted) has LED products installed.
2. Over 98 percent of new construction and major remodels (permitted) has LED products installed.
3. Overall, the Statewide CASE Team observed that retail stores are the largest adopters of LED products. However, hotels and restaurants are also employing significant quantities of LED products, especially when applied to new construction and major remodels.

Figure 3 shows the average percentage of LED products versus all observed lighting within hospitality and retail spaces visited between January 2016 and April 2017. Results are shown for spaces that appeared to have had re-lamping or minor retrofits, as well as new construction and major remodeled spaces.

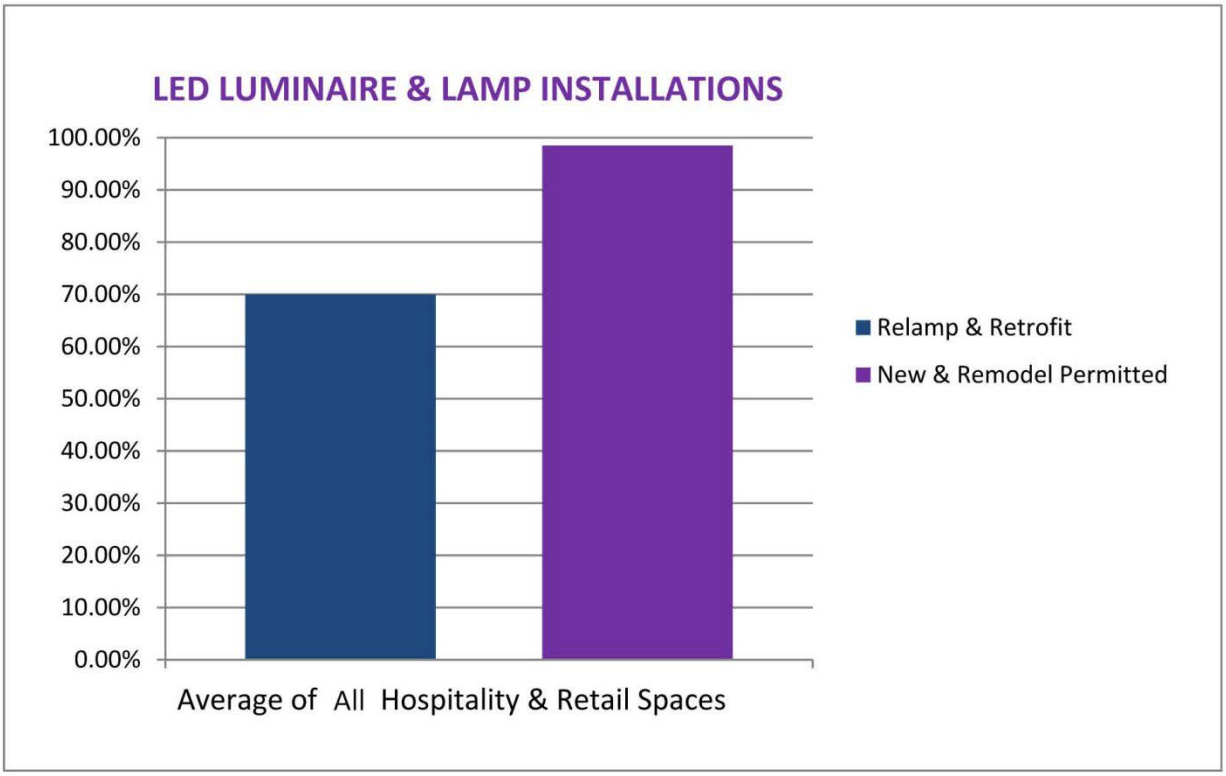

Figure 3: Percentage of LED luminaires and lamps observed within retail and hospitality venues.

Site visits were conducted at four airline terminals and surrounding sites (parking lots, roadways, and common spaces) at two major international airports. Spaces observed at an airport located in the New York Metro area were mostly existing spaces that received re-lamping or retrofits. Spaces observed at an airport located in the Los Angles Metro area were undergoing major renovations, including new construction and major remodels. Within each of the four terminals, airline support zones such as ticketing, lounges, waiting areas, and baggage claim were observed. Airport terminal concourse spaces, which included the concourse mall, retail shops, and restaurants, were also observed. Following are the results:

1. The New York Metro area airport consisted of existing spaces that only received re-lamping or retrofits and exhibited close to 60 percent use of LED luminaires and lamps.
2. The Los Angeles Metro area airport, which was undergoing a major renovation, exhibited slightly more than a 90 percent use of LED luminaires and lamps.

Figure 4 depicts the average percentage of LED luminaires and lamps versus all lighting observed within the four terminals (two at the New York Metro area airport and two at the Los Angeles Metro area airport). Please note that a large portion of new construction and remodel spaces at the Los Angeles Metro area airport were permitted under 2013 Title 24, Part 6. Only the most recent projects were permitted under the newer 2016 Title 24, Part 6.

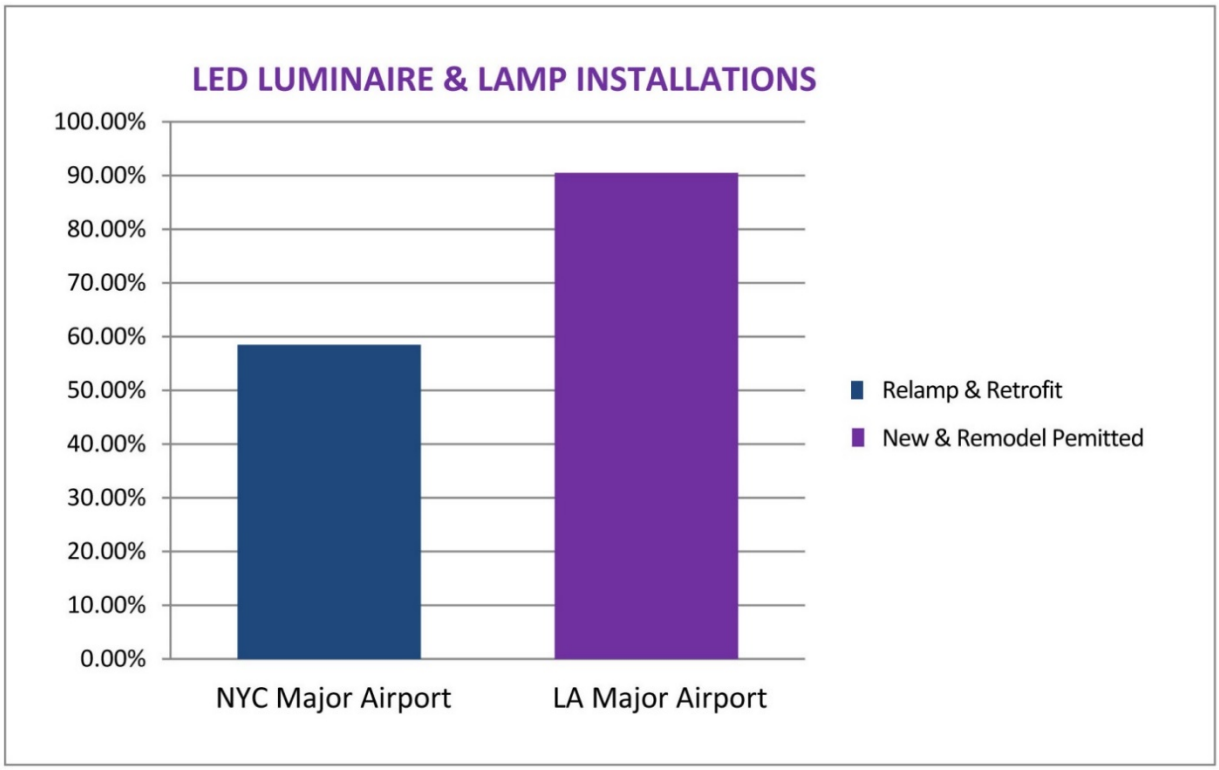

Figure 4: Percentage of LED luminaires and lamps observed at two major metropolitan airports.

Interviews of Market Participants

To establish rationale for an ASHRAE/IES 189.1-2017 and 2019 Title 24, Part 6 proposal based on 100 percent LED lighting, interviews were conducted with market participants. These participants included lighting designers, engineers, contractors, and manufacturers (lighting manufacturers' representative agencies and end users). Interviews were conducted via phone as well as in person. The in-person interviews took place at trade shows and conferences. Interviews spanned a period from October 2015 through February 2017. Trade shows and conferences where interviews took place were:

- LightShow West 2015 – Los Angeles, CA, October 21–22 2015
- LED Specifier Conference – Chicago, IL, November 17, 2015
- ASHRAE Winter Conference – Orlando, FL, January 23–27, 2016
- IES LA Product Fair – Los Angeles, CA, February 23, 2016
- LightFair 2016 – San Diego, CA, April 26–28, 2016
- ASHRAE January Conference – Las Vegas, CA, January 28– February 1, 2017
- IES LA Product Fair – Los Angeles, CA, February 16, 2017

Interview participants were asked about the use of LED products versus incumbent products relative to a variety of lighting applications. Questions included:

- What percentage of lighting sales and/or specifications are LED luminaires?
- What are the barriers for using LED luminaires?
- Are there applications or luminaire functions where/when LED is not technically or performance-base appropriate?

Results of these interviews indicated that there is substantial penetration of LED products in the market. However, the extent of penetration varies significantly. Participants also indicated some issues with the high first cost of LED luminaires versus incumbent products. Also, a small number of participants expressed concern about whether LED products could provide alternatives for all applications and design scenarios.

Details of findings are as follows:

- Penetration of LED products in California is significantly higher than in the Midwest and Southeast. See Figure 5 for an illustration of the penetration of LED products in California versus areas outside of California.
- LED exterior products have reached over 90 percent penetration, due to the provision in the 2013 Title 24, Part 6 Standards that require exterior parking lot and site lighting to provide uniform multi-level (high-low) illumination.

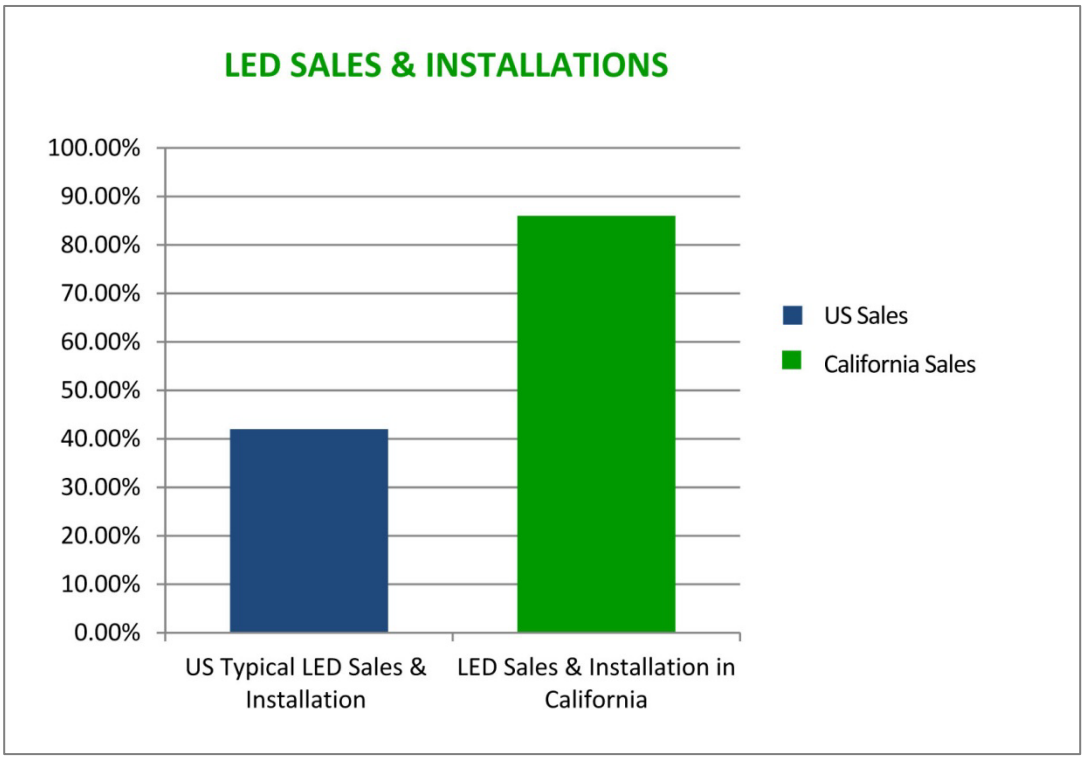

Figure 5: Penetration of LED products in California versus areas outside California.

Designer Surveys

Six professional lighting designer stakeholders were solicited for input to develop a more accurate wall washing component for Lumen Method models. The outreach was designed to identify:

- Issues complying with Title 24, Part 6
- What fraction of lighting designs are LED building type or luminaire type
- Which spaces are critical to use advanced tools – included in Designer Stakeholder Wall Wash survey
- Review of wall washing methodology and recommended "typical" luminaires – included in Designer Stakeholder Wall Wash survey

The lighting designer stakeholder team identified important application techniques and equipment selections. These recommendations were then applied to the wall washing scenarios selected for the AGi32 modeling and conversion to a wall washing factor when used in Lumen Method modeling.

In addition to wall washing input, the stakeholder team identified several spaces and applications where AGi32 modeling could provide more accurate and comprehensive lighting renditions and corresponding LPDs. These AGi32 models include:

- Retail, hospitality, and restaurant dining lighting applications (complexity of designs).
- NOTE: Retail, hospitality, and restaurant dining AGi32 models will be updated versions of legacy models from prior Title 24 case work.
- Office lighting (emphases on layered lighting – task/ambient – plug load lighting factor).
- Spaces with extremely high room cavity ratio (RCR) factors (e.g., warehouse/storage high stack, library stacks and corridors).

Figure 6 and Figure 7 present a copy of the distributed survey.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Wall Washing Questionnaire

Date: January 10, 2017

To: Lighting Design Processional - CA Title 24 2019 Stakeholders

From: Statewide Utility Codes and Standards Team

Subject: Improved Lumen Method Models for Wall Washing

1. Improved Lumen Method Models for Wall Washing

The 2019 Title 24, part 6 (California Energy Code) Non Residential Lighting Utility CASE (Codes and Standards Enhancement) Team welcomes stakeholder input and feedback on how to update the lighting power calculation procedure for wall-washing when using the lumen method.

1.1 Background

In developing lighting power density (LPD) updates for the 2019 California Energy Code, the Utility CASE team is leveraging the LPD calculation methodology used by the ASHRAE 90.1 lighting subcommittee to develop the ASHRAE 90.1 LPDs. This methodology uses the lumen method to calculate lighting power densities for general lighting, task lighting, ornamental lighting and wall wash lighting and combine these LPDs to generate the total LPD for the space. Some of these calculations are then adjusted based upon professional judgement.

The current calculation method is based on Watt per square foot factors that are a function of room cavity ratio (RCR) and design illuminance. We are looking at replicating this approach, for the majority of the modeling used to determine LPD targets, but modify assumptions as needed to align with CA Title 24 criteria and update the reference products used for developing these factors to typical LED luminaires including wall washing products.

With respect to the lumen method as it relates to wall washing, if one can calculate the watts per square foot of wall area needed to wall wash all the perimeter walls in a room to a given illuminance level, using the room cavity ratio one can convert this to an effective lighting power density (Watts per square foot of floor area) adder to account for wall washing all the walls in a given room. We are anticipating that the wall washing watts needed will be linearly proportional to wall illuminance levels and wall area with some adjustment needed for wall height.

1.2 Proposed Methodology

We are planning on developing several prototypical models using the AGI-32 radiosity lighting design software to simulate various wall washing designs at different illuminance levels. We will then create a matrix of Watts per square foot of wall area illuminated for different illumination levels and different wall heights. We will see if we can characterize or differentiate different luminaire types by commonly published data.

Figure 6: Copy of the Wall Wash Survey with details of the content (page 1 of 2).

The matrix of Watts per square foot of wall area will be converted to an effective W/sf of floor area as described in the section above.

Our thoughts for developing this new matrix are as follows:

1. Identify a series of wall-washing types that represent the range of wall-washing needs such as retail, corridor, grazing, feature wall (architectural) and others?
2. From the list of wall-washing needs and types develop accurate detailed AGI-32 models for these wall-wash applications.
3. Convert the actual wall-wash illuminance range into an average illuminance (foot-candles) for the vertical wall surface.
4. Based on the extent of wall washing used the formula will equal 100% when all walls have wall-washing. This is captured already in the fraction of floor area receiving a give illuminance. In this instance this term will reflect the fraction of perimeter wall area that has wall washing.

1.3 Questions

Specifically, we are interested in:

1. What wall-washing applications and applications should be modeled (using AGI-32) to create a meaningful set of wall-washing environments?
2. Is our approach sound? What are we missing? What should we add?
3. When used within the lumen method modeling wall-washed surfaces will be expressed in average illuminance. However when developing wall-wash applications should we define the lighting application as average illuminance, peak illuminance, a zone of illuminance or some other value?
4. What is the reasonable range of ratios of min to maximum illuminances? For defining the vertical task which height is the task of interest?
5. Any other thoughts or comments you may have that we have not expressed or may have overlooked.

1.4 Additional Stakeholder Input Relative to AGI-31 Modeling

Since use of AGI-32 detailed modeling will have time and funding restraints the team is limited to the number of AGI-32 models that can be developed for this project. Therefore, we are also soliciting stakeholder input on which space types are prime candidates for detailed AGI 32 modeling. As an example, Retail Space LPD's (under Tailored Compliance) has historically been developed with the use of AGI models. When submitting your recommendations for spaces that should be modeled using AGI-32 please provide us with the following:

1. Description of the space type and range (configuration and sizes typical within the space).
2. Any design and application techniques key to a successful lighting design for the space type.
3. Rationale for use of AGI-32 detailed modeling versus lumen method modeling of the space.

Thank you for your input and feedback.

Bernard V. Bauer, L.C.
Integrated Lighting Concepts
Design Lead

Title 24-2019 Non Residential Lighting Utility Case Team

Figure 7: Copy of the Wall Wash Survey with details of the content (page 2 of 2).

Stakeholder Survey

The Statewide CASE Team conducted a survey in 2017 to solicit feedback on the proposed code changes from a wide variety of stakeholders. The anonymized responses are shown in Figure 8 through Figure 13 and Table 29 through Table 35.

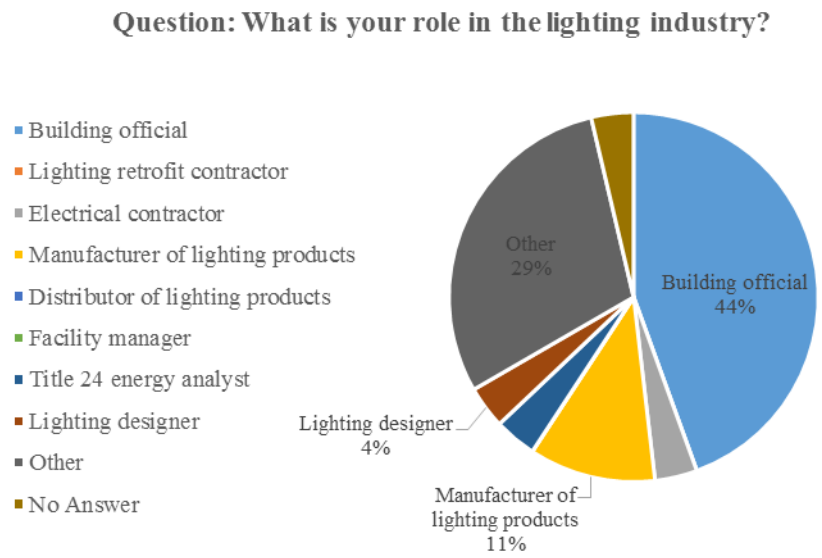

Figure 8: Stakeholder survey respondents' industry role.

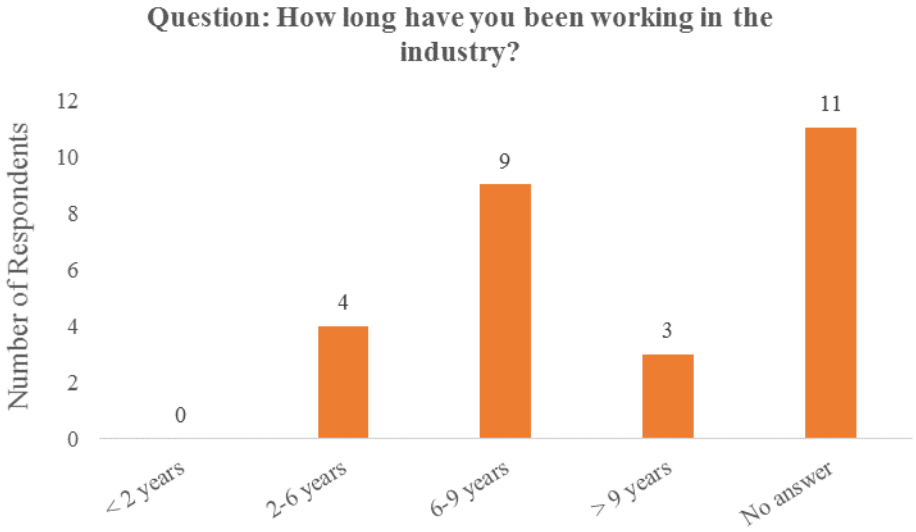

Figure 9: Stakeholder survey respondents' experience in lighting industry (as number of years).

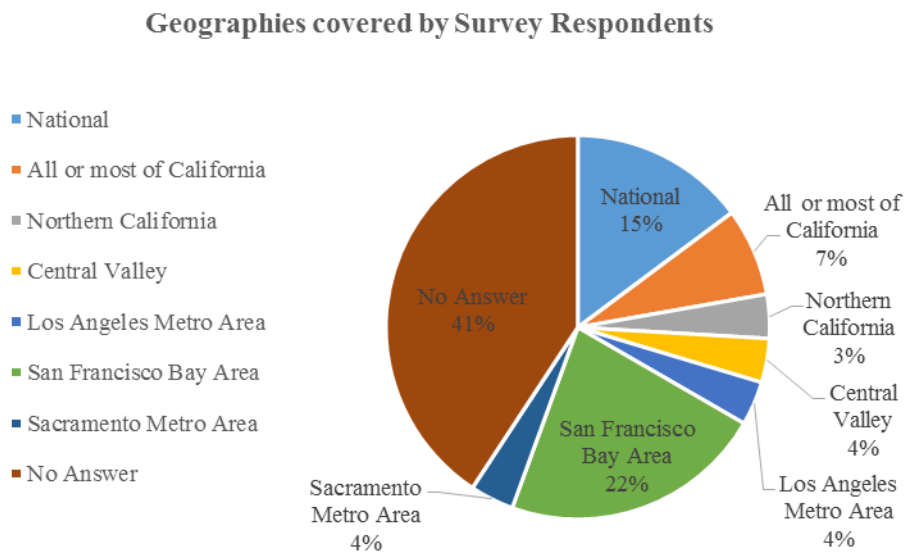

Figure 10: Stakeholder survey respondents' geography.

Table 29: Capability of LED Replacements

Question: How strongly do you agree or disagree with the following statement: "LED sources have the capability of replacing..."						
Answer Options	**Strongly agree**	**Somewhat agree**	**No opinion**	**Somewhat disagree**	**Strongly disagree**	**Response Count**
General lighting in nonresidential indoor applications?	6	2	0	0	0	8
Display lighting in nonresidential indoor applications?	5	1	2	0	0	8
Ornamental lighting in nonresidential indoor applications?	3	2	2	1	0	8
Other Comments: - The technology for dimmers surprisingly, still needs work. - LEDs are getting better when it comes to radiant versus spot lighting. - CRI options are not always readily available.						2
answered question						**8**
skipped question						**19**

Table 30: LED Amenity

Question: How strongly do you agree or disagree with the following statement: "LED sources provide the same amenity as...?"						
Answer Options	**Strongly agree**	**Somewhat agree**	**No opinion**	**Somewhat disagree**	**Strongly disagree**	**Response Count**
General lighting in nonresidential indoor applications?	5	3	0	0	0	8
Display lighting in nonresidential indoor applications?	6	1	1	0	0	8
Ornamental lighting in nonresidential indoor applications?	5	2	1	0	0	8
Other Comments: - LEDs have a wide color temperature, so this may make them a better alternative than incandescent or fluorescent. Ornamental lighting also has a different "texture" with LEDS. The bulbs themselves are not a pretty as incandescent, but the application is more flexible.						1
					answered question	**8**
					skipped question	**19**

Table 31: LED Trends

Question: How strongly do you agree or disagree with the following statements?						
Answer Options	**Strongly agree**	**Somewhat agree**	**No opinion**	**Somewhat disagree**	**Strongly disagree**	**Response Count**
Prices for LED products used in nonresidential indoor applications will decrease by 25% by 2020.	5	3	0	0	0	8
The efficacy of LED products used in nonresidential indoor applications will increase by 20% by 2020.	4	1	2	1	0	8
					answered question	**8**
					skipped question	**19**

Table 32: CCT Techniques in Fixtures

Question: How frequently are the following correlated color temperature (CCT) techniques used in nonresidential interior spaces (% of fixtures)?			
Answer Options	**Response Average**	**Response Standard Deviation**	**Response Count**
Dim to Warm Tuning	33%	42%	3
White Color Tuning	7%	12%	3
Full Color Tuning	5%	5%	3
		answered question	**3**
		skipped question	**24**

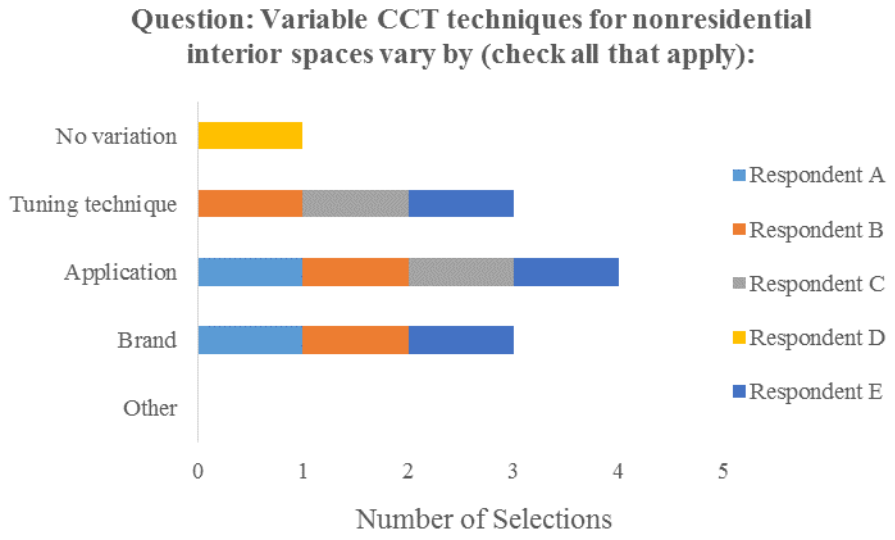

Figure 11: Variation of CCT techniques.

Table 33: Variable CCT Systems Compared to Non-Tunable Luminaires

Questions: How strongly do you agree or disagree with the following statements?						
Answer Options	**Strongly agree**	**Somewhat agree**	**No opinion**	**Somewhat disagree**	**Strongly disagree**	**Response Count**
Variable CCT systems are less efficient than non-tunable luminaires. Example: variable CCT system set at 3000K vs non-tunable 3000K luminaire.	2	0	4	0	0	6
Variable CCT systems are significantly more expensive than non-tunable luminaires and this prevents their widespread use.	1	2	3	0	0	6
					answered question	**6**
					skipped question	**21**

Table 34: Determining "Max" Power with IES LM79

Question: The industry standard IES LM79 specifies that variable CCT systems be tested at each setting. Is this sufficient for determining "max" power?	
Answer Options	**Response Count**
Yes	1
No	1
N/A	3
Other Comments: - nobody tests them… - Another burden on manufacturer making it more difficult to provide lighting quality. Variable color is a "gimmick", a "nice to have feature" that should not be forced in standards for general lighting. It will only dramatically increase the cost for building owners	2
answered question	**5**
skipped question	**22**

Table 35: Definition of Lighting Application for Wall Wash Applications

14. When used in lumen method modeling, wall-washed surfaces will be expressed in average illuminance. Please select from the following options how best to define the lighting application when developing wall-wash applications.	
Answer Options	**Response Count**
Average Illuminance	1
Peak Illuminance	0
Zone of Illuminance	2
N/A	0
Other (please specify)	0
answered question	**3**
skipped question	**24**

Table 36: Method for Addressing Wall Washing Applications

16. Which method do you use when addressing wall-washing applications?	
Answer Options	**Response Count**
Lumen method	1
AGi32 or similar modeling software	2
Other	0
answered question	**3**
skipped question	**24**

Table 37: Wattage Requirement for Track Lighting

Question: We are proposing to reduce the allowances for track lighting with and without current limiters in Title 24, Part 6. What should the wattage requirements be reduced to?	
Answer Options	**Response Count**
Track lighting with current limiter allowance (12.5 watts/linear foot) should be reduced to the following (X watts/linear foot)	2
Track lighting without current limiter allowance (45 watts/linear foot) should be reduced to the following (X watts/linear foot)	2
The current limiter allowances should not be reduced	0
Other Comments: - if you reduce the non limiter, limiters will be used	1
answered question	**2**
skipped question	**25**

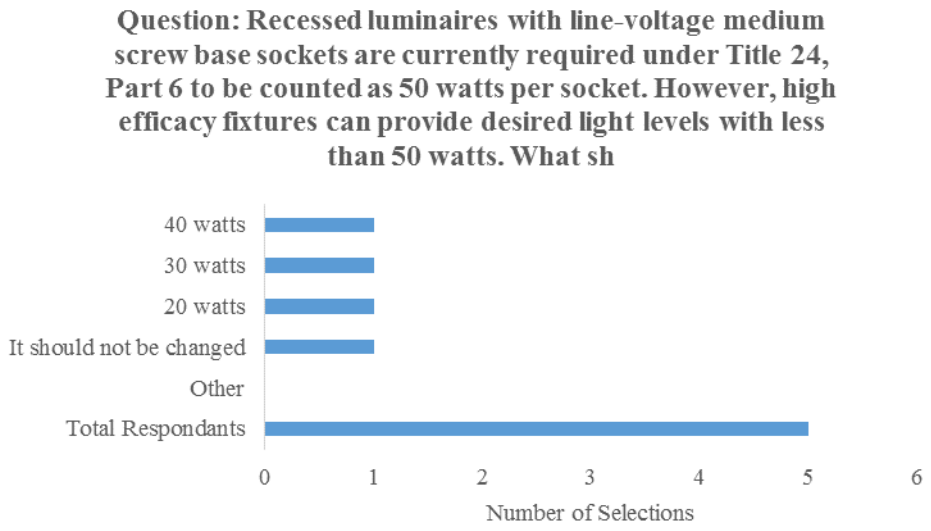

Figure 12: Wattage requirement for recessed luminaires with line-voltage medium screw-base sockets.

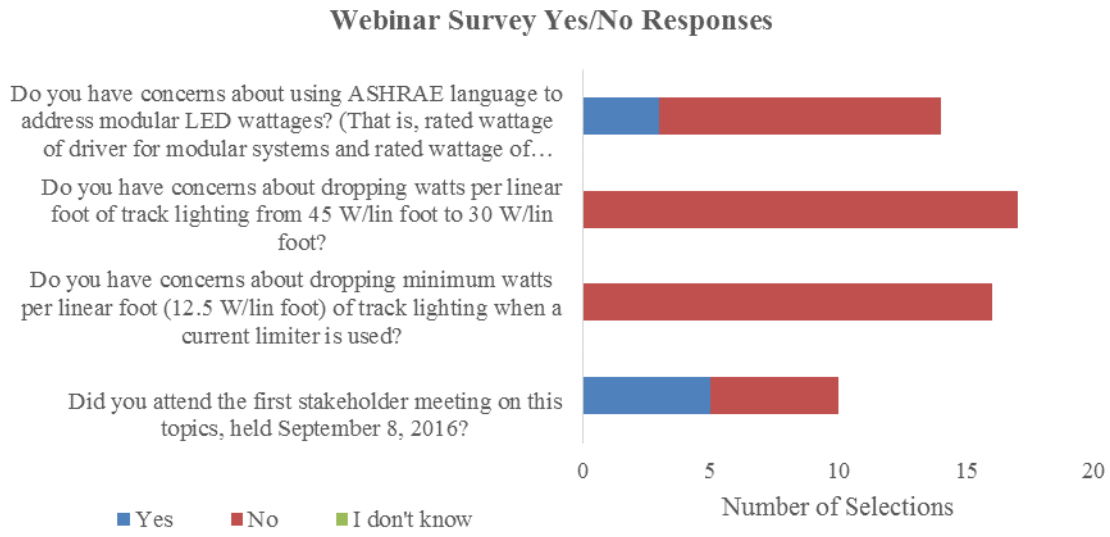

Figure 13: Yes/no survey responses regarding stakeholder concerns.

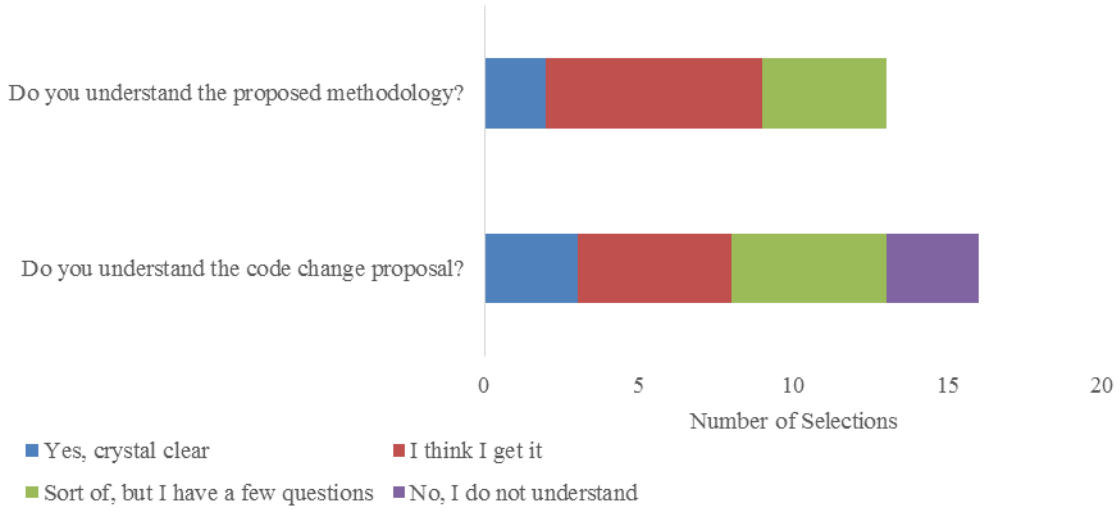

Figure 14: Stakeholder understanding of proposal and proposed methodology.

Table 38: Write-in Responses Clarifying Survey Selections

Webinar Survey Questions	Anonymous Responses
Do you understand the code change proposal?	*the table is great to clarify things. not totally clear on why two different exceptions for number of luminaires.*
	including non-retrofitted items in the reduction calculations (path 3) will cause people to abandon certain projects. it will increase expenses for doing surverys, and create a ton of paperwork for jurisdictions. not a good idea!
	I need to review it in detail
Do you understand the proposed methodology?	*I always have concerns about simulations vs. real world data. the past standards that relied too much on only simulations were very disconnected from the real world*
Do you have concerns about dropping minimum watts per linear foot (12.5 W/lin foot) of track lighting when a current limiter is used?	*That will help clear up issues in the field for what was used for compliance documents but then the VA rating of current limiter EXCEEDs the linear length*
	This is a great change, resolves the design issue of long linear runs
Do you have concerns about using ASHRAE language to address modular LED wattages? (That is, rated wattage of driver for modular systems and rated wattage of driver/lamp combination for hardwired linear systems.)	*this could penalize projects by requiring them to report much higher wattage than they are using in the space*
	should be set by the as-delivered output of the assembly, not the driver rating

Appendix D: CALCULATION BASIS OF INVERTED LUMEN METHOD SPREADSHEET CALCULATION

Basis of Inverted Lumen Method Spreadsheet Calculation

Most of the LPDs in ASHRAE 90.1-2016 were based on a variant of the Lumen Method calculation. The updates to LPDs proposed for the 2019 Title 24, Part 6 standards are mostly based on this same method as well. The results of these calculations were reviewed and adjusted based on the Statewide CASE Team's professional experience, and a subset of the areas were evaluated with more detailed simulations using radiosity-based lighting design software (AGi32).

The average maintained illuminance (luminous flux density), $\dot{E}_{maintained}$, (in units of foot-candles or lux in SI units) in a space is calculated by the following Lumen Method equation:[5]

$$\dot{E}_{maintained} = \frac{(no.luminaires)\left(\frac{lamps}{luminaire}\right)(lamp\ lumens)(CU)(LLF)}{workplane\ area}$$

Where,

CU = coefficient of utilization, or fraction of lumens from light sources that reaches the workplane directly or via interreflections. This is a function of luminance distribution of the luminaire, the geometry of the space (as described by the RCR), and the reflectance of the ceiling, walls, and floor of the space. CUs are commonly provided by luminaire manufacturers in a table format with respect to the RCR, for standard room surface reflectances. A number of software programs calculate CUs from a luminaire's luminance distribution.

LLF = the product of recoverable and non-recoverable light loss factors. Recoverable light loss factors are the product of lamp lumen depreciation, or reduced light source output due to aging; luminaire dirt depreciation, or reduced optical efficiency due to dirt buildup on the luminaire and its elements; and room surface dirt depreciation, or the decrease of reflected light in the space due to dirt reducing the reflectances of surfaces. Non-recoverable light loss factors are ballast factor, thermal factor, and equipment operating factor (such as lamp operating position).

For integral LED luminaires, this equation is slightly different because the light output of the LED is significantly impacted by its temperature which, in turn, is a function of the thermal performance of the luminaire in rejecting heat. As a result, the IES LM-79 test method for measuring the light output of solid state lighting products measures the light output of the entire luminaire. Therefore, the equation for integral LED luminaires can more accurately be described as follows:

$$\dot{E}_{maintained,LED} = \frac{(no.luminaires)(luminaire\ lumens)(CU)(LLF)}{workplane\ area}$$ [FC or Lumens/ft2]

Where luminaire lumens represent the lumens leaving the luminaire and accounts for both the thermal effects of a luminaire and its optical efficiency. As a result, the same luminaire tested with an integral LED will have a higher CU than one with fluorescent lamps. This is because the CU for LEDs represents the fraction of light leaving the luminaire (after luminaire optical losses) that then reaches the workplane, whereas the CU for the same fixture fitted with fluorescent lamps represents the light leaving the lamps that reaches the workplane.

[5] Illumination Engineering Society (IES).2011. The Lighting Handbook 10th edition. Equation 10.30.

The total maintained lumens (luminous flux) delivered to the space, $\Phi_{main,\ delivered}$, is found by multiplying the maintained illuminance, $\dot{E}_{maintained}$, by the areas of the work plane.

$$\Phi_{maint,delivered} = \dot{E}_{maintained} \times workplane\ area \text{[Lumens]}$$

$$\Phi_{maint,delivered\ LED} = (no.luminaires)(luminaire\ lumens)(CU)(LLF) \text{ [Lumens]}$$

The maintained delivered luminous efficacy, $K_{maint,delivered}$, of a given lighting system in a given space having a particular geometry (RCR) and surface reflectances is as follows:

$$K_{Maint,delivered} = \frac{\Phi_{maint,delivered}}{Total\ Input\ Watt} \text{ [Lumens/Watt]}$$

The ASHRAE 90.1-2016 committee developed a database of luminaires which includes:

- Luminaire lumens
- Input watts
- CUs for RCRs one through ten for surface reflectances that represent the types of spaces in which the luminaire would be used.

The committee also developed light loss factors from the constituent recoverable components for these luminaires:

- Lamp lumen depreciation
- Luminaire dirt depreciation
- Room surface dirt depreciation

From these components, maintained, delivered luminous efficacies, and $K_{maint,delivered}$ were calculated for RCRs of two, four, six, eight, and ten. This proposal added higher performance luminaires to this database, and modified the light loss factors to best represent the performance of the equipment over their expected life and expected maintenance schedule.

For a space having a design illuminance, E_{design}, with a given RCR, and being illuminated by a lighting system with a maintained delivered luminous efficacy, $K_{maint,delivered}$, the LPD for the space is:

$$LPD_{design}[W/ft^2] = \frac{E_{Design}\ [lm/ft^2]}{K_{Maint,delivere}[lm/W]} \times Space\ Fraction\ [no\ units]$$

Where the space fraction indicates what fraction of the space area is being illuminated to a given design illuminance (foot-candle) value.

A given space can have an area-weighted LPD where part of the space is illuminated by one lighting system type and other parts are illuminated by other system types with different efficacies.

For most spaces, this was used to develop the space-by-space method LPDs in ASHRAE 90.1. These models have been validated by the professional experience of designers on the committee with only a few models replaced by detailed Radiosity models where the Lumen Method breaks down (such as hallways and retail spaces).

For the whole building approach, the LPD values are area-weighted LPDs of the various spaces. The area weightings were developed from building surveys.

The original ASHRAE 90.1-2016 spreadsheet was over six megabytes and contained 55 tabs. There were separate tabs for each whole building LPD calculation, multiple tabs with the luminaire data, summaries of the luminaire data, and summaries of the summaries. The spreadsheet contained data from prior versions of the ASHRAE standards, the Advanced Energy Design Guidelines, etc. The Statewide CASE Team reduced the spreadsheet down to all the calculations used for the 2013 version of ASHRAE 90.1-2016 and placed all the luminaire data on one tab (including the summary averages of each

luminaire type). The new file is only 400 kilobytes and has five tabs as well as significantly easier to follow calculations (three tabs for the calculations, one tab memorializing the calculations used by the ASHRAE 90.1-2016 committee, and one tab for notes). The Statewide CASE Team compared both spreadsheets and obtained the same results with both before changing the luminaire selection to improved luminaires. The methodology has not changed as a result of simplifying the spreadsheets.

ASHRAE 90.1-2016 Wall Washing Calculation Method

The wall washing calculation in the ASHRAE 90.1-2016 spreadsheet was not documented. The LPD for wall washing was selected from the look-up table in Figure 15, and derated by the fraction of walls in the room that are illuminated by the wall washing system.

	Wallwash Component (w/ft^2)				
	RCR Category				
Illuminance Level (fc)	2	4	6	8	10
0	0	0	0	0	0
3	0.1083	0.1219	0.1775	0.1909	0.2879
4	0.1348	0.1554	0.2127	0.2354	0.3568
5	0.1613	0.1889	0.2479	0.2799	0.4257
6	0.1878	0.2224	0.2831	0.3244	0.4946
7	0.2143	0.2559	0.3183	0.3689	0.5635
8	0.2408	0.2894	0.3535	0.4134	0.6324
9	0.2673	0.3229	0.3887	0.4579	0.7013
10	0.2938	0.3564	0.4239	0.5024	0.7702
11	0.3203	0.3899	0.4591	0.5469	0.8391
12	0.3468	0.4234	0.4943	0.5914	0.908
13	0.3733	0.4569	0.5295	0.6359	0.9769
14	0.3998	0.4904	0.5647	0.6804	1.0458
15	0.4263	0.5239	0.5999	0.7249	1.1147
16	0.4528	0.5574	0.6351	0.7694	1.1836
17	0.4793	0.5909	0.6703	0.8139	1.2525
18	0.5058	0.6244	0.7055	0.8584	1.3214
19	0.5323	0.6579	0.7407	0.9029	1.3903
20	0.5588	0.6914	0.7759	0.9474	1.4592
50	1.3538	1.6964	1.8319	2.2824	3.5262

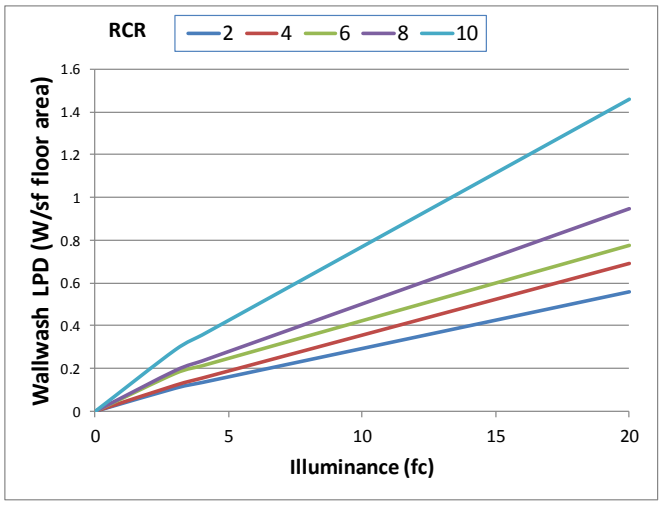

Figure 15: Lookup table for wall wash (watts per square foot) as a function of RCR and illuminance.

There is only one set of values in this look-up table approach. Therefore, there is no direct way to modify this calculation method for wall washing luminaires with different distributions or different luminous efficacies.

Documented Lumen Method Models for Title 24, Part 6 Wall Washing Calculation

The Statewide CASE Team leveraged the LPD calculation methodology used by the ASHRAE 90.1-2016 lighting subcommittee to develop the 2019 Title 24, Part 6 LPDs. This methodology used the Lumen Method to calculate LPDs for general lighting, task lighting, ornamental lighting, and wall wash lighting, and combined the LPDs to generate the total LPD for the space. Some of these calculations were adjusted based upon professional judgement or will be adjusted by detailed lighting models (AGi32) of the space of interest.

The current calculation method is based on watt per square foot factors that are a function of RCR and design illuminance. The Statewide CASE Team is considering replicating this approach and documenting the assumptions used to update the reference products. The reference products are used to develop the factors for typical LED wall washing products. As previously mentioned, the ASHRAE 90.1-2016 spreadsheet has a single wall washing look-up table for a single unknown luminaire.

Wall washing luminaires have a variety of distributions for different purposes. The updated method allows users to simulate six different types of wall washing luminaires. However, more luminaire types can be added over time. The six types currently modeled are:

- Forward Wall Washer – Linear: These luminaires light the wall surface but also throw a significant amount of light to the area in front of the wall.
- Wall Grazer – Aperture: Wall grazers light the wall, highlighting wall texture or architectural features such as brick, stone, and similar wall design elements. Aperture grazers focus their lumen output, which is ideal for higher ceiling applications or when intense grazing is desired.
- Wall Grazer – Linear: Linear wall grazers also highlight wall textures, architectural features, and similar design elements. Linear grazers hug the wall (slot of soffit immediately against a wall) which is preferred for some grazer applications. Their lumen output is ideal for applications where uniform grazing is preferred.
- Wall Washer – Aperture: Aperture wall washer luminaires effectively light the vertical wall service as well as provide significant light at the area in front of the wall. They also exhibit subtle scalping on the wall surface (depending on spacing) which is desirable for some applications.
- Wall Washer – Linear: These luminaires light the wall surface, providing highly uniform vertical illumination. They are used when a continuous line of light or close to the wall luminaire placement is desired.
- High Ceiling Wall Washer – Aperture: High output wall washer aperture luminaires provide sufficient lumen output and the optics needed for effective wall washing for high ceiling applications.

Users must define the RCR of the space modeled for each room type.

In addition, there are high CRI versions of these luminaires, where the efficacy is derated by 20 percent to account for the impact of high CRI on efficacy. For each room type modeled in the Title 24, Part 6 Lumen Method spreadsheet, the user must define the RCR of the space modeled.

$$RCR = \frac{5 \times height \times (Width + Length)}{Width \times Length} = \frac{2.5 \times Perimeter\ Wall\ Area}{Floor\ Area}$$

$$\frac{Area_{Wall}}{Area_{Floor}} = \frac{RCR}{2.5} = 0.4 \times RCR$$

Where,

AreaWall = area of all the walls of the room (square feet)

AreaFloor = floor area of the room (square feet)

The RCR is directly proportional to the ratio of wall area to floor area. This makes it relatively easy to convert the wall washing W/ft^2 of wall area to W/ft^2 of floor area.

LPDs (W/ft^2 of floor area) can be calculated using the RCR of a given space to convert the W/ft^2 of wall areas needed to wall wash all the perimeter walls in a room to given illuminance level. An $LPD_{Wall\ Wash}$ adder accounts for wall washing all the walls in a given room.

$$LPD_{Wall\ Wash}[W/sf\ floor\ area] = \frac{P_{WallWash}}{Area_{Floor}} = \frac{P_{WallWash}}{Area_{Wall}} \times \frac{Area_{Wall}}{Area_{Floor}}$$

$$LPD_{Wall\ Wash}[W/sf\ floor\ area] = \frac{P_{WallWash}}{Area_{Wall}} \times 0.4 \times RCR$$

The Statewide CASE Team anticipates that the wall washing watts needed will be linearly proportional to wall illuminance levels and wall area with some adjustment needed for wall height. Alternatively, specific luminaires that are specified for tall wall heights can be used.

In addition to wall washing increasing the LPD for illuminating walls, the presence of wall washing luminaires provides spill light that displaces some of the luminaires needed for providing general lighting. This is commonly seen in many designs, where the last row of luminaires for general lighting are replaced with wall washing luminaires that provide both wall washing and general lighting. The equation below calculates both the increase in W/ft^2 to account for wall washing and the decrease in W/ft^2 for general lighting to account for reflected light on the horizontal work plane.

The required power for wall washing, $P_{WallWash}$, and the area of the wall, A_{Wall}, are inputs for a given detailed (radiosity) simulation. The luminaires are always mounted half of the wall height away from the wall. Both average vertical foot-candles on the wall and average horizontal foot-candles on a workplane are 30 inches above the floor for an area that is, measured from the wall, half the wall height horizontally away from the wall. The results of the average vertical illuminance on the wall, $E_{v,wall}$, are multiplied by the area of the wall to yield the total maintained lumens (luminous flux) delivered to the wall, $\Phi_{main,v,wall}$. Dividing the lumens delivered to the wall by the power for wall washing gives the delivered luminous efficacy of the wall washing luminaires. This luminous efficacy value is significantly less than the luminous efficacy of the luminaire itself because much of the light from the luminaire does not end up on the wall.

The maintained delivered luminous efficacy, $K_{maint,wall}$, of a given lighting system located in a space with a particular geometry (RCR) and surface reflectances is represented by the following:

$$K_{Maint,Wall} = \frac{\Phi_{maint,v,Wall}}{P_{WallWash}} = \frac{E_{v,wall} \times A_{Wall}}{P_{WallWash}} \text{[Lumens/Watt]}$$

Lighting power (per square foot) of a wall area required to light the wall to target average illuminance can be calculated by rearranging the formula:

$$\frac{P_{WallWash}}{A_{Wall}} = \frac{E_{v,wall}}{K_{Maint,Wall}}$$

Inserting the lighting power (per square foot) of the wall area into the equation for the wall wash power density (per square foot of floor area) provides the desired LPD adder for wall washing, $LPD_{Wall\ Wash}$:

$$LPD_{Wall\ Wash} = \frac{E_{v,wall}}{K_{Maint,Wall}} \times 0.4 \times RCR\ X\ Wall\ Fraction \text{ [W/ft}^2\text{ of floor area]}$$

where Wall Fraction is the fraction of the wall that is illuminated with wall washing luminaires. This is a variable selected by the user of the model similar to the SpaceFraction variable, which is the fraction of the floor area illuminated by the other lighting systems.

The maintained delivered luminous efficacy, $K_{maint,wall}$, of each luminaire type was calculated from several space simulations with different room geometries. The average for each luminaire type was used in the modified Lumen Method calculation.

As previously mentioned, the average horizontal foot-candles on the workplane 30 inches above the floor was extracted for the room area that is within half a wall-height distance from the wall, illuminated by the simulated wall washer. The ratio of average horizontal illuminance on the workplane to the average vertical illuminance on the wall, $R_{HtoV,L}$, was calculated for each detailed prototype space simulation and averaged for each luminaire type evaluated. This becomes a characteristic of the luminaire type, which varies more between luminaires than within the simulation of the same luminaire type for different space geometries.

The average horizontal illuminance within half a wall-height distance from the wall, E_H, can be calculated for a wall washing system that has a target design average vertical illuminance on the wall, $E_{Wall,Design}$, as follows:

$$E_H = E_{Wall,Design} \times R_{HtoV,L}$$

The fraction of general lighting illuminance (and wattage) that is displaced one half of a wall height in from walls, F1, is given by the following equation:

$$F1 = \min\left[1, \frac{\left(E_{Wall,Design} \times R_{HtoV,L}\right)}{E_{Floor,Design}}\right]$$

Where,

$E_{Wall,Design}$ = Design (target) illuminance for wall washing (foot-candles)

$E_{Floor,Design}$ = Design (target) general lighting floor illuminance (foot-candles)

Note that the equation is capped at 1 so more light or more power than is used for providing general lighting for the floor is not displaced.

As was described earlier, the ratio of wall area to floor area is given by the following:

$$\frac{Area_{Wall}}{Area_{Floor}} = \frac{RCR}{2.5} = 0.4 \times RCR$$

However, the floor area simulated for receiving horizontal spill light from the wall washers is one-half the wall height in from the walls, or approximately one half of the wall area. The fraction of floor area where horizontal general lighting is displaced, F2, is given by the following:

F2 = 0.5 x 0.4 x RCR = 0.2 x RCR x WallFraction

Combining this with the ratio of wall area to floor area yields the General Lighting Reduction Fraction, GLRF:

GLRF = - F1 x F2

The General Lighting Power Density Reduction, $LPD_{Gen,Red}$, is given by the following:

$$LPD_{Gen,Red} = LPD_{Gen} \times GLRF\ X\ Wall\ Fraction$$

$$LPD_{Gen,Red} = LPD_{Gen} \times \min\left[1, \frac{\left(E_{Wall,Design} \times R_{HtoV,L}\right)}{E_{Floor,Design}}\right] \times 0.2 \times RCRX\ Wall\ Fraction$$

Key characteristics of the wall washing luminaires are tabulated in Appendix F.

Appendix E: LED Lumen Method Models

Table 39 and Table 40 present excerpts from the inputs and results from the Lumen Method calculation spreadsheets. Summary light loss factors and CUs used for the models are found in Appendix F.

Table 39: Base Case (2016) Lumen Method Inputs and Calculated Results

		General						Task						Supplemental						Wall Wash					Total Calc	Modifed
Application	RCR	Floor Area	(fc)	Source	Distribution	REF	Gen W/sf	Floor Area	(fc)	Source	Distribution	REF	Task W/sf	Floor Area	(fc)	Source	Distribution	REF	W/sf	Floor Area	(fc)	Source	Distribution	REF	Wall W/sf	Total W/sf	Mod W/sf
Auditorium: Audience/Seating Area	4	100%	5	PAR	Downlight open - flood	511	0.44	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.19	0.63	1.40
Corridor/Transition	8	100%	14	LED	Downlight open (repl INC)	701	0.38	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Linear WW Open (re	703	0.28	0.66	0.60
Classroom/Lecture/Training	2	85%	45	FL	High Perf Lensed	600	0.72	30%	13	LED	Downlight open	701	0.07	0%	0	NA	NA	0	0.00	100%	5	LED	Linear WW Open (re	703	0.16	0.95	1.20
Court House: Audience/Seating Area	4	100%	10	LED	Downlight open	522	0.36	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.19	0.55	1.30
Court House: Courtroom	4	70%	5	LED	Indirect Pendant (repl CF)	723	0.16	70%	35	LED	Downlight open	522	0.88	0%	0	NA	NA	0	0.00	100%	10	LED	WW Open (repl CF	727-2	0.36	1.40	1.30
Electrical/Mechanical	4	100%	10	LED	Linear Industrial (repl FL)	738	0.23	15%	40	LED	Task (repl FL)	739	0.20	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.43	0.55
Dining Area	2	100%	10	LED	Narrow Linear (repl FL)	731	0.16	30%	20	LED	Downlight open	522	0.18	0%	0	NA	NA	0	0.00	100%	10	FL	Linear WW Open	537-1	0.29	0.63	1.00
Lounge/Leisure Dining: Dining Area	2	60%	10	PAR	Downlight open - flood	511	0.49	50%	5	INC	indirect Pendant	503	0.40	40%	4	LED	Task (repl MR	719	0.04	0%	0	NA	NA	0	0.00	0.93	1.00
Family Dining: Dining Area	2	100%	16	LED	Downlight open	522	0.48	20%	10	LED	Indirect Pendant	723	0.07	0%	0	NA	NA	0	0.00	100%	5	FL	Linear Wall Cove	534-2	0.16	0.71	1.00
Food Preparation	4	100%	40	LED	Narrow Linear (repl FL)	731	0.90	30%	30	LED	Linear Direct Les	730	0.16	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.06	1.20
Lounge/Recreation	2	100%	11	LED	Downlight open	522	0.33	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	10	LED	WW Open (repl CF	727-2	0.29	0.62	0.90
Stairway	8	100%	10	LED	Narrow Linear (repl FL)	731	0.29	100%	5	LED	Linear Wall Cove	702	0.29	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.58	0.60
Stairway	8	100%	10	LED	Linear Direct Lensed (repl FL	730	0.26	100%	5	LED	Linear Wall Cove	702	0.29	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.55	0.60
Restrooms	6	40%	18	FL	Wall Mounted Linear Dir/Ind	604	0.29	100%	5	LED	Downlight Lense	720	0.17	0%	0	NA	NA	0	0.00	100%	5	FL	Linear Wall Cove	534-2	0.25	0.71	0.60
Parking Garage: Parking	2	100%	6	LED	Lowbay Lensed (Lin Ind - rep	759-1	0.14	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.14	0.14
Medical/Industrial Research Laborato	4	80%	48	LED	Narrow Linear (repl FL)	731	0.86	20%	50	LED	Downlight open	522	0.36	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.22	1.40
Education Laboratory	4	85%	49	LED	Narrow Linear (repl FL)	731	0.93	15%	5	LED	Downlight Lense	720	0.02	2%	100	LED	Downlight Ler	720	0.06	100%	5	FL	Linear WW Open	537-1	0.19	1.20	1.40
Library: Stacks	2	100%	20	LED	Narrow Linear (repl FL)	731	0.32	80%	40	LED	Linear WW Ope	703	0.69	0%	0	NA	NA	0	0.00	100%	0	FL	Linear Indirect Cove	534-1	0.00	1.00	1.50
Library: Reading Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	735	0.50	70%	20	LED	Downlight Lense	720	0.32	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.82	1.10
Lobby	2	100%	20	LED	Indirect Pendant (repl CF)	723	0.72	20%	20	LED	Downlight open	522	0.12	0%	0	NA	NA	0	0.00	100%	5	FL	Linear Wall Cove	534-2	0.16	1.00	0.95
Gymnasium/Fitness Center: Locker I	4	70%	30	LED	Linear Direct Lensed (repl FL	730	0.37	30%	10	LED	Downlight open	522	0.11	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.48	0.70
Office - enclosed	6	100%	30	LED	Linear Rec Hi Perf Lensed (r	700	0.68	25%	25	LED	Task (repl FL)	739	0.26	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.93	1.00
Office - open plan	2	100%	30	LED	Linear Dir/Ind (repl FL)	735	0.50	30%	20	LED	Task (repl FL)	739	0.15	0%	0	NA	NA	0	0.00	100%	5	LED	Linear WW Open (re	703	0.16	0.81	0.75
Conference Meeting/Multipurpose	4	100%	20	LED	Narrow Linear (repl FL)	731	0.45	50%	10	PAR	Downlight open	511	0.44	0%	0	NA	NA	0	0.00	100%	5	LED	WW Open (repl CF	727-1	0.19	1.07	1.20
Workshop: Workshop	4	100%	50	LED	Linear Industrial (repl FL)	738	1.14	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.14	0.90
Manufacturing Facility: General Low I	2	100%	42.5	LED	Lowbay Lensed (Lin Ind - rep	759-1	0.96	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.96	0.90
Manufacturing Facility: General Low I	2	100%	42.5	FL	Low Bay	608-1	1.33	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.33	0.90
Manufacturing Facility: General High	2	100%	42.5	LED	High Bay (repl MH)	759-2	0.75	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.75	1.00
Manufacturing Facility: Extra High Ba	2	100%	43	MH	Extra High Bay	559-3	1.05	100%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.05	1.20
Active storage	4	100%	20	LED	Linear Industrial (repl FL)	738	0.46	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.46	0.60
Warehouse: Fine Material	4	100%	30	LED	Linear Industrial (repl FL)	738	0.69	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.69	0.70
Warehouse: Medium/Bulky Material	2	100%	20	LED	High Bay (repl MH)	759-2	0.35	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.35	0.60
Transportation: Air/Train/Bus - Bagga	2	50%	10	LED	Linear Direct Lensed (repl FL	730	0.07	50%	10	LED	Linear Dir/Ind (re	735	0.08	0%	0	NA	NA	0	0.00	100%	10	FL	Linear WW Open	537-1	0.29	0.45	0.50
Transportation: Terminal - Ticket cou	2	100%	10	LED	Narrow Linear (repl FL)	731	0.16	50%	20	LED	Downlight open	522	0.30	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.16	0.62	1.00
WHOLE BULDING ANALYSIS ONLY	4	100%	11	LED	Narrow Linear (repl FL)	731	0.25	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.19	0.44	1.00
Office: Banking Activity Area	4	100%	30	LED	Narrow Linear (repl FL)	731	0.67	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.19	0.86	1.00
Barber & Beauty Parlor	6	100%	20	LED	Linear Direct Lensed (repl FL	730	0.43	25%	30	PAR	Downlight open	511	0.70	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.14	1.70
Religious: Audience/Seating Area	2	100%	15	PAR	Downlight open - flood	511	1.22	80%	5	FL	Linear Indirect C	534-1	0.14	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-2	0.16	1.53	1.50
Religious: Worship - pulpit, choir	2	100%	15	PAR	Downlight open - flood	511	1.22	80%	5	FL	Linear Indirect C	534-1	0.14	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-2	0.16	1.53	1.50
Court House: Judges Chambers	6	100%	30	LED	Narrow Linear (repl FL)	731	0.73	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	WW Open (repl CF	727-2	0.25	0.98	1.30
Hospital/Healthcare: Exam/Treatmen	6	100%	50	LED	Linear Rec Hi Perf Lensed (r	700-1	1.34	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.34	1.20
Hospital/Healthcare: Hospital/Medica	4	100%	30	LED	Linear Direct Lensed (repl FL	730	0.53	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.53	0.54
Hospital/Healthcare: Nurse station	4	100%	15	LED	Linear Dir/Ind (repl FL)	735	0.32	50%	30	LED	Task (repl FL)	739	0.49	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.81	0.81
Hospital/Healthcare: Physical therapy	4	100%	20	LED	Linear Dir/Ind (repl FL)	735	0.42	50%	40	LED	Linear Dir/Ind (re	735	0.42	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.84	0.84
Hospital/Healthcare: Patient Room	4	100%	10	FL	Linear Dir/Indir	535	0.30	50%	25	FL	Linear Direct len	530	0.31	50%	1	FL	Task	539	0.01	0%	0	NA	NA	0	0.00	0.62	0.62
Hospital/Healthcare: Pharmacy	4	100%	60	LED	Linear Direct Lensed (repl FL	730	1.07	20%	40	LED	Linear Direct Les	730	0.14	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.21	1.22
Hospital/Healthcare: Radioly/Imaging	4	75%	50	LED	Downlight Lensed (repl CF)	720	1.06	25%	0	LED	Downlight Lense	720	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.06	1.06
Hospital/Healthcare: Operating Room	4	100%	100	LED	Linear Rec Hi Perf Lensed (r	700-1	2.17	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	2.17	2.17
Hospital/Healthcare: Recovery	4	100%	39	LED	Linear Rec Hi Perf Lensed (r	700-1	0.85	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	FL	Linear Wall Cove	534-2	0.19	1.03	1.03
Hospital/Healthcare: Active storage	4	100%	20	LED	Linear Industrial (repl FL)	738	0.46	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.46	0.60
Convention Center: Exhibit space	2	100%	20	LED	High Bay (repl MH)	759-2	0.88	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.88	1.20
Hotel/Conference Center - Conferenc	2	100%	10	LED	Indirect Pendant (repl CF)	723	0.36	50%	20	LED	Downlight open	522	0.30	0%	0	NA	NA	0	0.00	50%	5	LED	WW Open (repl CF	727-1	0.08	0.74	1.20
Laundry-Ironing & Sorting	2	100%	30	LED	Linear Direct Lensed (repl FL	730	0.43	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.43	0.70
Museum: General exhibition	4	100%	10	TH	Downlight open	572	1.05	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.05	1.80
Museum: Restoration	4	100%	30	LED	Linear Rec Hi Perf Lensed (r	700-1	0.65	25%	45	LED	Linear Direct Les	730	0.20	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.85	1.80
Museum: Active Storage	4	100%	20	LED	Linear Industrial (repl FL)	738	0.46	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.46	0.60
Automotive Facility: Garage Service/I	2	100%	25	LED	Linear Industrial (repl FL)	738	0.43	50%	10	LED	Task (repl FL)	739	0.13	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.56	0.90
Performing Arts Theatre: Audience/S	6	0%	0	NA	NA	0	0.00	100%	19	PAR	Downlight open	511	1.78	100%	0	NA	NA	0	0.00	100%	5	LED	WW Open (repl INC	707-2	0.25	2.03	1.40
Motion Picture Theatre: Audience/Se	2	100%	14	PAR	Downlight open - flood	511	1.14	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.14	0.90
Performing Arts theatre: Lobby	4	90%	21	PAR	Downlight open - flood	511	1.66	0%	0	NA	NA	0	0.00	30%	10	LED	WW Open (re	707-2	0.05	0%	0	NA	NA	0	0.00	1.70	1.40
Auditorium: Lobby	2	100%	10	LED	Downlight open	522	0.30	30%	10	LED	Indirect Pendant	723	0.11	0%	0	NA	NA	0	0.00	100%	10	FL	Linear Wall Cove	534-2	0.29	0.70	1.40
Motion Picture Theatre: Lobby	2	100%	15	LED	Downlight open	522	0.45	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.45	0.95
Religious Buildings: Lobby	4	100%	10	LED	Downlight open	522	0.36	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	WW Open (repl CF	727-2	0.19	0.55	0.95
Retail: Department Store Sales Area	2	100%	20	LED	Narrow Linear (repl FL)	731	0.32	50%	40	PAR	Downlight open	511	1.63	0%	0	NA	NA	0	0.00	100%	10	FL	Linear Wall Cove	534-2	0.29	2.24	1.20
Retail: Supermarket Sales Area	2	100%	20	LED	Linear Rec Hi Perf Lensed (r	700	0.28	60%	30	LED	Downlight open	741	0.44	0%	0	NA	NA	0	0.00	100%	5	FL	Linear WW Open	537-1	0.16	0.89	1.20
Retail: Mass Merchandising Sales Ar	2	100%	20	LED	Linear Direct Lensed (repl FL	730	0.28	70%	30	LED	High Bay (repl M	759-2	0.37	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.65	1.20
Retail: Mall Concourse	2	100%	24	LED	PAR downlight flood	751	0.62	0%	0	NA	NA	0	0.00	100%	10	LED	Linear Wall C	734-1	0.28	0%	0	NA	NA	0	0.00	0.90	0.95
Retail: Dressing/Fitting Room	6	100%	10	LED	Linear Direct Lensed (repl FL	730	0.22	65%	20	LED	Linear Direct Les	730	0.28	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.50	0.70
Convention Center: Audience/Seating	2	100%	10	PAR	Downlight open - flood	511	0.82	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.82	1.20
Sports Arena: Audience/Seating Area	2	100%	5	MH	indirect Pendant	553	0.29	100%	5	MH	PAR Downlight d	551	0.14	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.43	1.20
Gymnasium: Audience Seating/Perm	4	100%	15	FL	Low Bay	608-1	0.65	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.65	1.00
Fitness Center: Audience/Seating Ar	2	100%	15	LED	Linear Direct Lensed (repl FL	730	0.21	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.21	1.00
Gymnasium: Playing Area	2	100%	50	LED	High Bay Industrial (repl FL)	709-1	0.82	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.82	1.00
Fitness Center: Fitness Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	735	0.50	0%	0	NA	NA	0	0.00	100%	0	NA	NA	0	0.00	100%	0	NA	NA	0	0.00	0.50	1.00
Gymnasium: Fitness Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	735	0.50	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0.50	1.00
Sports Arena: Class 1 -Court Sports	2	100%	150	LED	High Bay Industrial (repl FL)	709-1	2.47	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	2.47	2.47
Sports Arena: Class 2 - Court Sports	2	100%	100	LED	Lowbay Lensed (Lin Ind - rep	759-1	2.27	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	2.27	2.27
Sports Arena: Class 3 - Court Sports	2	100%	75	LED	Lowbay Lensed (Lin Ind - rep	759-1	1.70	0%	0	NA	NA	0	0.00	0%	2	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.70	1.70
Sports Arena: Class 4- Court Sports	2	100%	50	LED	Lowbay Lensed (Lin Ind - rep	759-1	1.13	0%	0	NA	NA	0	0.00	0%	3	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	1.13	1.13

Table 40: Proposed (2019) Lumen Method Inputs and Calculated Results

		General						Task						Supplemental						Wall Wash							Calc Total
Application	RCR	Floor Area	(fc)	Source	Distribution	REF	W/sf	Floor Area	(fc)	Source	Distribution	REF	W/sf	Floor Area	(fc)	Source	Distribution	REF	W/sf	% Wall Area	(fc)	Source	Distribution	REF	WW W/sf	Gen Offset W/sf	Total W/sf
Auditorium: Audience/Seating Area	4	100%	5	LED	PAR downlight flood	811	0.11	70%	25	LED	PAR downlight flood	811	0.39	0%	0	NA	NA	0	0.00	100%	5	LED	WW - Aperture HC	906	0.05	-0.02	0.54
Corridor/Transition	8	100%	14	LED	Downlight open (repl INC)	801	0.34	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Forward WW - Linear	901	0.91	-0.66	0.60
Classroom/Lecture/Training	2	85%	45	LED	Linear Rec Hi Perf Lensed (r	800	0.51	30%	13	LED	Downlight open (repl INC)	801	0.07	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Linear	905	0.19	-0.06	0.71
Court House: Audience/Seating Ar	4	100%	10	LED	Downlight open (repl INC)	801	0.19	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED Hi CR	CRI-Wall Graze - Linea	953	0.06	-0.02	0.23
Court House: Courtroom	4	100%	5	LED	Indirect Pendant (repl CF)	823	0.21	70%	35	LED	Downlight open (repl INC)	801	0.47	0%	0	NA	NA	0	0.00	100%	10	LED Hi CR	CRI-Wall Graze - Aper	952	0.17	-0.04	0.81
Electrical/Mechanical	4	100%	10	LED	Linear Industrial (repl FL)	838	0.22	15%	40	LED	Task (repl FL)	839	0.17	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.39
Dining Area	2	100%	10	LED	Narrow Linear (repl FL)	831	0.17	30%	20	LED	Downlight open (repl INC)	801	0.10	0%	0	NA	NA	0	0.00	100%	10	LED	Wall Wash - Linear	905	0.09	-0.03	0.34
Lounge/Leisure Dining: Dining Area	2	100%	10	LED	PAR downlight flood	811	0.20	50%	5	LED	Linear WW Open (repl FL	803	0.05	50%	5	LED	Task (repl MR)	819	0.06	100%	5	LED Hi CR	CRI-Wall Graze - Aper	952	0.17	-0.05	0.43
Family Dining: Dining Area	2	100%	16	LED	Downlight open (repl INC)	801	0.27	40%	10	LED	Indirect Pendant (repl CF)	823	0.13	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Linear	905	0.12	-0.05	0.47
Food Preparation	4	100%	40	LED	Linear Direct Lensed (repl FL	830	0.66	30%	30	LED	Linear Industrial (repl FL)	838	0.20	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.86
Lounge/Recreation	2	100%	11	LED	Downlight open (repl INC)	801	0.19	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	10	LED Hi CR	CRI-Wall Graze - Linea	953	0.54	-0.12	0.60
Stairway	8	100%	10	LED	Narrow Linear (repl FL)	831	0.32	100%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Forward WW - Linear	901	0.91	-0.64	0.59
Stairway	8	100%	10	LED	Linear Direct Lensed (repl FL	830	0.24	100%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Linear	905	0.58	-0.36	0.47
Restrooms	6	40%	18	LED	Wall Mount LED Linear	804	0.21	100%	5	LED	Downlight Lensed (repl CI	820	0.13	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Graze - Linear	903	0.43	-0.12	0.65
Parking Garage: Parking	2	100%	5	LED	Parking structure luminaire	859-3	0.09	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.09
Medical/Industrial Research Labora	4	80%	48	LED	Narrow Linear (repl FL)	831	0.84	20%	50	LED	Downlight open (repl INC)	801	0.19	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.04
Education Laboratory	4	85%	49	LED	Narrow Linear (repl FL)	831	0.92	15%	5	LED	Downlight Lensed (repl CI	820	0.02	2%	100	LED	Downlight Lens	820	0.05	100%	5	LED	Wall Wash - Linear	905	0.19	-0.09	1.08
Library: Stacks	2	100%	20	LED	Narrow Linear (repl FL)	831	0.35	80%	40	LED	Linear WW Open (repl FL	803	0.58	0%	0	NA	NA	0	0.00	100%	0	N/A	N/A	0	0.00	0.00	0.93
Library: Reading Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	835	0.46	70%	20	LED	Downlight Lensed (repl CI	820	0.27	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.73
Lobby	2	100%	20	LED	Indirect Pendant (repl CF)	823	0.65	20%	20	LED	Downlight open (repl INC)	801	0.07	0%	0	NA	NA	0	0.00	100%	5	LED	WW - Aperture HC	906	0.21	-0.11	0.82
Gymnasium/Fitness Center: Locke	4	70%	30	LED	Linear Direct Lensed (repl FL	830	0.35	30%	10	LED	Downlight open	822	0.08	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.42
Office - enclosed	6	100%	20	LED	Linear Rec Hi Perf Lensed (r	800	0.43	25%	30	LED	Task (repl FL)	839	0.25	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.68
Office - open plan	2	100%	20	LED	Linear Dir/Ind (repl FL)	835	0.31	30%	30	LED	Task (repl FL)	839	0.21	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Linear	905	0.09	-0.03	0.57
Conference Meeting/Multipurpose	4	100%	30	LED	Narrow Linear (repl FL)	831	0.66	50%	10	LED	PAR downlight flood	811	0.11	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Linear	905	0.19	-0.11	0.86
Workshop: Workshop	4	100%	50	LED	Linear Industrial (repl FL)	838	1.09	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.09
Manufacturing Facility: General Lo	2	100%	42.5	LED	Lowbay Lensed (Lin Ind - rep	859-1	0.61	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.61
Manufacturing Facility: General Lo	2	100%	42.5	LED	Lowbay Lensed (Lin Ind - rep	808-1	0.69	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.69
Manufacturing Facility: General Hig	2	100%	42.5	LED	High Bay (repl MH)	859-2	0.58	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.58
Manufacturing Facility: Extra High	2	100%	43	LED	Industrial Super High Bay	869	0.73	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.73
Active storage	4	100%	20	LED	Linear Industrial (repl FL)	838	0.43	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.43
Warehouse: Fine Material	2	100%	35	LED	Linear Industrial (repl FL)	838	0.57	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.57
Warehouse: Medium/Bulky Materia	6	100%	20	LED	High Bay (repl MH)	859-2	0.42	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.42
Transportation: Air/Train/Bus - Bag	2	50%	10	LED	Linear Direct Lensed (repl FL	830	0.07	50%	10	LED	Linear Dir/Ind (repl FL)	835	0.08	0%	0	NA	NA	0	0.00	100%	10	LED	Wall Graze - Aperture	902	0.20	-0.02	0.33
Transportation: Terminal - Ticket co	2	100%	10	LED	Narrow Linear (repl FL)	831	0.17	50%	20	LED	Downlight open (repl INC)	801	0.17	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Graze - Aperture	902	0.10	-0.03	0.42
Bank Customer Area	4	100%	11	LED	Narrow Linear (repl FL)	831	0.24	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED Hi CR	CRI-WW - Aperture Hi	956	0.15	-0.04	0.35
Office: Banking Activity Area	4	100%	30	LED	Narrow Linear (repl FL)	831	0.66	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Graze - Linear	903	0.12	-0.06	0.72
Barber & Beauty Parlor	6	100%	20	LED	Linear Direct Lensed (repl FL	830	0.40	25%	30	LED	PAR downlight flood	811	0.18	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.59
Religious: Audience/Seating Area	2	100%	15	LED	PAR downlight flood	811	0.31	80%	5	LED	Linear Wall Cove (repl FL	834-1	0.12	70%	15	LED	PAR downlight	811	0.21	100%	5	LED Hi CR	CRI-Wall Graze - Linea	953	0.27	-0.11	0.80
Religious: Worship - pulpit, choir	2	100%	15	LED	PAR downlight flood	811	0.31	80%	5	LED	Linear Wall Cove (repl FL	834-1	0.12	70%	15	LED	PAR downlight	811	0.21	100%	5	LED Hi CR	CRI-Wall Graze - Aper	952	0.28	-0.08	0.85
Court House: Judges Chambers	6	100%	30	LED	Narrow Linear (repl FL)	831	0.81	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Wash - Aperture	904	0.15	-0.10	0.86
Hospital/Healthcare: Exam/Treatm	6	100%	50	LED	Linear Rec Hi Perf Lensed (r	800-1	1.16	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.16
Hospital/Healthcare: Hospital/Medi	4	100%	30	LED	Linear Direct Lensed (repl FL	830	0.50	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.50
Hospital/Healthcare: Nurse station	4	100%	15	LED	Linear Dir/Ind (repl FL)	835	0.29	50%	30	LED	Task (repl FL)	839	0.43	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.72
Hospital/Healthcare: Physical thera	4	100%	20	LED	Linear Dir/Ind (repl FL)	835	0.39	50%	40	LED	Linear Dir/Ind (repl FL)	835	0.39	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.78
Hospital/Healthcare: Patient Room	4	100%	10	LED	Linear Dir/Ind (repl FL)	835	0.19	50%	25	LED	Linear Direct Lensed (repl	830	0.21	50%	1	LED	Task (repl FL)	839	0.01	0%	0	N/A	N/A	0	0.00	0.00	0.41
Hospital/Healthcare: Pharmacy	4	100%	60	LED	Linear Direct Lensed (repl FL	830	0.99	20%	40	LED	Linear Direct Lensed (repl	830	0.13	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.12
Hospital/Healthcare: Radioly/Imagi	4	75%	50	LED	Downlight Lensed (repl CF)	820	0.86	25%	20	LED	Downlight Lensed (repl CI	820	0.11	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.98
Hospital/Healthcare: Operating Roo	4	100%	100	LED	Linear Rec Hi Perf Lensed (r	800-1	1.87	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.87
Hospital/Healthcare: Recovery	4	100%	39	LED	Linear Rec Hi Perf Lensed (r	800-1	0.73	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED Hi CR	CRI-Wall Wash - Linea	955	0.24	-0.09	0.88
Hospital/Healthcare: Active storage	4	100%	20	LED	Linear Industrial (repl FL)	838	0.43	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.43
Convention Center: Exhibit space	2	100%	50	LED	High Bay (repl MH)	859-2	0.69	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.69
Hotel/Conference Center - Conferer	2	100%	10	LED	Indirect Pendant (repl CF)	823	0.33	50%	20	LED	Downlight open (repl INC)	801	0.17	0%	0	NA	NA	0	0.00	50%	5	LED	Wall Wash - Aperture	904	0.08	-0.06	0.51
Laundry-Ironing & Sorting	2	100%	30	LED	Linear Direct Lensed (repl FL	830	0.39	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.39
Museum: General exhibition	4	100%	10	LED	PAR downlight flood	811	0.22	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.22
Museum: Restoration	4	100%	30	LED	Linear Rec Hi Perf Lensed (r	800-1	0.56	25%	45	LED	Linear Direct Lensed (repl	830	0.19	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.75
Museum: Active Storage	4	100%	20	LED	Linear Industrial (repl FL)	838	0.43	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.43
Automotive Facility: Garage Servic	2	100%	25	LED	Linear Industrial (repl FL)	838	0.41	50%	10	LED	Task (repl FL)	839	0.12	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.53
Performing Arts Theatre: Audience	6	100%	5	LED	PAR downlight flood	811	0.12	70%	25	LED	PAR downlight flood	811	0.43	100%	0	NA	NA	0	0.00	100%	10	LED Hi CR	CRI-Wall Graze - Aper	952	0.57	-0.08	1.04
Motion Picture Theatre: Audience/S	2	100%	30	LED	PAR downlight flood	811	0.61	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	LED	Wall Graze - Linear	903	0.00	0.00	0.61
Performing Arts theatre: Lobby	4	100%	21	LED	PAR downlight flood	811	0.47	0%	0	NA	NA	0	0.00	40%	10	LED	WW Open (re	807-2	0.11	0%	0	LED	Wall Graze - Linear	903	0.00	0.00	0.58
Auditorium: Lobby	2	100%	10	LED	Downlight open (repl INC)	801	0.17	30%	10	LED	Indirect Pendant (repl CF)	823	0.10	0%	0	NA	NA	0	0.00	100%	10	LED	Wall Graze - Aperture	902	0.46	-0.11	0.61
Motion Picture Theatre: Lobby	2	100%	30	LED	Downlight open (repl INC)	801	0.51	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	LED	Wall Graze - Linear	903	0.00	0.00	0.51
Religious Buildings: Lobby	4	100%	10	LED	Downlight open (repl INC)	801	0.19	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	100%	5	LED	Wall Graze - Linear	903	0.22	-0.10	0.31
Retail: Department Store Sales Are	2	100%	15	LED	Narrow Linear (repl FL)	831	0.26	80%	35	LED	PAR downlight flood	811	0.57	0%	0	NA	NA	0	0.00	30%	30	LED	Wall Wash - Aperture	904	0.27	-0.05	1.06
Retail: Supermarket Sales Area	2	100%	20	LED	Linear Rec Hi Perf Lensed (r	800	0.27	70%	30	LED	Downlight open (repl MH)	841	0.37	0%	0	NA	NA	0	0.00	40%	50	LED	Wall Wash - Linear	905	0.78	-0.07	1.34
Retail: Mass Merchandising Sales	2	100%	20	LED	Linear Direct Lensed (repl FL	830	0.26	90%	30	LED	High Bay (repl MH)	859-2	0.37	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.63
Retail: Mall Concourse	2	100%	24	LED	PAR downlight flood	851	0.49	0%	0	NA	NA	0	0.00	100%	10	LED	Linear Wall Co	834-1	0.30	0%	10	LED	WW - Aperture HC	906	0.00	0.00	0.79
Retail: Dressing/Fitting Room	6	100%	10	LED	Linear Direct Lensed (repl FL	830	0.20	40%	30	LED	Linear Direct Lensed (repl	830	0.24	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.44
Convention Center: Audience/Seati	2	100%	10	LED	PAR downlight flood	811	0.20	60%	20	LED	PAR downlight flood	811	0.25	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.45
Sports Arena: Audience/Seating A	2	100%	5	LED	Indirect Pendant (repl CF)	853	0.12	100%	5	LED	PAR downlight flood	851	0.10	60%	20	LED	Lowbay Lensed	808-1	0.19	0%	0	N/A	N/A	0	0.00	0.00	0.42
Gymnasium: Audience Seating/Pe	4	100%	15	LED	Lowbay Lensed (Lin Ind - rep	859-1	0.28	60%	15	LED	Lowbay Lensed (Lin Ind -	859-1	0.17	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.45
Fitness Center: Audience/Seating	2	100%	15	LED	Linear Direct Lensed (repl FL	830	0.20	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.20
Gymnasium: Playing Area	2	100%	50	LED	High Bay Industrial (repl FL)	809-1	0.75	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.75
Fitness Center: Fitness Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	835	0.46	0%	0	NA	NA	0	0.00	100%	0	NA	NA	0	0.00	100%	0	LED	Forward WW - Linear	901	0.00	0.00	0.46
Gymnasium: Fitness Area	2	100%	30	LED	Linear Dir/Ind (repl FL)	835	0.46	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.46
Sports Arena: Class 1 -Court Sport	2	100%	150	LED	High Bay Industrial (repl FL)	809-1	2.26	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	2.26
Sports Arena: Class 2 - Court Spor	2	100%	100	LED	Lowbay Lensed (Lin Ind - rep	859-1	1.45	0%	0	NA	NA	0	0.00	0%	0	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.45
Sports Arena: Class 3 - Court Spor	2	100%	75	LED	Lowbay Lensed (Lin Ind - rep	859-1	1.08	0%	0	NA	NA	0	0.00	0%	2	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	1.08
Sports Arena: Class 4- Court Spor	2	100%	50	LED	Lowbay Lensed (Lin Ind - rep	859-1	0.72	0%	0	NA	NA	0	0.00	0%	3	NA	NA	0	0.00	0%	0	N/A	N/A	0	0.00	0.00	0.72

Appendix F: Averaged Luminaire Light Loss Factors and Coefficients of Utilization

Luminaires used for Lumen Method calculations as well as more detailed AGi32 modeling are based on high performance LED light engines and drivers. While these luminaires represent an above-average LED performance selection for modeling, the Statewide CASE Team included sufficient samplings (minimum of three separate manufacturers' comparable products) to ensure competitive project implementation and design options.

Light loss factors used in the models were as follows:

- Lumen depreciation of 0.85
  NOTE: IES uses LM70 at 50,000 hours as the default for LED lumen depreciation. The models used by the Statewide CASE Team used a conservative 0.85 lumen depreciation target life (at the end of 15 years) for the models used in the Title 24, Part 6 calculations.
- Dirt depreciation of:
  - 0.90 (clean – medical, scientific, laboratory environments)
  - 0.80 (moderate – typical environments)
  - 0.65 (dirty – industrial environments)

Table 41 illustrates the luminaire efficacies and CUs for the sampling of RCRs used in the Lumen Method calculation in Appendix D.

Table 41: List of LED Luminaires Used for Title 24-2019 Modeling

Code	Luminaire Type/Description	Efficacy	CU at Target RCR Used in Models			
			RCR 2	RCR 4	RCR 6	RCR 8
800	Linear Rec Hi Perf Lensed	119	0.877	0.677	0.547	0.453
800-1	Linear Rec Hi Perf Lensed	119	0.877	0.677	0.547	0.453
801	Downlight Open	86	1.018	0.898	0.796	0.711
803	Linear WW Open	84	0.910	0.727	0.590	0.497
804	Wall Mount LED Linear	94	0.723	0.558	0.450	0.363
808-1	Low Bay Lensed	120	0.833	0.643	0.513	0.420
809-1	High Bay Industrial	117	0.860	0.682	0.558	0.470
811	PAR Downlight Flood	71	1.043	0.950	0.867	0.803
819	Task Light	68	0.948	0.787	0.673	0.585
820	Downlight Lensed	77	0.980	0.833	0.717	0.623
822	Downlight Open	77	0.980	0.833	0.717	0.623
823	Indirect Pendant	78	0.652	0.504	0.400	0.324
830	Linear Direct Lensed	106	0.906	0.716	0.586	0.488
831	Narrow Linear	87	0.910	0.724	0.592	0.494
834-1	Linear Wall Cove	81	0.668	0.515	0.408	0.328
835	Linear Direct/Indirect	105	0.796	0.626	0.505	0.416
838	Linear Industrial	130	0.790	0.595	0.468	0.378
839	Task Light	68	0.948	0.787	0.673	0.585
841	Downlight Open	86	1.018	0.898	0.796	0.711
851	PAR Downlight flood	71	1.043	0.950	0.867	0.803
853	Indirect Pendant	78	0.652	0.504	0.400	0.324
859-1	Low Bay Lensed	120	0.833	0.643	0.513	0.420
859-2	High Bay Industrial	117	0.860	0.682	0.558	0.470
859-3	Parking Structure Luminaire	112	0.750	0.475	0.328	0.258
869	Industrial Super High Bay	118	0.690	0.435	0.295	0.215

Appendix G: WALL WASHING LUMEN METHOD CALCULATION

Calculating the power density contribution from wall washing is challenging because the Lumen Method only provides average foot-candle results. Furthermore, incorrect application of a wall washing component in the Lumen Method results in inaccurate LPD and foot-candle targets. Wall washing can be modeled accurately, however, using a lighting analysis and design tool, such as AGi32.

To enhance the accuracy of Lumen Method models that included wall washing, the wall washing component was first modeled using AGi32. The AGi32 models established accurate baselines for the variety of wall wash applications that were used in the Lumen Method models. Data from the AGi32 models – illumination targets and performance characteristics of luminaires – were applied to the wall washing component in the Lumen Method models.

The conversion of AGi32 wall washing results to a usable wall washing component for the Lumen Method models is as follows:

- Performance data, wattage, efficiency, CU, and optical criteria for the luminaire used in the AGi32 models were inserted into the Lumen Method models.
- Foot-candle average, for the wall surface illuminated by the wall washers in the AGi32 model, was then applied to the corresponding Lumen Method model.
- Wall average foot-candles were then prorated, using a calculation that established the percentage of wall area to total floor area for the model.
- The Lumen Method wall washer component calculation then assigns a percentage of the wall washing, including the LPD, to the total floor area.

The resulting LPD for a Lumen Method model with wall washing is the sum of the LPD for all the lighting systems, including the prorated wall lighting LPD.

Additional data below provide a detailed accounting of the wall washing Lumen Method calculation.

- Figure 16: Lumen Method model spaces with a indicates space types in the Lumen Method modeling where wall washing is applied. Target average foot-candles for vertical and horizontal illumination are as indicated in the IES Handbook (10th Edition). The horizontal foot-candle target was used as a reference in the AGi32 models to verify that the primary visual zone of vertical illumination ratio was at least 1:1 of the horizontal surrounding foot-candles, as a ratio of less than 1:1 may result in the perception that the wall is not illuminated.
- Figure 17: Corridor and includes wall grazing, conventional wall washing, and a forward wall washing model for corridors. It also includes high ceiling washing/grazing models, a high 20-foot space, and extra high 40-foot space.
- Figure 18: Office application and includes the same subsets as the corridor models.
- Figure 19: General architectural wall washing and contains subsets for various lighting application techniques, systems, and ceiling heights.

BUS/VAN SPACES USING WALL-WASHING (Average vertical FC targets)
[Average horizontal foot-candle targets]

AUDIENCE SEATING
- Courtroom – (5-FC) [horizontal target =10-FC]
- Dining Areas – (1.5-FC low / 7.5-FC high) [horizontal target =3-FC / 20-FC]
- Religious – (5.0-FC low / 15-FC high)
- Preforming Arts – (3-FC) [horizontal target =10-FC]

CLASSROOM/TRAINING – (5-FC low / 15-FC high) (While Bd. 30-FC / Black Bd. 40-FC) [horizontal target =30-FC/ 50-FC]

CONFERENCE/MEETING ROOMS – (10-FC) (30-FC Presentation wall) [horizontal target =30-FC]

CORRIDORS/HALLWAYS – (3-FC low / 10-FC high) [horizontal target =5-FC low / 20-FC high]

LABORATORY – (10-FC) (30-FC at work area) [horizontal target = 30-FC / 50-FC to 100-FC at work area]

LIBRARY – (10-FC low / 20-FC high) [horizontal target =30-FC / 50-FC]

LOBBIES
- Auditorium – (7.5-FC) [horizontal target =15-FC]
- Elevator – (5-FC) [horizontal target =10-FC]
- General – (3.0-FC low / 10-FC high) [horizontal target =10-FC / 20-FC]
- Hotel– (3.0-FC low / 7.5-FC high) [horizontal target =10-FC / 20-FC]
- Post Office – (5-FC) [horizontal target =10-FC
- Religious Building – (5-FC) [horizontal target =10-FC]

LOUNGE – (1.5-FC low / 5-FC medium / 7.5-FC high) [horizontal target =4-FC / 10-FC / 15-FC]

OFFICE/OPEN PLAN – (7.5-FC low / 10-FC medium / 15-FC high) [horizontal target =15-FC / 20-FC / 30-FC]

RESTROOM – (3-FC low / 5-FC high) (20-FC at Vanities) [horizontal target =5-FC / 10-FC]

RETAIL SALES – (20-FC low / 30-FC medium / 75-FC high) (Retail average 1-6 from floor / 2-0 from ceiling)
[horizontal target = 30-FC Low / 40-FC Medium / 50-FC High]

STAIRWAY/ACTIVE – (3-FC low / 5-FC high) [horizontal target =5-FC / 10-FC]

STUDY HALL – (20-FC) [horizontal target =30-FC]

TRANSPORTATION
- Baggage – (5-FC) [horizontal target =10-FC]
- Concourse – (2.0-FC low / 5-FC high) [horizontal target =5-FC / 15-FC]
- Ticketing – (10-FC) [horizontal target =30-FC]
- Waiting/Reception – (5-FC) [horizontal target = 15-FC]

WAITING AREAS/RECEPTION –Hotel/Motel and Other – (10-FC low / 15-FC high) [horizontal target =5-FC / 30-FC]

Figure 16: Lumen Method model spaces with a wall washing component.

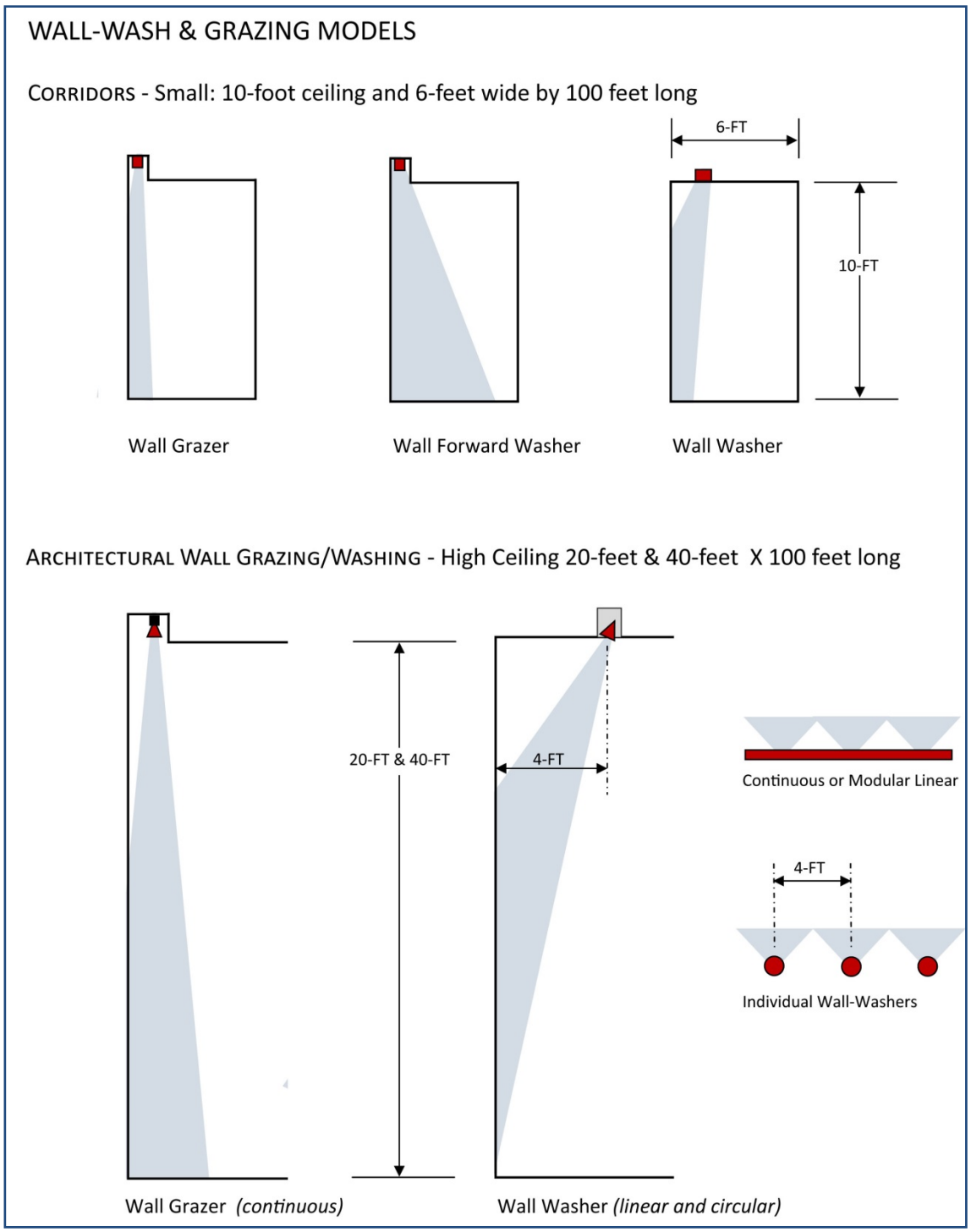

Figure 17: Corridor and high ceiling architectural wall washing.

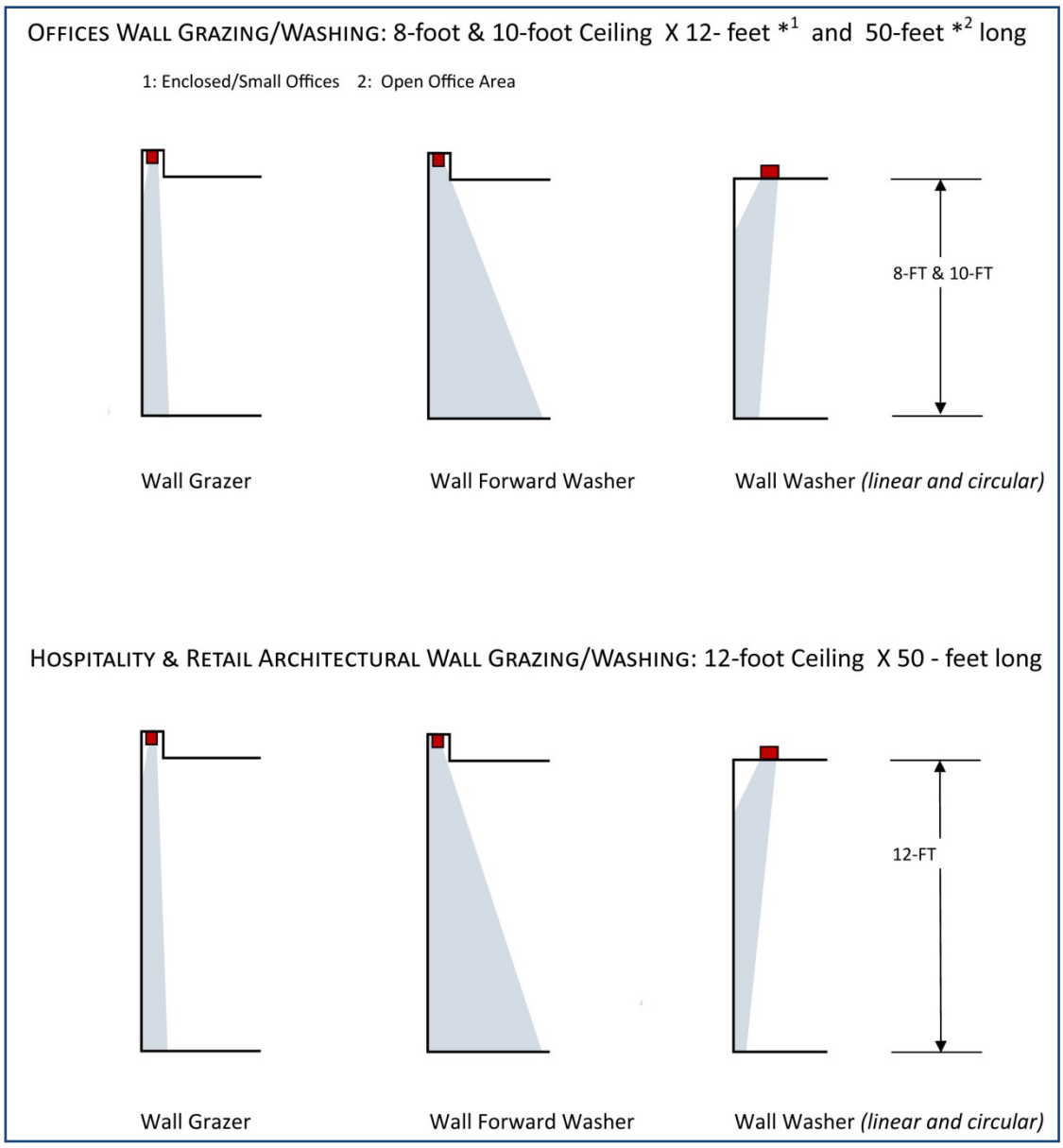

Figure 18: Office application and hospitality/retail architectural wall washing.

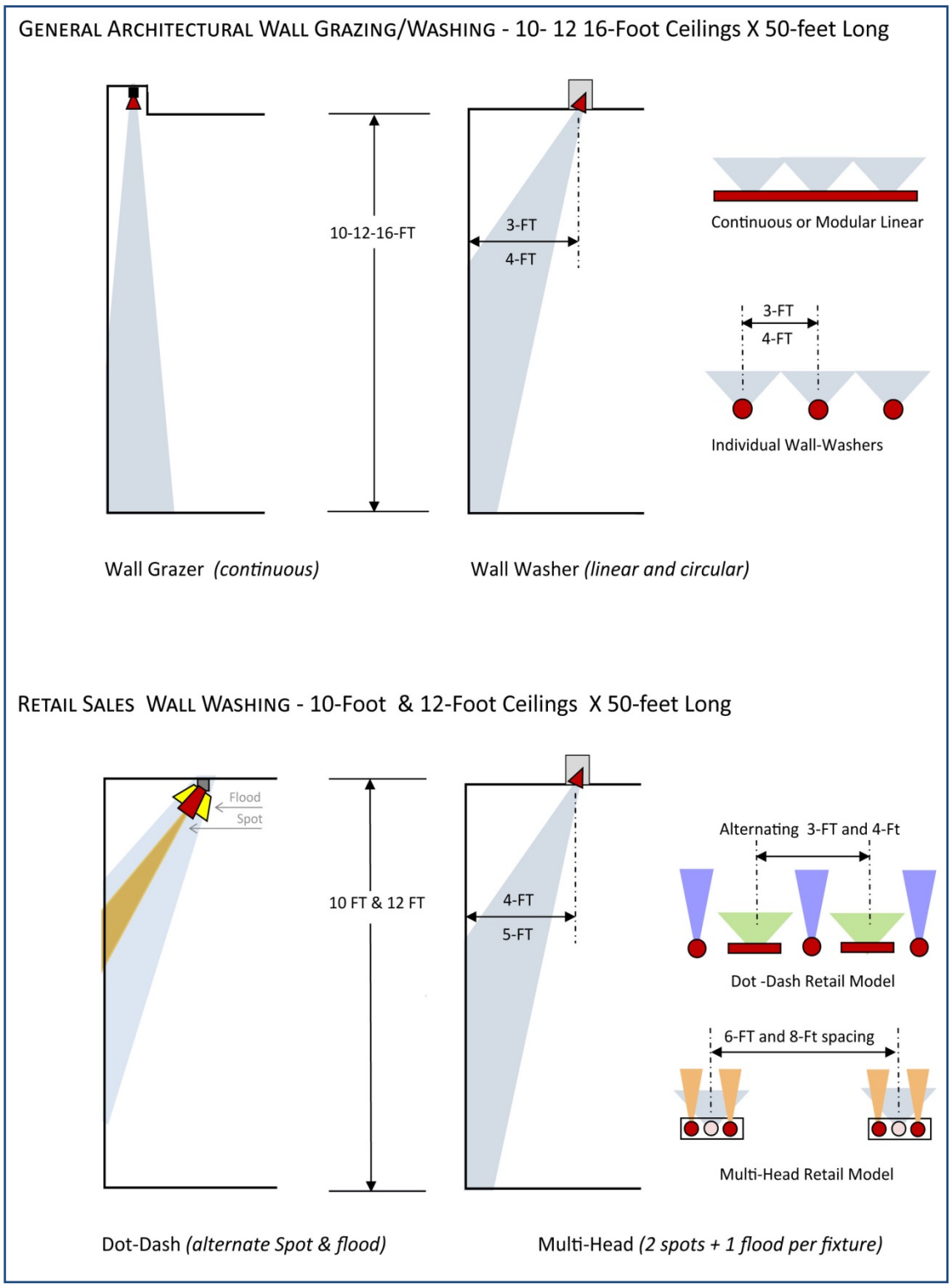

Figure 19: General architectural wall washing and retail sales merchandise wall washing.

Table 42 displays the results of the AGi32 wall washing models and prorated wall washing as applied to Lumen Method modeling where/when there is a wall washing component.

Table 42: Results of AGi32 Wall Washing Models

Luminaire Used		Luminaire efficacy (lm/W)	Delivered WW Efficacy (lm/W)	Delivered Floor[a] Efficacy (lm/W)	Delivered Ratio Floor to Wall (FC)
Code	Description				
901	Forward Wall Washer	104.5	21.90	29.73	2.71
902	Linear	73.3	29.29	16.48	1.14
903	Wall Grazer - Aperture	85.1	30.96	22.61	1.56
904	Wall Grazer - Linear	85.6	44.02	25.21	1.14
905	Wall Washer - Aperture	104.5	34.31	25.36	1.48
906	Wall Washer - Linear	70.0	31.21	16.32	1.06
952	Wall Washer - Aperture	83.6	23.43	13.18	1.14
953	High Ceiling	58.7	24.77	18.09	1.56
954	Wall Grazer - Aperture	68.1	35.22	20.17	1.14
955	High 90+ CRI	68.5	27.45	20.29	1.48
956	Wall Grazer - Linear	83.6	24.97	13.05	1.06

a. Half wall height into room.

Appendix H: Space Type Area Fractions by Building Type

Table 43 was developed by the Pacific Northwest Laboratory in support of the ASHRAE 90.1-2016 LPD development process.

The Complete Building values are simply the areas' weighted average values for the component Space Type areas that make up the various building types.

Table 43: Mapping of Areas Categories to Buildings

Application	Automotive 0.60	Convention 0.71	Courthouse 0.69	Dining-Family 0.60	Dining-Bar 0.64	Dining-Fast 0.64	Healthcare 0.67	Hotel 0.62	Hospital 0.81	Library 0.84	Manufacturing 0.60	Office 0.63	Parking 0.15	Retail 0.94	Religious 0.77	School 0.65	Sports 0.76	Performing Arts 0.80	Motion Picture 0.81	Town Hall 0.67	Warehouse 0.48
Auditorium: Audience/Seating Area																1.3%			34.9%		
Corridor/Transition		8.2%	11.5%	1.9%	4.3%	3.7%	21.7%	10.5%	21.0%		3.4%	9.6%	0.2%	1.9%	10.8%	14.0%	0.5%	8.6%	9.9%	8.4%	1.0%
Classroom/Lecture/Training							5.6%					0.8%		0.2%	13.3%	38.7%		4.1%	0.2%		
Court House: Audience/Seating Area			3.8%																		
Court House: Courtroom			22.8%																		
Electrical/Mechanical		6.9%	1.5%	2.0%	0.8%	0.8%	2.2%	2.6%	7.4%	1.7%	2.7%	2.8%	2.5%	0.8%	2.2%	3.3%	1.1%	5.1%	0.6%	1.8%	0.5%
Dining Area							4.2%	0.4%			0.7%	1.5%		0.8%		1.6%					
Lounge/Leisure Dining: Dining Area					28.5%			1.0%											2.1%		
Family Dining: Dining Area				50.1%	8.4%	32.2%															
Food Preparation		3.3%		26.1%	24.7%	33.4%	1.6%	1.2%		0.3%	0.1%	1.6%		1.4%	2.0%	1.7%	4.6%	1.7%	3.5%	1.9%	
Lounge/Recreation	0.9%	0.2%	1.3%	0.6%	0.2%	0.9%	10.8%	0.7%	1.0%	2.1%	0.5%	5.9%	0.0%	1.4%	1.1%	1.5%	5.0%	1.5%	0.4%	3.8%	1.1%
Stairway	0.9%	0.9%	5.3%	0.1%			2.8%	3.2%	1.4%			2.2%	1.5%	0.5%	3.2%	0.6%	1.0%	3.5%	2.5%	2.5%	0.4%
Stairway																					
Restrooms	3.2%	4.7%	6.7%	6.4%	6.8%	8.0%	10.1%	3.0%	1.1%	4.3%	0.9%	4.7%	0.1%	1.8%	3.7%	4.5%	9.6%	4.7%	6.2%	4.6%	1.8%
Parking Garage: Parking												0.7%	91.1%								
Medical/Industrial Research Laboratory							3.2%		18.3%			0.1%		0.1%		0.9%		3.4%			
Education Laboratory																					
Library: Stacks			1.0%							47.7%		0.3%				0.4%					
Library: Reading Area										14.0%	0.0%	0.2%			0.1%	0.1%		0.3%			
Lobby	5.7%	1.7%	12.1%	3.2%	11.4%	4.7%	10.5%	8.5%	6.1%	3.6%	1.0%	5.9%	1.7%	1.3%	0.6%	5.0%	45.5%	1.7%	3.8%	12.7%	1.1%
Gymnasium/Fitness Center: Locker Room	0.6%	0.2%						0.2%	0.5%			0.0%		0.2%		1.0%		0.2%	0.2%	0.1%	
Office - enclosed	29.0%	1.2%	12.2%	1.1%	3.6%	1.3%	8.7%	1.1%	9.3%	3.4%	3.7%	22.3%	0.6%	3.1%	9.6%	4.0%	1.1%	8.4%	3.5%	17.0%	2.2%
Office - open plan	2.5%	0.3%	2.1%	0.1%	0.5%	0.8%	1.7%	0.3%			0.4%	14.1%	0.1%	1.1%		0.9%		0.4%		2.3%	0.1%
Conference Meeting/Multipurpose		8.5%	7.8%				3.2%	1.7%	0.9%	3.8%	0.9%	10.2%	0.0%	0.2%	0.7%	3.7%	1.5%	14.8%	0.1%	24.2%	0.4%
Workshop: Workshop	0.8%	0.3%			0.2%			0.5%		1.4%		1.9%	0.1%	7.7%	3.2%	0.4%	0.1%	1.9%	0.3%	1.0%	0.7%
Manufacturing Facility: General Low Bay											80.7%										
Manufacturing Facility: General Low Bay																					
Manufacturing Facility: General High Bay																					
Manufacturing Facility: Extra High Bay																					
Active storage	0.3%	5.3%	9.1%	8.5%	10.0%	9.8%	2.2%	2.4%		17.6%	5.0%	12.9%	2.0%	10.0%	4.4%	10.5%	1.5%	4.8%	11.6%	17.5%	
Warehouse: Fine Material													0.1%								20.5%
Warehouse: Medium/Bulky Material																					70.0%
Transportation: Air/Train/Bus - Baggage Area																					
Transportation: Terminal - Ticket counter												0.4%									
WHOLE BULDING ANALYSIS ONLY: Bank Customer Area																					
Office: Banking Activity Area												0.1%		0.0%							
Barber & Beauty Parlor																					
Religious: Audience/Seating Area															9.0%						
Religious: Worship - pulpit, choir															26.5%						
Court House: Judges Chambers			2.8%																	0.6%	
Hospital/Healthcare: Exam/Treatment							3.7%		18.0%			0.6%		0.4%							
Hospital/Healthcare: Hospital/Medical supplies																					
Hospital/Healthcare: Nurse station		0.1%							3.5%		0.0%	0.1%				0.1%	0.3%				
Hospital/Healthcare: Physical therapy																					
Hospital/Healthcare: Patient Room									7.2%												
Hospital/Healthcare: Pharmacy							0.8%		0.7%					0.5%							
Hospital/Healthcare: Radiolylmaging																					
Hospital/Healthcare: Operating Room							0.3%		1.8%												
Hospital/Healthcare: Recovery																					
Hospital/Healthcare: Active storage							5.1%		1.7%			0.4%									
Convention Center: Exhibit space																					
Hotel/Conference Center - Conference/Meeting		23.8%																			
Laundry-Ironing & Sorting					0.1%		0.5%	1.2%	0.3%			0.1%		0.0%		0.0%		0.2%			
Museum: General exhibition		24.4%																0.8%			
Museum: Restoration																					
Museum: Active Storage																					
Automotive Facility: Garage Service/Repair	56.2%																			1.7%	
Performing Arts Theatre: Audience/Seating Area																		22.4%			
Motion Picture Theatre: Audience/Seating Area																			12.6%		
Performing Arts theatre: Lobby		5.5%																7.1%			
Auditorium: Lobby																		2.0%	3.1%		
Motion Picture Theatre: Lobby																			4.6%		
Religious Buildings: Lobby															8.8%						
Retail: Department Store Sales Area								0.1%						15.7%			0.7%	0.1%			0.2%
Retail: Supermarket Sales Area														20.4%							
Retail: Mass Merchandising Sales Area								0.1%						30.4%		0.2%					
Retail: Mall Concourse		4.4%																			
Retail: Dressing/Fitting Room															0.6%			1.9%			
Convention Center: Audience/Seating Area																					
Sports Arena: Audience/Seating Area																	11.4%				
Gymnasium: Audience Seating/Permanent Seating																	11.6%				
Fitness Center: Audience/Seating Area																					
Gymnasium: Playing Area					0.7%	4.5%	1.3%	0.9%				0.2%		0.1%		5.5%					
Fitness Center: Fitness Area								1.0%				0.5%									
Gymnasium: Fitness Area																0.1%					
Sports Arena: Class 1 -Court Sports Area																	4.3%				
Sports Arena: Class 2 - Court Sports Area																					
Sports Arena: Class 3 - Court Sports Area																					
Sports Arena: Class 4- Court Sports Area																					
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	40.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.6%	100.0%	100.0%	100.0%

Appendix I: Luminaire First Cost, Maintenance Cost, and Total Incremental Cost

Table 44 outlines the first costs, maintenance costs, and total incremental costs for all the luminaires used to develop the proposed 2019 LPDs.

Table 44: First Cost, Maintenance Cost, and Total Incremental Cost for All Luminaires

Building Type	Space Type Description	Luminaire Description	2016 First Cost	2016 Maintenance Cost	2019 First Cost	2019 Maintenance Cost	Total Incremental Cost
All buildings	Medical/Industrial Research Laboratory	Narrow linear LED surface/suspended	$280.00	$35.55	$320.00	$0.00	$40.00
	Education Laboratory	Narrow linear LED surface/suspended	$280.00	$19.18	$320.00	$0.00	$40.00
	Corridor/Transition	Downlight	$116.00	$56.11	$220.00	$0.00	$104.00
	Classroom/Lecture/Training	Linear LED lensed troffer	$78.00	$15.70	$130.00	$0.00	$52.00
	Electrical/Mechanical	Industrial LED channel - surface or suspended	$48.00	$12.56	$88.00	$0.00	$40.00
	Dining Area	Downlight	$116.00	$56.11	$320.00	$0.00	$204.00
	Food Preparation	Linear LED lensed troffer	$78.00	$15.70	$130.00	$0.00	$52.00
	Lounge/Recreation	Downlight	$184.00	$127.96	$420.00	$0.00	$236.00
	Stairway	Narrow linear LED surface/suspended	$250.00	$15.70	$320.00	$0.00	$70.00
	Stairway	Linear LED lensed troffer	$78.00	$15.70	$130.00	$0.00	$52.00
	Restrooms	Wall mount linear LED (up/down light)	$350.00	$27.42	$480.00	$0.00	$130.00
	Lobby	Indirect pendant - Linear LED	$280.00	$14.79	$450.00	$0.00	$170.00
	Office - enclosed	Linear LED direct/indirect troffer	$128.00	$31.92	$200.00	$0.00	$72.00
	Office - open plan	Linear LED suspended direct/indirect distribution	$280.00	$12.34	$470.00	$0.00	$190.00
	Conference Meeting/Multipurpose	Narrow linear LED surface/suspended	$250.00	$31.39	$320.00	$0.00	$70.00
	Active storage	Industrial LED channel - surface or suspended	$48.00	$12.50	$88.00	$0.00	$40.00
Auditorium	Audience/Seating Area	PAR downlight flood	$126.00	$209.91	$450.00	$0.00	$324.00

Building Type	Space Type Description	Luminaire Description	2016 First Cost	2016 Maintenance Cost	2019 First Cost	2019 Maintenance Cost	Total Incremental Cost
		Wall washer	$280.00	$27.36	$420.00	$0.00	$140.00
	Lobby	Downlight	$126.00	$134.48	$320.00	$0.00	$194.00
Automotive Facility	Garage Service/Repair	Industrial LED channel - surface or suspended	$130.00	$26.95	$280.00	$0.00	$150.00
Bank Customer Area		Narrow linear LED surface/suspended	$250.00	$45.60	$320.00	$0.00	$70.00
Barber & Beauty Parlor		Linear LED lensed troffer	$78.00	$22.80	$130.00	$0.00	$52.00
Convention Center	Exhibit space	High-bay	$192.00	$56.59	$550.00	$0.00	$358.00
	Audience/Seating Area	Downlight	$116.00	$69.69	$320.00	$0.00	$204.00
Court House	Audience/Seating Area	Downlight	$184.00	$127.41	$320.00	$0.00	$136.00
	Courtroom	Indirect pendant - LED Modules	$450.00	$198.36	$550.00	$95.48	$100.00
	Judge’s Chambers	Narrow linear LED recessed or suspended	$250.00	$62.87	$320.00	$0.00	$70.00
Family Dining	Dining Area	Downlight	$116.00	$99.18	$320.00	$0.00	$204.00
Fitness Center	Audience/Seating Area	Linear LED lensed troffer	$78.00	$31.44	$130.00	$0.00	$52.00
	Fitness Area	Indirect pendant - LED Modules	$450.00	$96.80	$560.00	$0.00	$110.00
Gymnasium	Audience Seating/Permanent Seating	Low-bay (130W)	$210.00	$36.89	$480.00	$0.00	$270.00
	Playing Area	Low-bay (88W)	$86.00	$14.38	$220.00	$0.00	$134.00
	Fitness Area	Indirect pendant - LED Modules	$450.00	$58.46	$560.00	$0.00	$110.00
Gymnasium/Fitness Center	Locker Room	Linear LED lensed troffer	$78.00	$47.29	$130.00	$0.00	$52.00
Hospital/ Healthcare	Exam/Treatment	Linear LED High Performance lensed troffer	$158.00	$36.42	$203.00	$0.00	$45.00
	Hospital/Medical supplies	Linear LED lensed troffer	$78.00	$7.99	$130.00	$0.00	$52.00
	Hospital - Nursery	Linear LED direct/indirect troffer	$128.00	$31.92	$200.00	$0.00	$72.00
	Nurse station	Linear LED suspended direct/indirect distribution	$280.00	$12.34	$470.00	$0.00	$190.00
	Physical therapy	Linear LED suspended direct/indirect distribution	$280.00	$12.34	$470.00	$0.00	$190.00
	Patient Room	Linear LED direct/indirect troffer	$128.00	$20.74	$200.00	$0.00	$72.00

Building Type	Space Type Description	Luminaire Description	2016 First Cost	2016 Maintenance Cost	2019 First Cost	2019 Maintenance Cost	Total Incremental Cost
	Pharmacy	Linear LED lensed troffer	$78.00	$14.81	$130.00	$0.00	$52.00
	Radiology/Imaging	Linear LED direct/indirect troffer	$128.00	$31.92	$200.00	$0.00	$72.00
	Operating Room	Linear LED High Performance lensed troffer	$158.00	$18.68	$203.00	$0.00	$45.00
	Recovery	Linear LED High Performance lensed troffer	$158.00	$18.68	$203.00	$0.00	$45.00
	Active storage	Industrial LED channel - surface or suspended	$30.00	$12.50	$58.00	$0.00	$28.00
	Laundry-Washing	Linear LED lensed troffer	$78.00	$15.62	$130.00	$0.00	$52.00
Hotel/Conference Center - Conference/Meeting		Indirect pendant - LED Modules	$450.00	$139.39	$550.00	$86.86	$100.00
Laundry-Ironing & Sorting		Linear LED lensed troffer	$78.00	$22.80	$130.00	$0.00	$52.00
Library	Stacks	Narrow linear LED Bat-Wing distribution	$300.00	$10.90	$400.00	$0.00	$100.00
Lounge/Leisure Dining	Dining Area	MR16 downlight flood	$110.00	$96.08	$320.00	$0.00	$210.00
Manufacturing Facility	General Low Bay	Low-bay	$210.00	$18.91	$480.00	$0.00	$270.00
	General Low Bay	Low-bay	$144.00	$0.00	$420.00	$0.00	$276.00
	General High Bay	High-bay	$192.00	$56.59	$550.00	$0.00	$358.00
	Extra High Bay	Industrial super high-bay LED High Output	$380.00	$387.19	$1,500.00	$0.00	$1,120.00
Motion Picture Theatre	Audience/Seating Area	Downlight	$80.00	$134.70	$320.00	$0.00	$240.00
	Lobby	Downlight	$184.00	$96.60	$320.00	$0.00	$136.00
Museum	General exhibition	MR16 downlight flood	$95.00	$103.54	$320.00	$0.00	$225.00
	Restoration	Linear LED High Performance lensed troffer	$158.00	$35.19	$203.00	$0.00	$45.00
	Active Storage	Industrial LED channel - surface or suspended	$30.00	$18.24	$58.00	$0.00	$28.00
Office	Banking Activity Area	Linear LED direct/indirect troffer	$128.00	$31.92	$200.00	$0.00	$72.00
Parking Garage	Parking	Parking structure LED luminaire	$350.00	$57.30	$550.00	$0.00	$200.00
Performing Arts Theatre	Audience/Seating Area	Downlight	$126.00	$95.91	$320.00	$0.00	$194.00
	Lobby	Downlight	$126.00	$172.04	$320.00	$0.00	$194.00
Religious	Audience/Seating Area	Downlight flood	$120.00	$283.47	$360.00	$0.00	$240.00

Building Type	Space Type Description	Luminaire Description	2016 First Cost	2016 Maintenance Cost	2019 First Cost	2019 Maintenance Cost	Total Incremental Cost
	Worship - pulpit, choir	Downlight flood	$120.00	$283.47	$360.00	$0.00	$240.00
Retail	Department Store Sales Area	2X2 Low brightness direct/indirect LED troffer	$142.00	$68.40	$250.00	$0.00	$108.00
	Supermarket Sales Area	Narrow linear LED surface/suspended	$280.00	$54.72	$380.00	$0.00	$100.00
	Mass Merchandising Sales Area	2X4 LED low-brightness direct/indirect basket	$130.00	$31.92	$280.00	$0.00	$150.00
	Mall Concourse	Downlight flood	$250.00	$125.21	$380.00	$0.00	$130.00
	Dressing/Fitting Room	Downlight	$184.00	$94.57	$420.00	$0.00	$236.00
	Merchandising Sales Area	Downlight	$180.00	$70.43	$320.00	$0.00	$140.00
Sports Arena	Audience/Seating Area	Indirect pendant - LED Modules	$450.00	$140.86	$550.00	$88.03	$100.00
	Class 1 - Court Sports Area	High-bay	$192.00	$57.16	$550.00	$0.00	$358.00
	Class 2 - Court Sports Area	High-bay	$192.00	$56.59	$550.00	$0.00	$358.00
	Class 3 - Court Sports Area	Low-bay (130W)	$210.00	$56.59	$480.00	$0.00	$270.00
	Class 4 - Court Sports Area	Low-bay (236W)	$144.00	$26.59	$420.00	$0.00	$276.00
Transportation	Air/Train/Bus - Baggage Area	Narrow linear LED surface/suspended	$250.00	$45.60	$320.00	$0.00	$70.00
	Terminal - Ticket counter	Narrow linear LED surface/suspended	$250.00	$15.98	$320.00	$0.00	$70.00
Warehouse	Fine Material	Industrial LED channel - surface or suspended	$26.00	$27.36	$88.00	$0.00	$62.00
	Medium/Bulky Material	High-bay	$192.00	$56.59	$550.00	$0.00	$358.00
Workshop	Workshop	Industrial LED channel - surface or suspended	$26.00	$27.67	$88.00	$0.00	$62.00

Appendix J: RATIONALE FOR CHANGES TO LIGHTING STANDARDS

Lighting technology has changed rapidly in recent years but, until relatively recently, there were no suitable replacements for incandescent directional lighting. With the introduction of high quality, long lived, and relatively affordable LEDs, the least efficient incandescent light sources in nonresidential construction have begun to be replaced with LED products with greater frequency. Additionally, LED light sources are rapidly displacing higher efficacy legacy products such as fluorescent, metal halide, and CFL sources. National building energy efficiency standards such as ASHRAE 90.1-2016 are now primarily based on LED light sources. Similar to the ASHRAE 189.1-2017 standard for Green High Performance buildings, the Statewide CASE Team recommends that the basis of the Title 24, Part 6 Standards be LED-level performance. This CASE Report documents that an LED performance level is feasible and cost-effective and is reflective of the majority of the new construction lighting market. Some proposed changes are also designed to more closely align with the ASHRAE standard that is used frequently in other states.

The risk that building occupants will replace high quality, low wattage LED sources with incandescent sources is now significantly reduced. As a result, there is a diminished need for a high level of documentation required to ensure that higher efficacy sources installed at time of occupancy are not immediately removed and replaced. Thus, the Statewide CASE Team recommends that Title 24, Part 6 align with ASHRAE 90.1-2016 and allow projects with track lighting to directly use the wattage of a current limiter to establish the installed wattage of the track lighting system (according to the current standards, one must use the larger of the current limiter rating or 12.5 watts per linear foot of track lighting). In addition, the current standards require maintaining an Energy Commission database for current limiters as well as a special construction installation document for validating installation of current limiters. The Statewide CASE Team also recommends that current limiters be certified to their UL rating rather than certified to an Energy Commission database. Inspecting or specifying the rating of a current limiter should be no more onerous than inspecting or specifying the wattage of a luminaire.

The following section outlines in detail the proposed changes, by section, and the rationale for each.

SECTION 100.1 – Definitions and Rules of Construction

- Added definitions of solid state lighting and solid state lighting driver, as this type of equipment is the basis of the proposed lighting power densities in the new standard.
- The solid state lighting definition is based upon a definition of solid state lighting in the 10th Edition of the IES Handbook.[6]
- The definition for solid state driver is based upon a definition in the IES Publication Nomenclature and Definitions for Illuminating Engineering.[7]

SECTION 110.9 – Mandatory Requirements for Lighting Control Devices and Systems, Ballasts, and Luminaires

- Removed Section 110.9(c) Track Lighting Integral Current Limiter and Section 110.9(d) Track Lighting Supplementary Overcurrent Protection Panel. Being listed by UL 1077 is sufficient.

[6] P 7-58 IES Handbook

[7] Section 6.8.4.1 IES RP-16-10

- UL 1077 Standard for Supplementary Protectors for Use in Electrical Equipment (2015) is proposed to be added to Appendix 1-A: Standards and Documents Referenced in the Energy Efficiency Regulations.

SECTION 130.0 – Lighting Systems and Equipment, and Electrical Power Distribution Systems — General

Section 130.0(c) Luminaire Wattage.

- Changed name of subsection to "Luminaire Wattage" instead of “Classification and Power” as all the text in the section refers to luminaire wattage.
- Luminaires are no longer classified as low or high efficacy in this section as that determination is conducted only for the low rise residential requirements in Section 150.0.
- Requirements are reorganized based primarily on preexisting format. This section could be further reorganized so that most common configurations are listed first and least common are listed last. The Statewide CASE Team requests input on this section.
    - Luminaires without permanently installed ballasts or drivers – luminaires with removable lamps
    - Luminaires with permanently installed ballasts
    - SSL luminaires with permanently installed drivers where it is difficult to change the wattage
    - SSL luminaires with permanently installed drivers but that allow for easy “daisy chaining” of added SSL modules
    - Track lighting systems – line and low voltage systems combined in this section
    - Low voltage systems where lamps or lamp holders cannot be added without rewiring the system
    - Power over Ethernet systems
    - Miscellaneous lighting

Section 130.0(c)1

- For a new luminaire without a permanently installed ballast, driver, or transformer, the rated wattage would be the labeled wattage of the luminaire. This removes the requirements about how labels are structured and indicates the expectation that the product has a label of its rated wattage.
- The description of ratings based on the diameter of the aperture would be removed from this section. As effectiveness increases, luminaire wattages are dropping, so it does not make sense to fix the wattage of a luminaire based upon legacy technologies. In addition, higher efficacy products are now improving in color quality and dropping in price, and have relatively long lives. The labor cost of removing lamps and replacing them with low efficacy lamps is often not cost-effective. This reduces the complexity of complying with the standard – now one only has to consider the wattage that is actually installed in a luminaire, rather than a minimum wattage allowed to be claimed for a given luminaire dimension.
- This proposal would remove the prohibition against using luminaires with a screw-base socket. If the luminaire is labeled for a given wattage and has a product installed that is less than or equal to that wattage, the luminaire could use the labeled wattage in installed lighting wattage calculations.
- The proposed exception to Section 130.0(c)1 would allow the wattage for altered luminaires to be based upon the input wattage of the lamp and the control equipment. In other words, one does not have to hire a UL inspector to install new labels on luminaires when the wattage is dropped by installing lower wattage lamps, as long as those lamps have at least a 25,000 hour rated life. This eliminates an unnecessary cost associated with lighting energy efficiency upgrades.

Section 130.0(c)3 and 4

- These two companion sections clarify when the installed watts should be the maximum rated wattage of a driver versus the rated wattage for the driver/light source combination. The proposed rule set is similar to that for low voltage luminaires, and is based on ASHRAE 90.1-2016.
    - If the configuration of the luminaire does not allow for adding additional light sources without rewiring, the installed wattage is the rated input wattage of the driver and light source combination.
    - If the additional light sources or luminaires can be easily "daisy chained" without rewiring, the installed wattage of the luminaire is considered to be the maximum rated input wattage of the driver.

Section 130.0(c)5

- The proposal combines the rules for line voltage and low voltage track lighting systems.
    - Installed wattage is the higher of installed lighting wattage or 30 watts per linear foot of track lighting (this was dropped from 45 watts per linear foot to align with ASHRAE 90.1-2016); or
    - The maximum wattage of a device that limits the amount of power than can be drawn by the track lighting system. This can be a current limiter, overcurrent protection, or a low voltage transformer.
        - In alignment with ASHRAE 90.1-2016, when using a current limiter, one does not have to select the greater of the current limiter wattage and 12.5 watts per linear foot of track lighting. This simplifies compliance and allows low wattage track lighting systems.

Section 130.0(c)6&7

- This describes explicitly how to calculate the wattage of low voltage lighting systems. This identifies how to calculate low voltage luminaire watts for all situations other than low voltage track lighting (described in Section 130.0(c)5).
    - If the luminaire is designed so one cannot add lamps or luminaires without rewiring, the luminaire wattage is the wattage of the lamp/transformer combination.
    - If added lamps or luminaires can be added to the low voltage system without rewiring, use the maximum rated wattage of the transformer.

Section 140.6 – Prescriptive Requirements for Indoor Lighting

Section 140.6(a) Calculation of ~~Actual~~ Adjusted Indoor Lighting Power

- Changing the name from "actual power" to "adjusted power" will clear up a common point of confusion. The primary purpose of this section is to describe how the actual installed wattage is derated to account for:
    - Interlocked systems
    - Power Adjustment Factors
    - Excluded lighting wattage
    - Tailored Method height adjustment wattage reduction (newly added)
- The term "adjusted lighting power" is easy to understand as it is similar to adjusted income. The installed wattage of a system is derated by various factors to compare the adjusted power against the allowed power. This is similar to calculating adjusted income from gross income after removing various deductions.
- A new subsection "Tailored Method display lighting wattage reduction" makes explicit that the mounting height multipliers are applied to the installed wattage of display lighting that is

mounted higher than 11 feet above the finished floor. The resulting adjustment yields the adjusted power for these display lighting luminaires.

Section 140.6(c)2 Area Category Method

- **Section 140.6(c)2A.** Clarifies that one can use an equivalent primary function area when an exact match does not exist in the list of spaces.
- **Section 140.6(c)2E.** Unleased tenant area lighting reduced from 0.6 W/ft^2 to 0.4 W/ft^2 to account for increased lighting efficacy. Additional lighting can be added at the time of the tenant improvement.
- **Section 140.6(c)2G.** Allowed Additional Lighting Allowances have been moved into a column in TABLE 140.6-C instead of being listed as footnotes to the table. This allows for easier recognition of these allowances.
- **Section 140.6(c)2Gvi** – Removes the undefined term "actual design wattage" and replaces it with the defined term "Adjusted Indoor Lighting Power."
- **Section 140.6(c)2Gvii** – The additional allowed lighting power for videoconferencing studio is reduced from 1.5 W/ft^2 to 1.0 W/ft^2 to account for technology improvements. This allowance was introduced in the 2013 Title 24, Part 6 standards.

Section 140.6(c)3 Tailored Method

- **Section 140.6(c)3A.** Removed Section 140.6(c)3H, which allowed the use of the IES Handbook and Table 140.6-G. See commentary below on Section 140.6(c)3H for more detail. This section now clarifies that for "primary function areas not listed in TABLE 140.6-D, selection of a reasonably equivalent function area from TABLE 140.6-D shall be permitted." This matches the approach taken by ASHRAE 90.1-2016. An exact match between the primary function of the space and the table is not required.
- **Section 140.6(c)3F.** This section removed as general lighting allowance does not prohibit one from using directional sources that are more typical of display lighting.
- **New Section 140.6(c)3F** (used to be G). Language modified so that heading names in TABLES 140.6-D and G match the descriptions in this section.
- **Section 140.6(c)3H.** This section entirely removed. This is aligned with ASHRAE 90.1-2016 which requires that one choose the category most closely matched in the standard and design to that LPD. It is not reasonable to expect building officials to validate the space selection and illuminance criteria from the IES Handbook. This goes hand-in-hand with the changes to Section 140.6(c)3A, which allows reasonably close selection of a primary function area allowance for the area being designed. Areas that have been specifically called out are Exercise Center, Gymnasium Medical and Clinical Care, Police Stations and Fire Stations and interior areas that one might find in a Public Rest Area, which are included in the Complete Building and Area Category Methods. Finally, as mentioned earlier, "Other primary function areas that are listed in neither TABLE 140.6-C nor TABLE 140.6-D" are addressed by allowing the “selection of a reasonably equivalent function area from TABLE 140.6-C."
- **New Section 140.6(c)3G**. Clarified that integral luminaires with a directional source can be display lighting. When this was originally written, display lighting was provided only with lamps. Also clarifies that the mounting height adjustment factor is multiplied by the installed wall display wattage for luminaires that are mounted above 11 feet to yield Adjusted Indoor Lighting Power. The original text introduced an undefined term, "design watts." This concept of design watts does not match the terms at the beginning of Section 140.6, which states one is comparing Allowed Indoor Lighting Power to Adjusted Indoor Lighting Power. This section also allows one to assign display case power to the wall display allowance if the display case is attached or adjacent to a wall.

- **New Section 140.6(c)3H.** Similar clarification to that given for wall display. Also that floor display power can be allotted to display cases that are neither attached to nor adjacent to a wall.
- **New Section 140.6(c)3J.** Allowed wattage dropped from the lesser of 0.8 W/ft^2 of floor area and 12 W/ft^2 of display case area to the lesser of 0.55 W/ft^2 of floor area and 8 W/ft^2 of display case area.

Appendix K: TAILORED METHOD MODELS

Spaces and function areas associated with the Tailored Method under Title 24, Part 6 are by design considered to be more complex with layered lighting needs and conditions that may not be adequately served under the Area Category Method. Therefore, the LPDs for the Tailored Method were developed using detailed spreadsheet analysis, extensive AGi32 luminosity modeling, and evaluation of incumbent versus LED sources for the numerous lighting layers associated with the Tailored Method.

A wide range of retail sales areas from Big Box retail to Department Store and High End Specialty retail areas, along with High Atrium Hotel spaces were modeled using the AGi32 luminosity software. The general ambient illumination for the models is based on Table 140.6-G in Title 24, Part 6. Luminaires used in the modeling were based on high CRI (90+ for ambient lighting luminaires) and 95+ CRI with R9 values of 90+ for luminaires providing display and accent lighting. See Table 45 for more details. Figure 20 through Figure 26 provide visualizations for each of the modeled spaces and whether the designs as rendered "Passed or Failed" the proposed LPD target. Examples of AGi32 modeling of accent/display at three different mounting heights is shown in Figure 27.

Floor and Wall Display/Accent lighting was modeled within the AGi32 retail examples. It was explored further through luminaire comparison of incumbent and legacy versus 92 CRI to 97 CRI (90+ R9) LED sources which are the basis for the proposed Title 24 2019 display and accent lighting LPD targets. See Table 46 for more details on Floor Accent/Display lighting and Table 47 for Wall Display/Accent lighting. Figure 28 illustrates the comparison of incumbent/legacy fixtures/lamps versus LED fixtures/lamps at the baseline (11-foot) mounting height. Similar studies and analyses were conducted for the valuable display allowance; see Figure 27 for details.

With the advent of LED lamps and luminaires, the mounting height factor for display and accent lights in the Tailored Method (Table 140.6-E) needed to be re-evaluated. Incumbent/legacy sources (halogen and ceramic MH) used previously to develop the height factor have gaps in lumen output. This is no longer an issue with LED products. The updated Table 140.6-E (Table 17 in Section 7.1) has mounting height factors based on LED products, which are more appropriate for an LED based code. Table 50 presents results of the performance of LED directional lamps and luminaires at various mounting heights while Table 51 recaps the proposed heights and range of mounting height factors for Table 140.6-E.

The proposed LPD target for Ornamental Lighting is also based on using all LED sources; analysis was performed through luminaire comparison of incumbent and legacy sources versus 92 CRI to 97 CRI (90+ R9) LED sources. Table 48 illustrates the comparison between incumbent sources for sconces, chandeliers, and luminous panels versus LED sources. Table 49 provides a recap of the efficacy as an LED factor versus the efficacy of the incumbent/legacy source for Halogen, CFL, and CMH. Figure 30: Comparison of legacy/incumbent versus LED for ornamental lighting illustrates the comparison of incumbent/legacy fixtures/lamps versus LED fixtures/lamps for Ornamental Lighting applications. The weighted average LED factor of 0.80 for Ornamental Lighting is based on LED; it is a multiplier used to determine the proposed target of 0.40 W.

Table 45: Tailored Retail Space Compliance Models

Model Name	Description	Year Design	Base LPD	Wall LPD	Floor LPD	Ornamental LPD	Val LPD	Model LPD	Title 24, 2016 Max LPD
Big Box – A[a] Warehouse Store	LED Replicate: T5/HO – T8 High Bay	Actual 2013 Design Model	0.96	0.04	0.00	0.00	0.00	1.00	0.94
		Proposed 2019 Design Model	0.77	0.03	0.00	0.00	0.00	0.80	0.75
Big Box – B[a] Builders Supply	LED Replicate: Ceramic Metal Halide	Actual 2013 Design Model	1.13	0.04	0.00	0.00	0.00	1.17	0.94
		Proposed 2019 Design Model	0.83	0.03	0.00	0.00	0.00	0.86	0.75
Basic Retail Mom & Pop	LED Replicate: T8 Fluorescent & Halogen	Actual 2013 Design Model	0.50	1.30	0.34	0.00	0.00	2.14	2.42
		Proposed 2019 Design Model	0.48	0.50	0.10	0.00	0.00	1.08	1.32
Specialty – A Home Store	LED Replicate: CFL MR16 HIR & MR16 CMH	Actual 2013 Design Model	0.14	1.36	1.17	0.06	0.00	2.73	2.89
		Proposed 2019 Design Model	0.48	0.84	0.80	0.04	0.00	2.16	2.41
Specialty – B Kitchen & Gourmet	LED Replicate: CFL and MR16 CMH	Actual 2013 Design Model	0.30	1.54	0.86	0.00	0.00	2.70	2.84
		Proposed 2019 Design Model	0.42	0.80	0.80	0.00	0.00	2.06	2.33
High End – A Designer Shop 1 80CRI	LED Replicate: CFL and MR16 CMH	Actual 2013 Design Model	0.53	1.35	1.25	0.00	0.00	3.13	3.33
		Proposed 2019 Design Model	0.42	1.15	0.60	0.00	0.00	2.17	2.59
High End – B[d] Designer Shop 2 90+CRI	LED Replicate: CFL, T5 and PAR Halogen IR	Actual 2013 Design Model	0.50	1.49	1.43	0.26	0.94	4.62	4.53
		Proposed 2019 Design Model	0.54	1.21	0.80	0.00	0.00	2.55	2.85
High End – C[d] Fine Jewelry	LED Replicate: T5, CMH and MR16 IR	Actual 2013 Design Model	0.71	0.19	0.09	0.00	0.00	0.99	1.06
		Proposed 2019 Design Model	0.20	0.88	1.15	0.00	0.70	2.93	3.22
High Atrium – A[b] – High Rise Hotel – 80CRI	LED Replicate: T8, CFL & Halogen	Actual 2013 Design Model							
		Proposed 2019 Design Model	0.76	0.18	0.00	0.02	0.00	0.96	0.92
High Atrium – B[b] High Rise Hotel – 90+CRI	LED Replicate: T8, CFL & Halogen	Actual 2013 Design Model							
		Proposed 2019 Design Model	0.91	0.22	0.00	0.03	0.00	1.16	0.92
High Atrium – C[c] High Rise Hotel – 90+CRI	LED Replicate: T8, CFL & Halogen	Actual 2013 Design Model							
		Proposed 2019 Design Model	0.50	0.22	0.00	0.03	0.00	0.75	0.98

a. Allowed LPD under 2019 Area Compliance = 0.95W – Allowed LPD under 2016 Area Compliance = 1.20W – This model (PASS) under both 2019 and 2016 Area Compliance respectively.

b. Allowed LPD under 2019 Area Compliance = 0.90W (FAIL) – This space falls under both Area and Tailored Compliance (however, if retail it is allowed 1.20W (PASS)).

e. Original model was retail with OA higher FC targets and allowed LPD – Adjusting model to Hotel 40 FC baseline = lower LPD needed (PASS).

c. Baseline model is T24-2013 retail – Under 2013 Compliance Standard allowed = 4.65W (PASS).

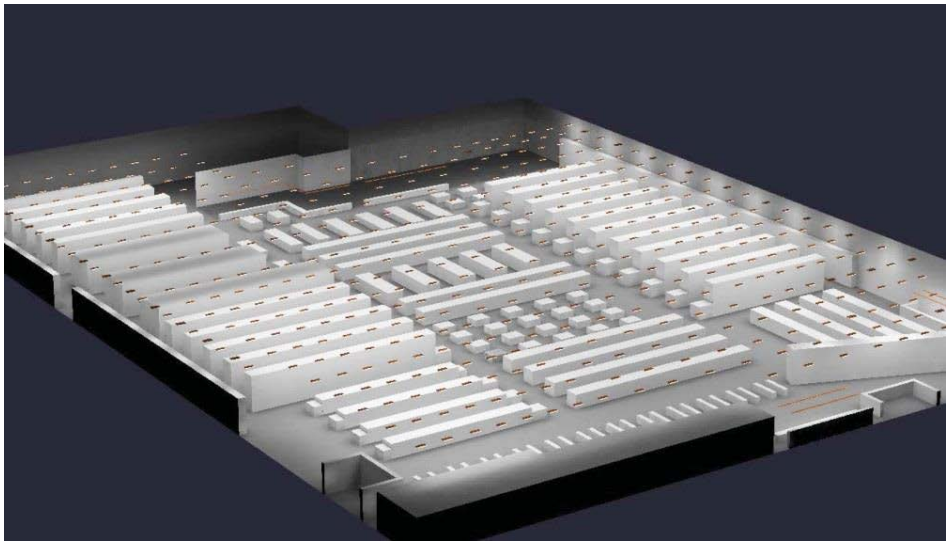

Figure 20: Big box models A & B. Model A = 0.80W (PASS using Area Category). Model B = 0.86 (PASS using Area Category).

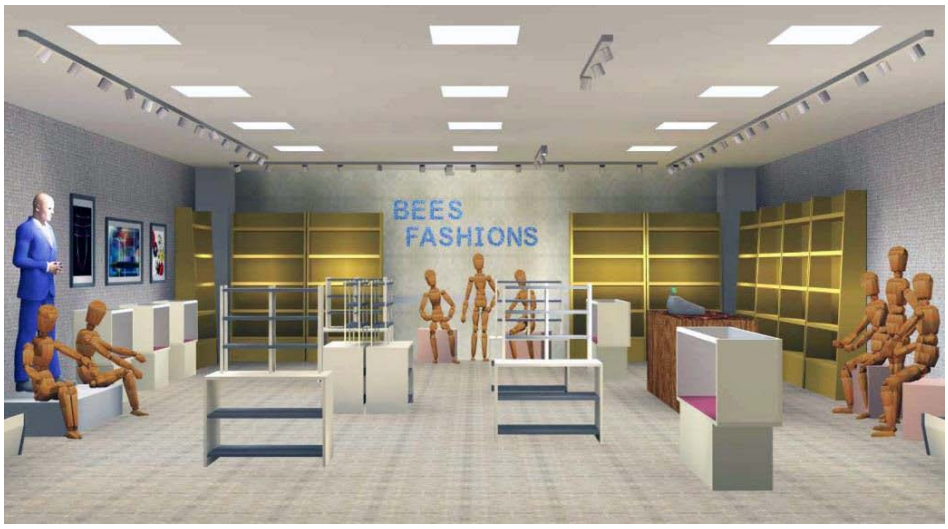

Figure 21: Basic retail model. Mom & Pop = 1.08W (PASS).

Figure 22: Specialty store model A. Home Store = 2.16W (PASS).

Figure 23: Specialty store model B. Kitchen & Gourmet = 2.06W (PASS).

Figure 24: High end retail models A & B. Designer shop 1 80CRI = 2.17W (PASS). Designer shop 2 90CRI = 2.55W (PASS).

Figure 25: High end model C. Fine jewelry = 2.93 (PASS).

Figure 26: High atrium models A, B, & C. High rise hotel A 2019 = 0.96W (FAIL). High rise hotel b 2019 = 1.16W (FAIL). High rise hotel C = 0.75W (PASS).

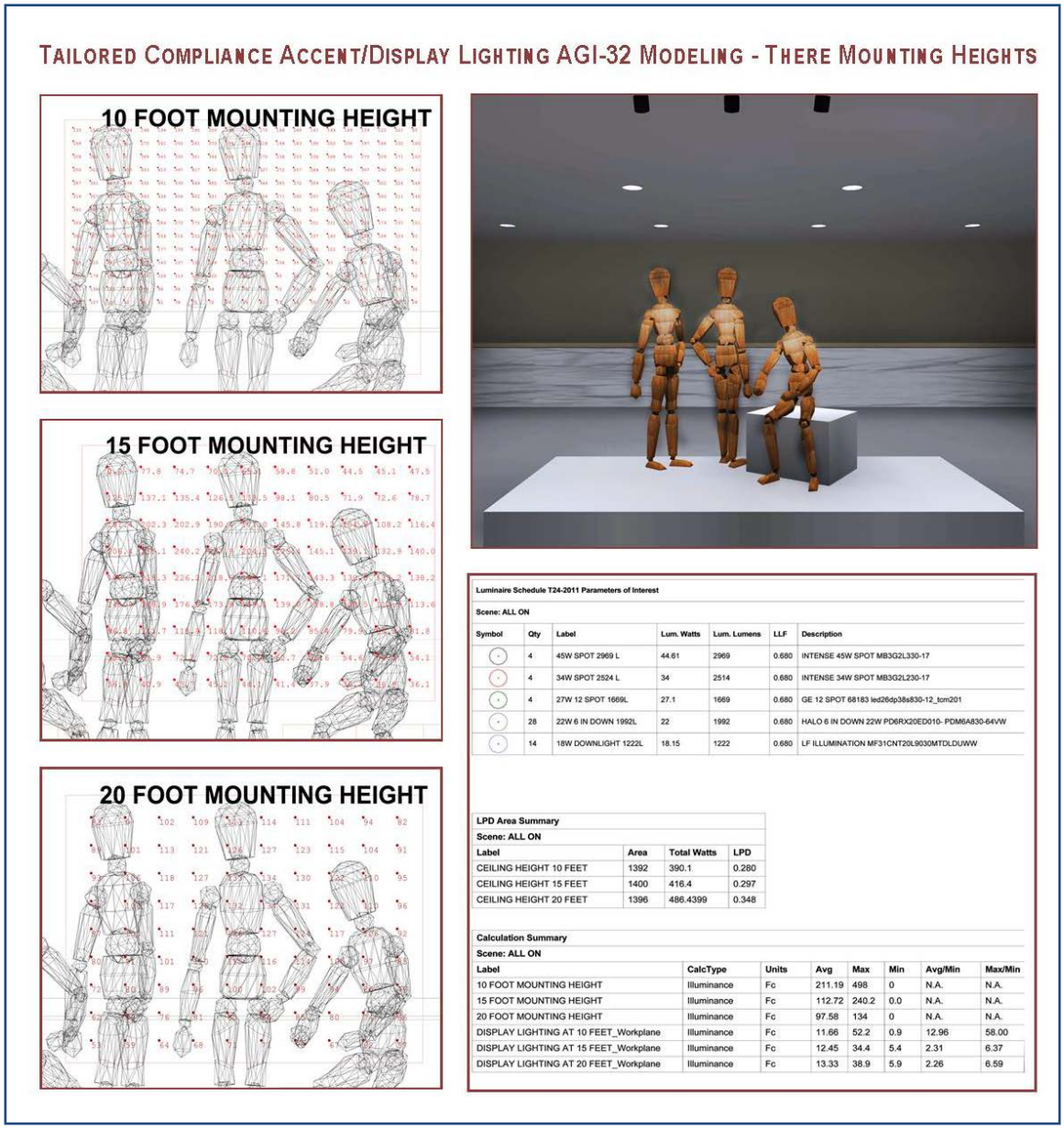

Figure 27: AGi32 Model study for accent/display lighting applications.

Table 46: Floor Accent and Display Lighting

Baseline T24-2016 9-foot to 11-foot Ceilings				LED for T24-2019 (90+ CRI)				LED Normalization Factor		LED Adjustment Factor		T24-2016	LED	Dim-to-Warm and Color Tuning	T24-2019 Proposed LPD
Lamp	Watts	Lumens	CRI	Lamp	Watts	Lumens	CRI	Factor	Adjusted Wattage	Factor	Percentage	LPD (Retail)	Average (Retail)	(small aperture luminaires)	(Retail)
MR16 IR	35	630	100	MR LED	9	460	96	1.40	13	0.38	10				
PAR HIR	48	970	100	PAR LED	20	1000	96	1.04	21	0.44	20				
CMH MR[a]	25	1000	81	LED Sp/Fl	16	1030	92	1.04	17	0.68	10			Factor	
CMH PAR[b]	25	1100	81	LED Sp/Fl	20	1080	90	1.03	21	0.84	60			1.2	
										0.70	**100**	**1.0W**	**0.70W**	**0.84W**	**0.80W**

a. Includes ballast

b. Application use/incumbent light source

Table 47: Wall Accent and Display

Baseline T24-2016 9-foot to 11-foot Ceilings				LED for T24-2019 (90+ CRI) (NOTE: R9 for these 90+ sources is 90 CRI minimum)				LED Normalization Factor		LED Adjustment Factor		T24-2016	LED	Dim-to-Warm and Color Tuning	T24-2019 Proposed LPD
Lamp	Watts	Lumens	CRI	Lamp	Watts	Lumens	CRI	Factor	Adjusted Wattage	Factor	Percentage	LPD (Retail)	Average (Retail)	(small aperture luminaires)	(Retail)
PAR/MR IR[a]	42	800	100	LED Sp/Fl	20	800	96	1.00	20	0.42	40				
CMH PAR/MR[a]	25	1050	81	LED Sp/Fl	20	1080	90	0.98	20	0.80	60				
Biax WW[b]	50	2750	82	LED WW	42	3280	97	0.82	34	0.68	40			Factor	
T5 WW[b]	30	2100	82	LED WW	22	1870	97	1.13	25	0.84	60			1.2	
										0.71	**200**	**14W lf**	**9.90W lf**	**11.88W**	**11.80W**

a. Average

b. Includes ballast

c. Application use/incumbent light source

CA TITLE 24 2019 TAILORED LIGHTING ACCENT/DISPLAY

Incumbent/Legacy Sources versus LED Sources

FLOOR ACCENT/DISPLAY

Baseline T24-2016 9-foot to 11-foot ceilings		LED for T24-2019 (95 +- CRI / 90 R9)	
LAMP	**WATTS**	**LAMP**	**WATTS**
 MR16 IR	35	MR LED	9
 PAR HIR	48	PAR LED	20
 CMH MR	25	LED Sp/Fl	16
 CMH PAR	25	LED Sp/Fl	20

WALL ACCENT/DISPLAY

Baseline T24-2016 11-foot ceilings		LED for T24-2019 (95 +- CRI / 90 R9)	
LAMP	**WATTS**	**LAMP**	**WATTS**
 PAR/MR IR	42	LED Sp/Fl	20
 CMH PAR/MR	25	LED Sp/Fl	20
 Biax WW	50	LED WW	42
 T5 WW	30	LED WW	22

Figure 28: Tailored lighting accent/display details.

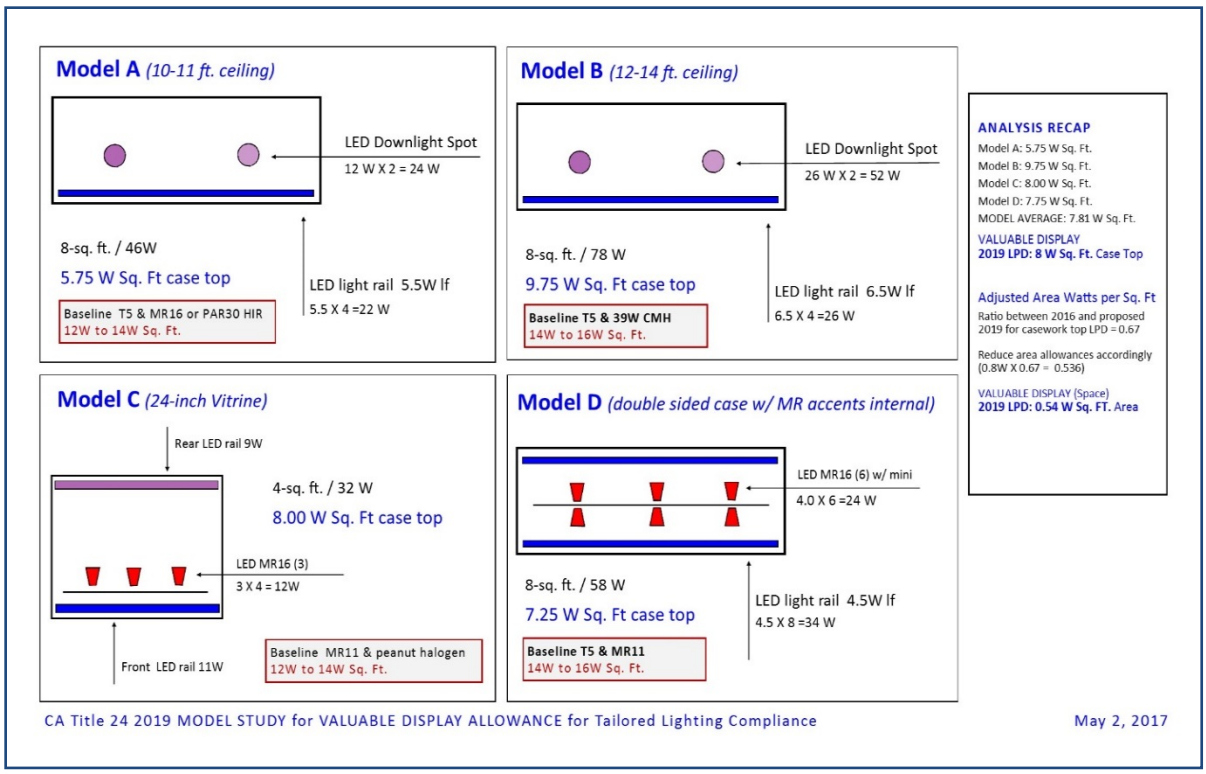

Figure 29: Model study for valuable display allowance.

Table 48: Ornamental Lighting Analysis for Tailored Compliance Adder

Wall Sconce Models	T24 2011-2016		T24 2019 Proposed Lumens	
	Wattage	**Lamp Type***	**Wattage**	**CRI**
Candelabra	25	Halogen	4-6	90+ with (R9 90+)
	7	CFL		
	11	(Average)		
Shade	43	Halogen	10-14	90+ with (R9 90+)
	13	CFL		
	19	(Average)		
Pendant	43	Halogen	12-14	95+ with (R9 90+)
	13	CFL		
	16	(Average)		
Chandelier Models	**Wattage**	**Lamp Type**	**Wattage**	**CRI**
Candelabra	150	Halogen	36-50	90+ with (R9 90+)
	54	CFL		
	92	(Average)		
Shade	432	Halogen	105	90+ with (R9 90+)
	178	CFL		
	202	(Average)		
Large Up-Light	200	HP-CFL	178	80+ (90+ R9 nott available)
	300	CMH		
	215	(Average)		
Luminous Walls Model	142	LED (80 CRI)	136	90

* CRI of Baseline/Incumbent sources 100 CRI (Halogen), 82 CRI (CFL) and 80 CRI (CMH)

Table 49: Decorative and Ornamental Lighting Recap

Type of Lighting System	LED Factor
Candelabra Wall Sconce	0.46
Shade Wall Sconce	0.68
Pendant	0.82
Average for Sconces & Pendants	**0.65**
Candelabra Chandelier	0.48
Shade Chandelier	0.52
Large Up-Light Chandelier	0.84
Average for Sconces & Pendants	**0.62**
Luminous Light Panels	0.96
Halogen Residual (Special Applications)	1.00
Average of all Ornamental Lighting	**0.80**

[Ornamental Lighting Title 24-2016 = 0.50 W X 0.80 (above factor) RESULT = 0.40 W LPD for Ornamental Lighting Proposed Title 24-2019]

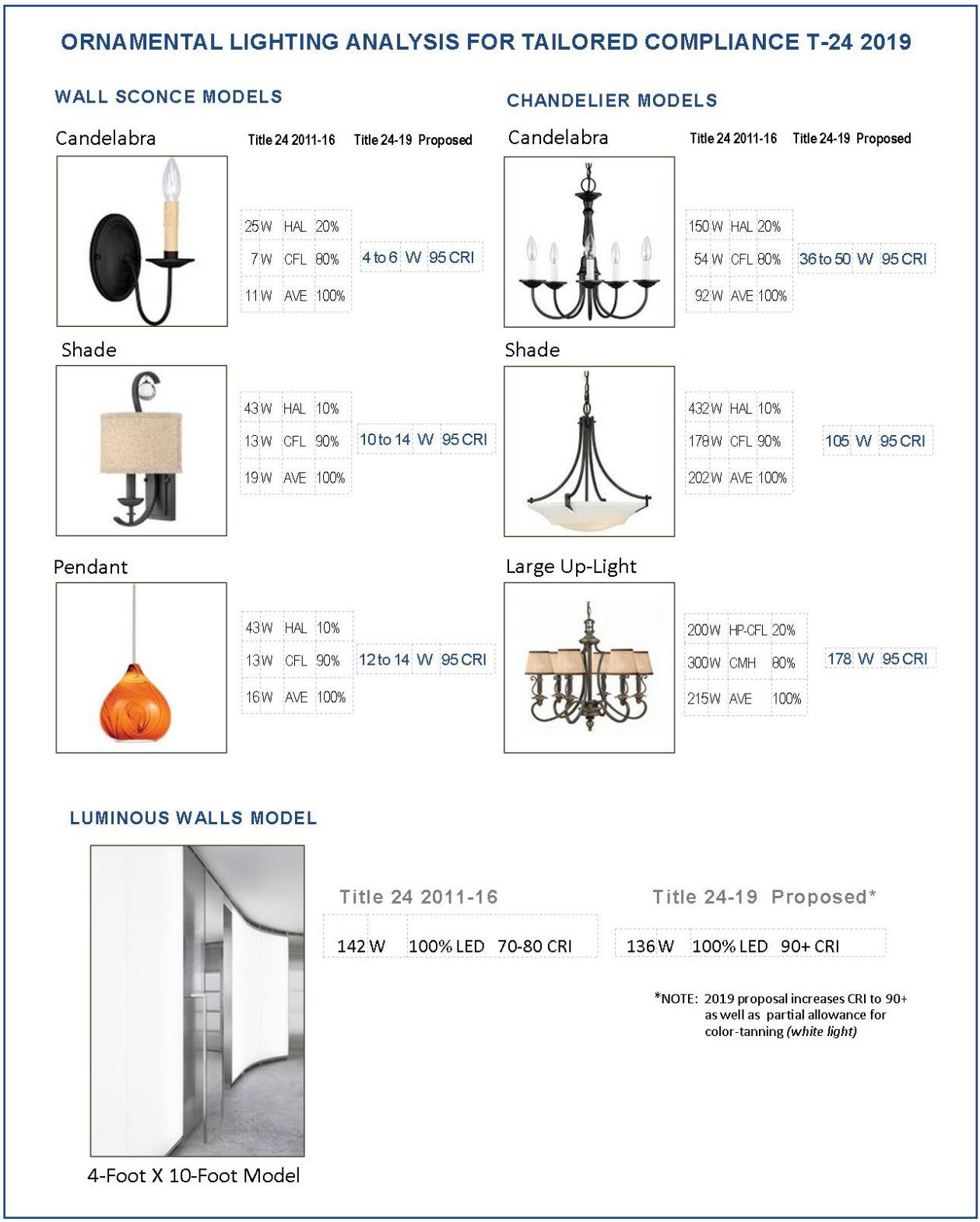

Figure 30: Comparison of legacy/incumbent versus LED for ornamental lighting.

Table 50: Mounting Height Studies Luminaires

Luminaire/ Lamp		**7W SORAA MR16**	**7W GE MR16**	10W Intense SP	12W GE PAR30	14W OSI P38 SP	18W SORAA P38	18W GE P38	20W Intense SP	26W GE P38	35W Intense SP	45W Intense SP
Center Beam Candle Power (feet)	Factor	6000	3200	11900	12000	14000	18500	15000	22000	24000	25000	30000
5-0	25	240	128	476	480							
6-0	36	167		331	333	389		417				
6-6	42.25	142		282	284	331	438	355				
7-0	49	122		243	245	286	378	306	449	490		
7-6	56.25	107		212	213	249	329	267	391	427	444	
8-0	64			186	188	219	289	234	344	375	391	469
8-6	72.25			165	166	194	256	208	304	332	346	415
9-0	81			147	148	173	228	185	272	296	309	370
9-6	90.25			132	133	155	205	166	244	266	277	332
10-0	100			119	120	140	185	150	220	240	250	300
10.6	110.25			108	109	127	168	136	200	218	227	272
11-0	121					116	153	124	182	198	207	248
11-6	132.25					106	140	113	166	181	189	227
12-0	144						128	144	153	167	174	208
12-6	156.25						118		141	154	160	192
14-0	196								112	122	128	153
14-6	210.25								105	114	119	143
16-0	256											117
17-0	289											104
18-0	324											
20-0	400											
		8-foot	Not Appropriate	8-1/2 to 10-1/2	8-1/2 to 10-1/2	8-1/2 to 11-0	10-1/2 to 13-0	9-1/2 to 12-0	10-0 to 14-0	10-1/2 to 14-1/2	10-1/2 to 15-0	11-1/2 to 16-0
		CEILING	CEILING	CEILING	CEILING	CEILING	CEILING	CEILING	CEILING	CEILING	CEILING	CEILING

Table 51: Mounting Height Studies Baseline and Adjustments

Typical Ceilings	LED Fixture Watts	
8-feet	7-10 W	**Baseline**
8-4 feet	7-10 W	
8-6 feet	10-12 W	
8-10 feet	10-12 W	
9-feet	10-12 W	
9-6 feet	10-12 W	
9-8 feet	10-12 W	
9-10 feet	10-12 W	
10-feet	10-12 W	
10-4 feet	10-12 W	
10-6 feet	10-12 W	**Baseline**
10-8 feet	12-18 W	**Adjustment 1**
11-feet	18 W	
11-4 feet	18 W	
11-6 feet	18 W	
11-8 feet	18 W	
12- feet	18 W	**Adjustment 1**
12-6 feet	20-26 W	**Adjustment 2**
12-8 feet	20-26 W	
14-feet	26 - 35 W	
14-6 feet	26 - 35 W	
14-8 feet	35 W	
16-feet	35 W	**Adjustment 2**
17- feet	above 45W	
18- feet	above 45W	
19-feet	above 45W	
20-feet	above 45W	

Appendix L: ASHRAE 90.1-2016 MEDICAL LIGHTING LPDS

The Statewide CASE Team developing LPDs for medical facilities based on similar LPDs developed for the ASHRAE/IES 189.1-2017 standards. Table 52 and Table 53 contain the 2016 ASHRAE 90.1 LPDs for medical facilities, which are less stringent than the ASHRAE 189.1 and proposed Title 24, Part 6 LPDs.

Table 52: ASHRAE 90.1-2016 Building Area Type Medical Lighting LPDs

Building Area Type	Allowed Lighting Power Density (W/ft^2)
Health-care clinic	0.82
Hospital	1.05

Table 53: ASHRAE 90.1-2016 Space by Space Method LPDs

Building Area Type		Allowed Lighting Power Density (W/ft^2)
Healthcare Facility	Exam/Treatment Room	1.68
	Imaging Room	1.06
	Medical Supply Room	0.54
	Nursery	1.00
	Nurse's Station	0.81
	Operating Room	2.17
	Patient Room	0.62
	Physical Therapy Room	0.84
	Recovery Room	1.03
	Lounge/Breakroom	0.78
	Corridor	0.92
Pharmacy Area		1.34

Appendix M: DIM-TO-WARM AND COLOR TUNING ANALYSIS

In developing the updates to the LPAs in Title 24, Part 6, the Statewide CASE Team interviewed a number of stakeholders individually as well as at group stakeholder meetings. A recurrent theme was that color-changing, white LED luminaires are a relatively new technology but their market presence is growing. The demand for color-changing luminaires is increasing in two major categories:

- White tunable luminaires that more closely match the color temperature of light outdoors; this approach would have warm, reddish (low CCT) light in mornings and evenings, and cold, bluish (high CCT) in the middle of the day.
- Dim-to-warm luminaires that attempt to more closely match the spectral content of legacy incandescent lamps, which have warmer, reddish (low CCT) when they are dimmed. This is especially desirable for hospitality applications where the intent is to have softer, warmer lighting later in the evening.

With increased interest in the effect of light (especially blue light) on entraining circadian rhythms, there is an enhanced interest in color tuning in medical facilities as well as other applications. The analysis below is a detailed evaluation of different products of different CRIs and capabilities (color tuning and dim-to-warm). For dim-to-warm, efficacy at full light output is most important since maximum power input is what is used for rating and for code compliance. The analysis shows that small aperture color-tuning (including dim-to-warm) products use about 34 percent more power than similar high CRI (90+) static color luminaires. The Statewide CASE Team noted that when compared to 80 CRI static white small aperture luminaires, small aperture color tuning products may use as much as double the power of the static product. However, large aperture color-tuning products only use roughly 9 percent more power.

This proposal allows the use of color-tuning products for any application through the “Adjusted Indoor Lighting Power.” The “Adjusted Indoor Lighting Power” is the reduced installed wattage of small aperture, dim-to-warm/color-tuning luminaires. It is calculated by multiplying the installed watts (of small aperture, dim-to-warm/color-tuning luminaires) by 0.75; therefore, a small aperture color-tuning product’s reported wattage would match a high CRI (90+) non-tunable luminaire (134% x 75% = 100.5%).

The large aperture color-tuning luminaires only have a 9 percent increased wattage usage. Therefore, the Statewide CASE Team decided this minor difference does not require a special adjustment factor for most applications. However, for nurseries, hospital patient rooms, recovery rooms, physical therapy rooms, and nurses’ stations, an additional use-it-or-lose-it added lighting allowance is specifically called out for extra power for color-changing luminaires. This exempts specialized medical lighting including "examination and surgical lights, low-ambient night-lights, and lighting integral to medical equipment, provided that these lighting systems are additions to and separately switched from a general lighting system" (see new Section 140.6(a)3F).

Table 54: 3.0- and 3.5-inch Aperture Downlights Efficacy Research

	Luminaire Manufacturers							
3.0- and 3.5-inch Aperture Downlights	**A1**	**A2**	**B**	**C**	**D**	**E**	**F**	**Average**
Efficacy in Lumens Per Watt	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W
Baseline 3500K 80+CRI Luminaires			81		58			70
Baseline 3000K 90+CRI Luminaires			70		46		62	59
Dim-to-Warm Luminaires			54		42		62	53
Color-Tuning (white light) Luminaires			42		48		62	50

Table 55: 4.0-inch Aperture Downlights Efficacy Research

	Luminaire Manufacturers							
4.0-inch Aperture Downlights	**A1**	**A2**	**B**	**C**	**D**	**E**	**F**	**Average**
Efficacy in Lumens Per Watt	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W
Baseline 3500K 80+CRI Luminaires	88	70	76	84	78	82		80
Baseline 3000K 90+CRI Luminaires	72	58	62	67	67	74		67
Very High 97CRI+-/R9-50+ Luminaires		53		61				57
Dim-to-Warm Luminaires	48	32	56	46	43	52		46
Color-Tuning (white light) Luminaires		30	42	44	48	66		46
Color-Tuning (RGB) Luminaires						[a]		

a. Manufacturer E offers product; however, there is no data on efficacy.

Table 56: 6.0-inch Aperture Downlights Efficacy Research

	Luminaire Manufacturers							
6.0-inch Aperture Downlights	**A1**	**A2**	**B**	**C**	**D**	**E**	**F**	**Average**
Efficacy in Lumens Per Watt	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W
Baseline 3500K 80+CRI Luminaires	86	74	80	102	74	78		82
Baseline 3000K 90+CRI Luminaires	68	62	64	80	62	64		67
Very High 97CRI+-/R9-50+ Luminaires		56		74				65
Dim-to-Warm Luminaires		66	42	45	64	61		56
Color-Tuning (white light) Luminaires			38	44	58	85		56
Color-Tuning (RGB) Luminaires						[a]		

a. Manufacturer E offers product – however, there is no data on efficacy.

Table 57: 8.0-inch Aperture Downlights Efficacy Research

	Luminaire Manufacturers							
6.0-inch Aperture Downlights	**A1**	**A2**	**B**	**C**	**D**	**E**	**F**	**Average**
Efficacy in Lumens Per Watt	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W	Lm/W
Baseline 3500K 80+CRI Luminaires	72	78	80	106	74	86		84
Baseline 3000K 90+CRI Luminaires	58	65	64	84	62	68		68
Very High 97CRI+-/R9-50+ Luminaires		59		76				67
Dim-to-Warm Luminaires		40		48	64	60		49
Color-Tuning (white light) Luminaires	72			48	58	84		66
Color-Tuning (RGB) Luminaires						[a]		

a. Manufacturer E offers product; however, there is no data on efficacy.

Table 58: Other Small Aperture Scenarios

Efficacy in Lumens Per Watt	**Lm/W**	**Efficacy (%)**	**Manufacturer/Comments**	**FACTOR Baseline EQ**	**FACTOR 90+CRI EQ**
Baseline 3500K 80+CRI 2-inch Slot	102	1.00	G	1.00	N/A
Baseline 3500K 80+CRI 4-inch Slot	97	1.00	H	1.00	N/A
Baseline 3500K 80+CRI Tape LED	84	1.00	Diode LED	1.00	N/A
3000K 95+CR/R9-50+ Tape LED	98	1.17	Alloy LED	0.86	1.00
Baseline 3500K 80+CRI Cove LED	88	1.00	I	1.00	N/A
Baseline 3500K 80+CRI PAR Lamp	94	1.00	I	1.00	N/A
3000K 90+CRI PAR Lamp	75	0.80	I	1.25	1.00
3000K 95+CR/R9-50+ PAR Lamp	54	0.58	J	1.74	1.39
Dim-to-Warm 2-inch Slot	not listed	unknown	G	N/A	N/A
Dim-to-Warm Tape LED	60	0.72	Alloy LED	1.40	1.63
Dim-to-Warm Cove LED	N/A				
Dim-to-Warm PAR Lamp	57	0.61	Swedish product (not available in USA)	1.65	1.30
Color-Tuning 2-inch Slot	121	1.20	G	0.85	N/A
Color-Tuning 4-inch Slot	62	0.64	F	1.56	N/A
Color-Tuning Tape LED	24	0.29	Alloy LED (RGB)	3.50	N/A
Color-Tuning Cove LED	64	0.73	F	1.38	N/A
Color-Tuning PAR Lamp	62	0.66	F	1.52	1.21

Table 59: Adder Factors for Dim-to-Warm and Color Tuning (4/6/8-inch Downlights)

	Baseline	**90+/CRI**	**Dim/Warm**	**Color/Tune**	**95+CRI/R9-50+**
Ave Lm/W	82	68	50	45	63
Adjustment Factor/Base	1.00	1.21	1.64	1.82	1.30
Adjustment Factor/90CRI	0.83	1.00	1.36	1.51	1.08

Table 60: Adder Factors for Dim-to-Warm and Color Tuning (LED PAR Lamps)

	Baseline	90+/CRI	Dim/Warm	Color/Tune	95+CRI/R9-50+
Ave Lm/W	81	74	57	62	60
Adjustment Factor/Base	1.00	1.10	1.42	1.31	1.35
Adjustment Factor/90CRI	0.91	1.00	1.30	1.19	1.23

Table 61: Large Aperture LED Direct/Indirect Linear Suspended

Luminaire Description	Manufacturer	BASE 3500K/80 CRI (lm/W)	3500K/90+ CRI	COLOR TUNE 80 CRI	COLOR TUNE 90+ CRI	Color Tune Factor
Linear fluorescent suspended direct/indirect	L	132	100	119	89	0.902
Linear fluorescent suspended direct/indirect	M	120	N/A	N/A	N/A	0.867
Linear fluorescent suspended direct/indirect	N	138	Available (loss?)	133	Available (loss?)	0.964
Manufacturer Averages		**130**	**Insufficient Data**	**119**	**Insufficient Data**	**0.911**
Linear fluorescent suspended direct/indirect	O	N/A	115	N/A	N/A	
Lithonia 2X4 Basket LED	P	130	N/A	120	N/A	0.923
Columbia 2X4 Basket LED	Q	123				
Finelite 2X4 Basket LED	R	130		115		0.885
Manufacturer Averages		**129**		**118**		**0.904**
Large Aperture Factor Average						**0.9075**

Appendix N: Additional AGi32 Modeling (Warehouse and Open Office)

The Statewide CASE Team received feedback from stakeholders concerned with the Lumen Method models used in the development of new LPDs for 2019 Title 24, Part 6. Specifically, stakeholders expressed that the Lumen Method may not properly account for interactions between objects, and therefore the RCRs assigned to the modeled spaces may be inappropriate. This can result in spaces receiving lower light levels than modeled, which would mean that LPDs developed this way are too low to ensure ample light levels. Since ASHRAE Lumen Method models were used as a starting point for developing the new LPDs, the Statewide CASE Team conducted additional analysis to validate that the proposed LPDs properly accounted for these potential issues.

The Statewide CASE Team used AGi32 models to validate the LPDs developed for warehouses and offices. These two spaces were identified as being critical areas to validate through AGi32 models due to the influence of "high-stack" objects (typical of warehouses) and high volume of open office space versus all space types. The results of the AGi32 modeling substantiated that the proposed LPDs allow for light levels consistent with IES recommended practice. The models and results of the analysis are detailed below.

Open Office Models

The following tables and figures outline the models and results for the AGi32 analysis for offices.

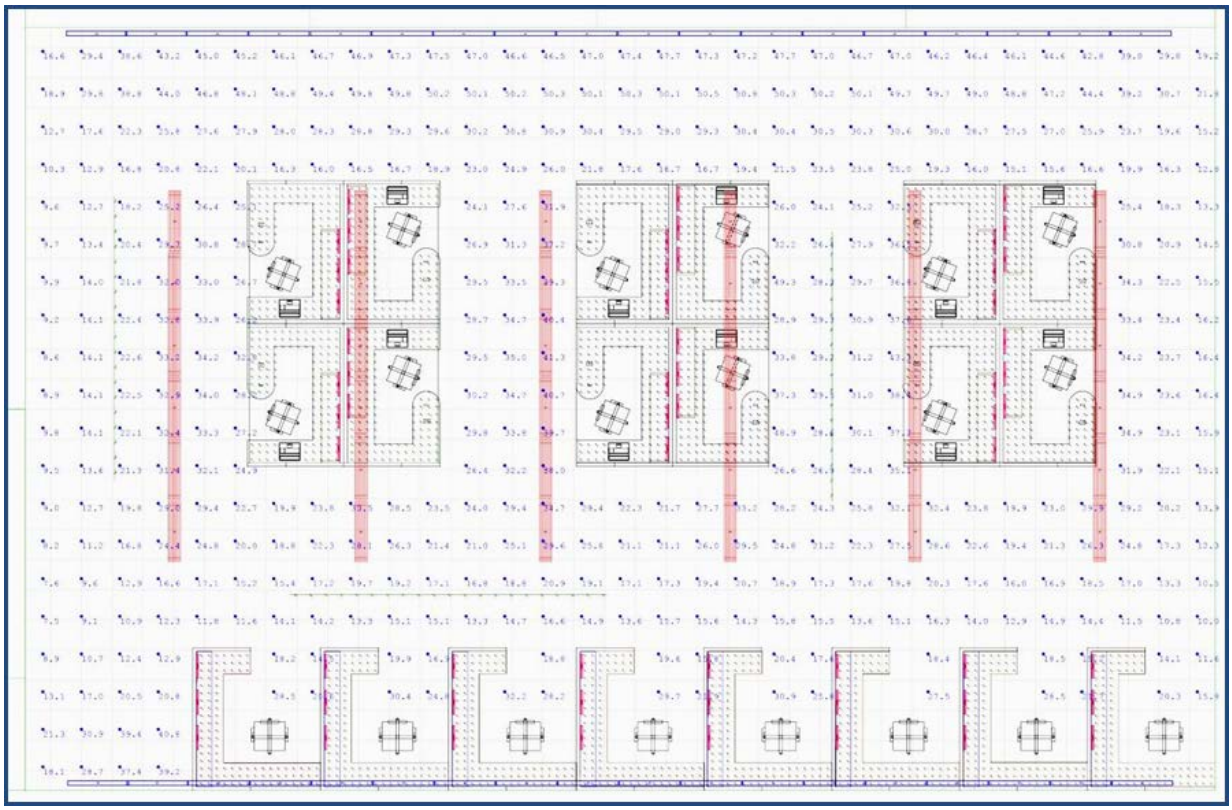

Figure 31: AGi32 open office model A plan view.

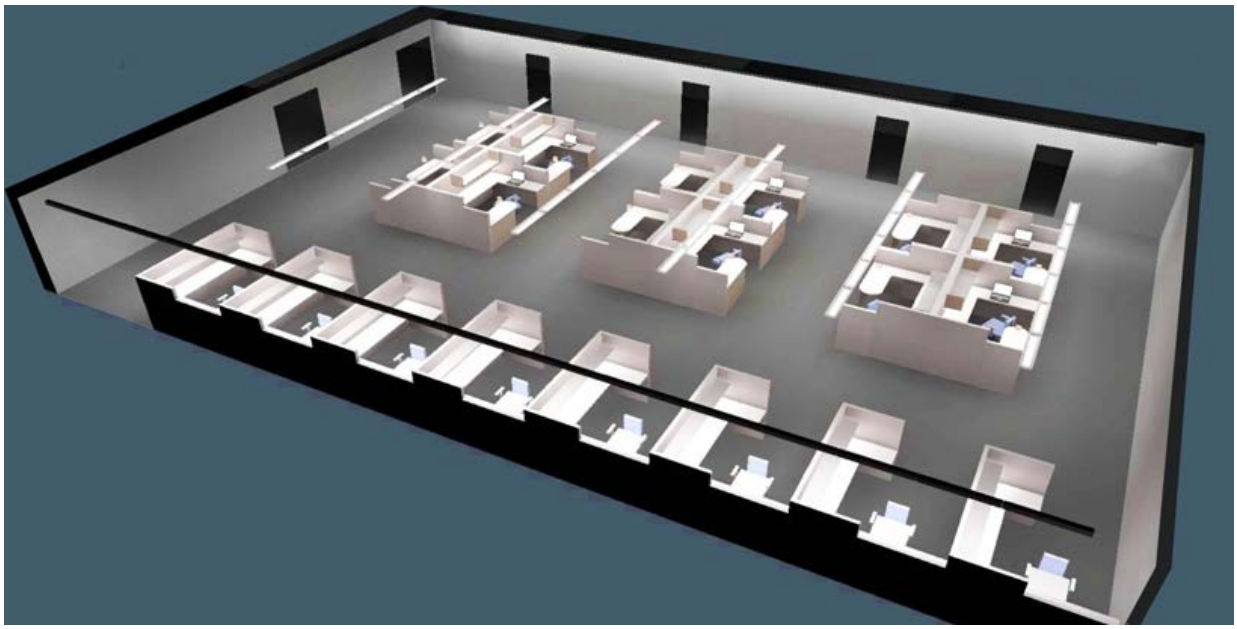

Figure 32: AGi32 open office model A rendered plan view.

Table 62: AGi32 Open Office Model A Luminaire Details

Luminaires	Efficacy (lm/W)	CCT (Kelvin)	CRI	CCT & CRI Options
Prudential Bionic (ww)	104	3500	82	3000K (0.96) - 90CRI*(2700K only)
Finelite S12 (pendant)	122	3500	80	3000K (0.98) - 90CRI (0.76)
Finelite Edge (task)	62	3500	87	No CCT or CRI options offered
Finelite Curve (task)	49	3500	82	No CCT or CRI options offered
Lithonia 2BLT Color Tune[a]	110	3000	82	No higher CRI option offered
Finelite S12 Color Tune[a]	111	3500	80	3000K (0.98) - 90CRI (0.75)
Finelite HPW Color Tune[a]	105	3500	80	3000K (0.98) - 90CRI (0.75)
Tech High 90+ CRI (task)[a]	60	3500	90	No color-tuning option offered
Tech High 90+ CRI (task)[a]	49	2700	90	No color-tuning option offered
Tech High 90+ CRI (task)[a]	66	4000	90	No color-tuning option offered

a. Luminaire options for color tuning and high CRI.

Table 63: AGi32 Open Office Model A Performance Recap

Performance Target	IES Recommended	AGi32 Radiosity Model	T24 VAN Lumen Model	T24-2019 Proposed	189.1 VAN Lumen Model	189.1 2017 STD
Circulation/Transition FC	10FC	26FC	20FC	NA	30FC	NA
Tasks/Work Surfaces FC	40FC-60FC	42FC	50FC	NA	50FC	NA
Vertical FC Cerc/Task	3FC/7.5FC	10FC/20FC	NA	NA	NA	NA
Uniformity (typical)	3:01	3.4:1	NA	NA	NA	NA
Base Lighting LPD	NA	0.34W	0.60W	0.60W	0.78W	0.78W
Portable Lighting LPD	NA	0.12W	0.00W	0.20W	0.00W	0.00W
Total Lighting LPD	NA	0.46W	0.60W	0.80W	0.78W	0.78W

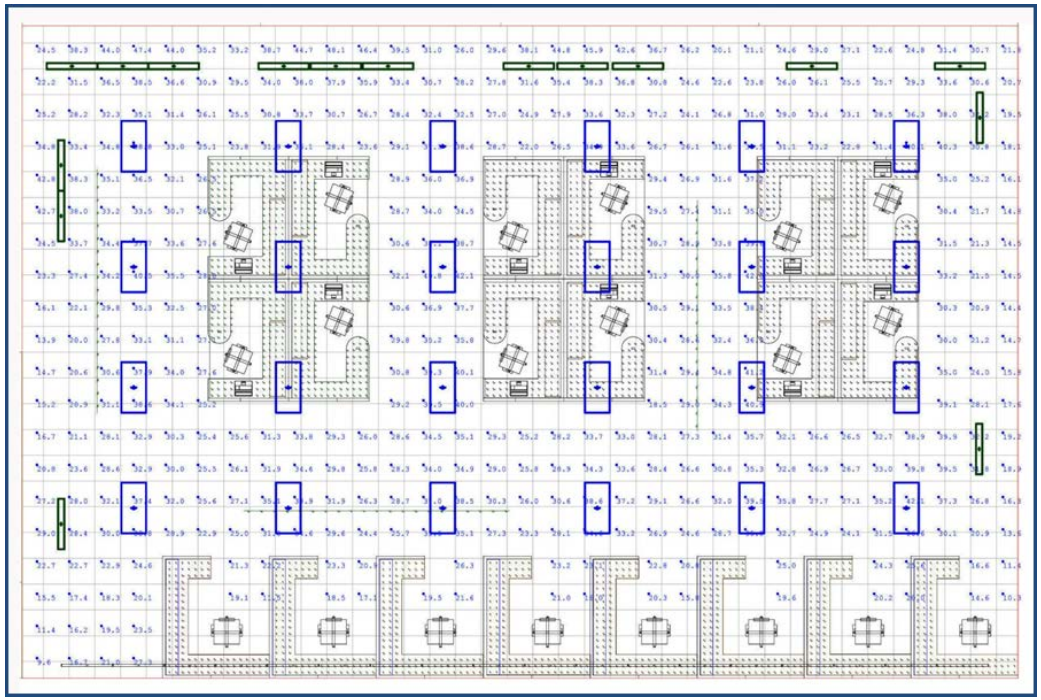

Figure 33: AGi32 open office model B plan view.

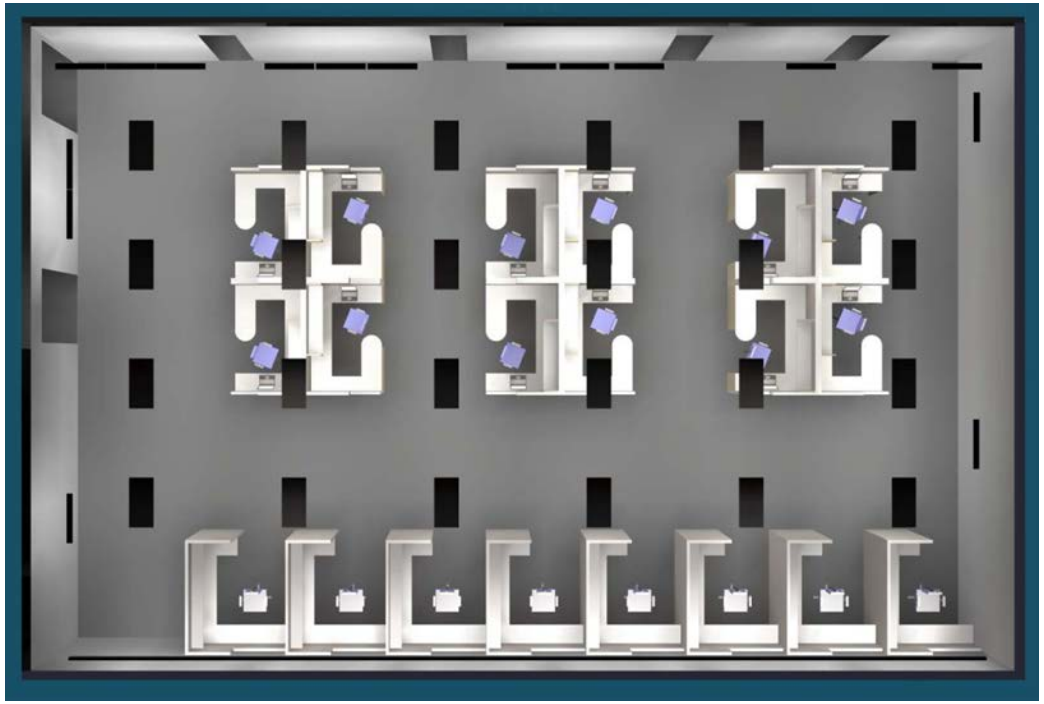

Figure 34: AGi32 open office model B rendered plan view.

Table 64: AGi32 Open Office Model B Luminaire Details

Luminaires	Efficacy (lm/W)	CCT (Kelvin)	CRI	CCT & CRI Options
Prudential Bionic (ww)	104	3500	82	3000K (0.96) - 90CRI*(2700K only)
Lithonia 2FSL4 (basket)	130	3500	80	No CCT or CRI options offered
Finelite HPW (ww)	109	3500	80	3000K (0.98) - 90CRI (0.76)
Finelite Edge (task)	62	3500	87	No CCT or CRI options offered
Finelite Curve (task)	49	3500	82	No CCT or CRI options offered

Table 65: AGi32 Open Office Model B Factors for Color Tuning and High CRI

AGi32 Model	Design LPD (W)	CT Factor	CRI factor	Adjusted LPD (W)
Open Office Model B (base)	0.36	0.91	0.76	0.53
Open Office Model B (task)	0.12	NA	0.74	0.16
Open Office Model B (total)	0.48	0.91	0.75	0.69

Table 66: AGi32 Open Office Model B Performance Recap

Performance Target	IES	AGi32	T24 VAN	T24-2019	189.1 VAN	189.1
	Recommended	Radiosity Model	Lumen Model	Proposed	Lumen Model	2017 STD
Circulation/Transition FC	10FC	31FC	20FC	NA	30FC	NA
Tasks/Work Surfaces FC	40FC-60FC	48FC	50FC	NA	50FC	NA
Vertical FC Cerc/Task	3FC/7.5FC	13FC/28FC	NA	NA	NA	NA
Uniformity (typical)	3:01	3.1:1	NA	NA	NA	NA
Base Lighting LPD	NA	0.36W	0.60W	0.60W	0.78W	0.78W
Portable Lighting LPD	NA	0.12W	0.00W	0.20W	0.00W	0.00W
Total Lighting LPD	NA	0.48W	0.60W	0.80W	0.78W	0.78W

Warehouse Models

The following tables and figures outline the models and results for the AGi32 analysis for warehouses.

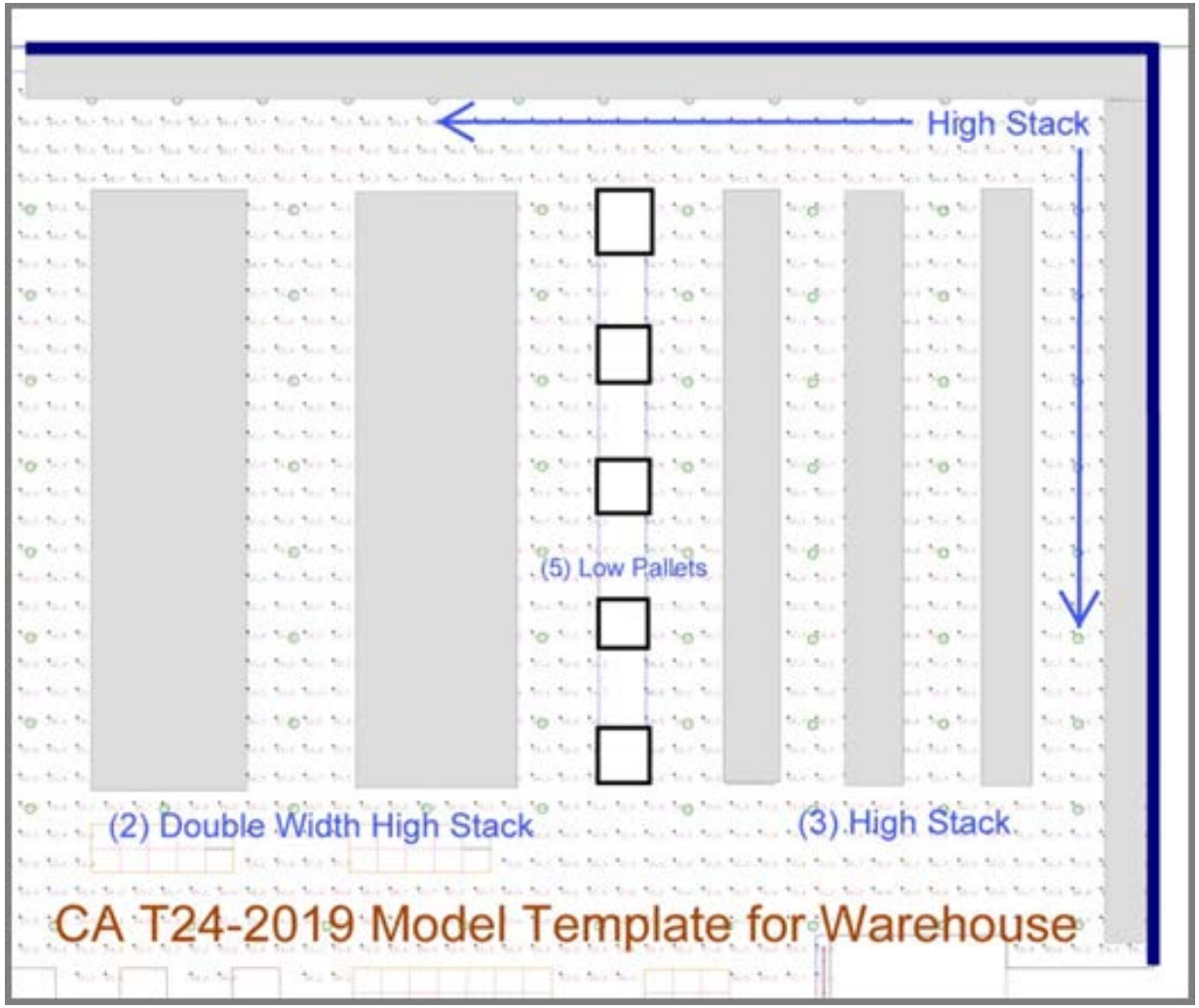

Figure 35: AGi32 warehouse model plan view.

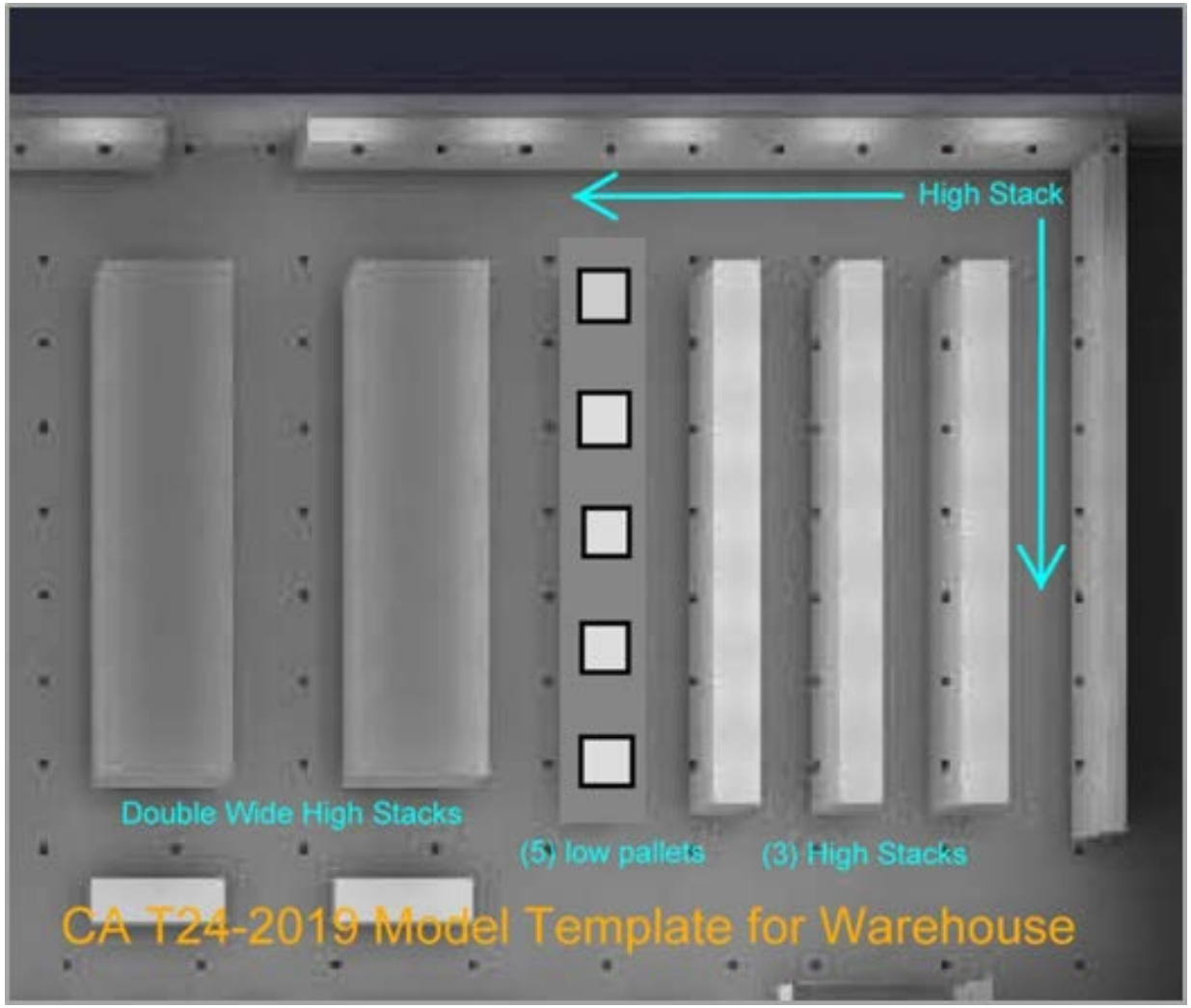

Figure 36: AGi32 warehouse model rendered plan view.

Table 67: Warehouse High Stack AGi32 Modeling Recap

AGi32 Models	Model LPD[a]	Poorest Lm/W Option[b]	Best Lm/W Option	Proposed 2019 LPD	ASHRAE 189.1-2017 LPD[c d]	ASHRAE 90.1 2016 LPD[c d]
20-foot Low-Bay Uniform Grid (170 lm/w)	0.207	0.379	0.259	0.45	0.27 / 0.65	0.35 / 0.69
28-foot High-Bay Uniform Grid (156 lm/w)	0.293	**0.490**	0.334	0.45	**0.27** / 0.65	0.35 / 0.69
40-foot High-Bay Uniform Grid (172 lm/w)	0.293	**0.542**	0.369	0.45	**0.27** / 0.65	0.35 / 0.69
20-foot Low-Bay Task/Optimized Layout (163 lm/w)	0.213	0.373	0.253	0.45	0.27 / 0.65	0.35 / 0.69
28-foot High-Bay Task/Optimized Layout (147 lm/w)	0.296	**0.468**	0.317	0.45	**0.27** / 0.65	0.35 / 0.69
40-foot High-Bay Task/Optimized Layout (164 lm/w)	0.301	**0.529**	0.316	0.45	**0.27** / 0.65	0.35 / 0.69

a. Least efficient luminaire from ASHRAE 189.1-2017 Lumen Method modeling.
b. Most efficient luminaire from ASHRAE 189.1-2017 Lumen Method modeling.
c. Bulky-Palletized 0.27/0.35 LPD/Small hand held and detailed labeling 0.65/0.69 LPD.
d. 90.1 & 189.1 Van/Bus Lumen Method modeling targets 20 FC/RCR2 (Bulk) and 30 FC RCR4 (fine/Detail).

Orange text = Does not meet proposed 0.45W 2019 Title 24, Part 6 LPD.
Red text = AGi32 model LPD exceeds allowed ASHRAE 189.1-2017 and/or ASHRAE 90.1-2016 LPD.

Summary and review of findings for AGi32 warehouse modeling versus Lumen Method (VAN):

- 20 FC horizontal target is the same for Title 24, Part 6 and IES/ASHRAE 90.1/189.1. However, Title 24, Part 6 VAN model is based on RCR 6, which resulted in .42 LPD, versus ASHRAE 90.1/189.1 based on RCR 2, which resulted in 0.27 LPD.
- Luminaires used for the AGi32 model were latest generation LED with an efficacy range of 147 lm/W to 172 lm/W, while ASHRAE 189.1-2017 VAN model averaged luminaires with an efficacy range of 94 lm/W to 137 lm/W. AGi32 model LPD results were adjusted using factors for the poorest and best luminaires used for the ASHRAE 189.1-2017 VAN modeling (results shown in columns in Table 67).
- The 0.45 LPD as currently proposed will provide adequate power for warehouse illumination (within IES recommended practice), provided that LED luminaires with above average efficiency are used. However, with less efficient luminaires (under 100 lm/w), the warehouse lighting may not conform to recommended IES targets with the 0.45 LPD allowance.

Table 68: Warehouse High Stack AGi32 Modeling Performance Uniform VS Task Designs

AGi32 Models	Average Horizontal FC[a e]	Vertical FC average LOW[a]	Vertical FC average MIDDLE[c]	Vertical FC average UPPER[d]	Vertical FC Overall Average[f]	Uniformity Horizontal/ Vertical[g]	Model LPD
20-foot Low-Bay Uniform Grid (170 lm/w)	23.3	11.2	17.6	12.3	13.7	**7.5:1**/1.9:1	**0.207**
20-foot Low-Bay Task/Optimized Layout (163 lm/w)	24.5	11.7	14.2	15.4	21.9	3.0:1/2.3:1	**0.213**
28-foot High-Bay Uniform Grid (156 lm/w)	22.0	11.2	17.7	12.4	13.8	**6.5:1**/1.8:1	**0.293**
28-foot High-Bay Task/Optimized Layout (147 lm/w)	24.1	8.4	11.7	19.4	13.3	2.1:1/2.3:1	**0.296**
40-foot High-Bay Uniform Grid (172 lm/w)	21.4	7.9	9.98	13.5	10.5	**5.5:1**/1.4:1	**0.293**
40-foot High-Bay Task/Optimized Layout (164 lm/w)	23.2	8.3	10.1	13.4	10.6	1.8:1/2.3:1	**0.301**

a. Horizontal FC @ 30 inches above grade.
b. Vertical FC Low @ 1/3 distance above grade to vertical face of high stack shelving.
c. Vertical FC Low @ 1/2 distance above grade to vertical face of high stack shelving.
d. Vertical FC Low @ 2/3 distance above grade to vertical face of high stack shelving.
e. Horizontal FC target of 20 FC average (maintained) per IES recommended practice for blended bulky/small items.
f. Vertical FC target of 5 FC average (maintained) per IES recommended practice for bulky items storage.
g. Average to minimum uniformity target of 3:1 (horizontal) and 10:1 (vertical) per IES recommended practice.

Orange text = Does not meet IES recommended target.

Summary and review of findings for AGi32 warehouse modeling uniform designs versus task designs:

- Both uniform and task designs (at all ceiling heights) conformed to 20 FC horizontal target (IES recommended practice). However, the uniform designs exhibited uniformity ratios above the IES recommended 3:11 (these are shown in Table 68 in orange text).
- Uniform and task designs (at all ceiling heights) exhibited uniformity ratios significantly better than the IES recommended 10:1 (average to minimum uniformity).
- The range of horizontal illumination between designs was minimal (21.4 to 24.5) FC. However, vertical illumination exhibited variations (FC) both between uniform designs versus task designs as well as between the lower and taller ceiling designs.

Conclusions:

1. AGi32 warehouse modeling verified that the 0.45W LED, as proposed in the CASE Report, is more than adequate for warehouse lighting applications, provided the design uses LED luminaires with an efficacy of over 100 lm/W.
2. Task-driven designs perform better than uniform designs, although they use slightly more energy.
3. A number of variations within vertical illumination are inconsistent with and contrary to the norm (i.e., expected result of uniform versus task-driven vertical illumination). While these do not negate the validation that 0.45W is adequate for the warehouse LPD, they should be investigated and discrepancies resolved.

Table 69: Comparison of AGi32 Warehouse Model to Title 24, Part 6 VAN Model and ASHRAE 189.1-2017 VAN (Lumen Method Model)

Title 24, Part 6 AGi32 Models	Model LPD	T24 2019 VAN Model	T24 Proposed 2019 LPD	ASHRAE 189.1-2017 VAN model	ASHRAE 189.1-2017 LPD	Comments/Remarks
20-foot Low-Bay Uniform Grid (170 lm/w)	0.207	0.42	0.45	0.27 / 0.65	0.27 / 0.65	T24-2019 & 189.1-2017 VAN models based on 116 and 119 lm/w LED industrial luminaires. ASHRAE separates warehouse storage into bulky-palletized and small hand held/detailed labeling materials; 0.27 (based on RCR 2) is allowed for bulky while 0.65 (based on RCR 4) is allowed for small handheld items.
28-foot High-Bay Uniform Grid (156 lm/w)	0.293	0.42	0.45	0.27 / 0.65	0.27 / 0.65	
40-foot High-Bay Uniform Grid (172 lm/w)	0.293	0.42	0.45	0.27 / 0.65	0.27 / 0.65	
20-foot Low-Bay Task/Optimized Layout (163 lm/w)	0.213	0.42	0.45	0.27 / 0.65	0.27 / 0.65	
28-foot High-Bay Task/Optimized Layout (147 lm/w)	0.296	0.42	0.45	0.27 / 0.65	0.27 / 0.65	
40-foot High-Bay Task/Optimized Layout (164 lm/w)	0.301	0.42	0.45	0.27 / 0.65	0.27 / 0.65	

Table 70: Comparison of Luminaires Used for AGi32 Models and VAN Models

Luminaire Performance	Lm/W	CCT	CRI	Comments/Remarks
20-foot Low-Bay T24 AGI Models	163-170	5000	80	Luminaire options/factors: 4000K (.99) Defuse lens (.90)
20-foot Low-Bay T24 & 189.1 VAN Models	119	4000, 5000	80	Luminaire efficacy average for range of 800 series industrial low bay luminaires
28-foot Low-Bay T24 AGI Models	147-156	5000	80	Luminaire options/factors: 4000K (.99) Defuse lens (.90)
28-foot Low-Bay T24 & 189.1 VAN Models	116	4000, 5000	80	Luminaire efficacy average for range of 800 series industrial high bay luminaires
40-foot High-Bay T24 AGI Models	164-172	5000	80	Luminaire options/factors: 4000K (.99) Defuse lens (.90)
40-foot High-Bay T24 & 189.1 VAN Models	116	4000, 5000	80	Luminaire efficacy average for range of 800 series industrial high bay luminaires

Summary and review of findings for AGi32 warehouse modeling vs Lumen Method (VAN):

- Title 24, Part 6 VAN model based on RCR 6 which resulted in 0.42 LPD, versus ASHRAE 90.1/189.1 based on RCR 2, which resulted in 0.27 LPD.
- Luminaires used (AGi32 model) are latest generation LED with an efficacy range of 147 lm/W to 172 lm/W. CCT for the luminaires is 5,000K with a CRI of 80+.
- Options for the AGi32 modeling luminaires include 4,000K vs 5,000K (1 percent efficacy loss) and frosted lens for glare control (9 percent efficacy loss). Based on manufacturers' stated losses, the efficacy for 4,000K/80CRI luminaires with glare control will range between 132 lm/W to 155 lm/W.

- The proposed 0.45 LPD will provide adequate power for warehouse illumination (within IES recommended practice), provided LED luminaires with an average efficiency of at least 115 lm/W are used. However, with less efficient luminaires (under 100 lm/W), the warehouse lighting may not conform to recommended IES targets with the 0.45 LPD allowance.

Appendix O: ADDITIONAL LPDS

An ongoing effort to simplify and render the lighting standards more enforceable has been to limit the Tailored Method approach to those areas where multiple layers of lighting are required to implement lighting designs that are unique to the geometry; tasks of the space that cannot be well characterized by general lighting LPDs; and use-it-or-lose-it adders for specified tasks, also in a LPD format. In the past, the Tailored Method could be used for any area based on the space RCR and the illuminance category of the space as published in the IES Handbook. However, this approach was hard to enforce as it was not realistic to expect that building officials in California's 500+ jurisdictions would all be familiar with and able to enforce the illuminance categories in the IES Handbook.

Over time, more categories have been added to the Area Category Method and use-it-or-lose-it adders for task, display, and ornamental lighting. This has reduced the need for the broad array of categories in the Tailored Method. The current process is that illuminance values are predefined in TABLE 140.6-D Tailored Lighting Power Allowances, which has general lighting illumination values. These illumination values are converted into W/ft^2 values based on RCRs in TABLE 140.6-G Illuminance Level (Lux) Power Density Values (Watts/Square Feet). In addition, TABLE 140.6-D also has use-it-or-lose-it task lighting, floor display lighting, and wall display lighting allowances, so additional layers of lighting are accommodated.

Therefore, the Statewide CASE Team recommends deleting Section 140.6(c)3H, which would then allow the following categories of spaces to use the Tailored Method approach for general lighting based on the illuminances in the IES Handbook:

- Exercise Center, Gymnasium
- Medical and Clinical Care
- Police Stations and Fire Stations
- Public rest areas along state and federal roadways
- Other primary function areas not already listed in Area Category Method or Tailored Method tables.

To accommodate for deleted spaces as a result of removing Section 140.6(c)3H, the Statewide CASE Team proposes to add them as a new category under the Area Category Method or identify another appropriate provision. Spaces that can be assigned to Area Category Compliance are:

- Exercise Center, Gymnasium
- Medical and Clinical Care
- Police Stations and Fire Stations

It is currently unclear whether public rest areas along state and federal roadways are nonresidential interior or exterior lighting. Therefore, a description for public rest areas needs to be developed, which includes determining whether these areas are interior or exterior.

Using the IES Handbook 10th Edition as the reference for setting the LPDs of primary function areas not already listed is arbitrary and difficult for code authorities enforce; understanding the IES Lighting Handbook can be difficult for non-lighting experts. The Statewide CASE Team proposes that spaces that are not already identified in Title 24, Part 6 should be compared to a space type or function area already listed. Furthermore, with the participation of a governing compliance official, the LPD for the non-listed space can be set using the closest identified existing space within Title 24, Part 6.

Appendix P: AGING EYE/LOW-VISION SPACES

As an ongoing effort to address specialized lighting needs and to align more closely with ASHRAE/IES 90.1, the Statewide CASE Team proposes to include provisions for spaces primarily occupied by individuals with low-vision needs. Additional LPDs that can accommodate the higher illumination necessary for low-vision needs have been added to the Area Category Method (Table 140.6-C). The Primary Function Area is identified as Aging eye/Low-Vision and includes the following spaces:

- Entry/Main Lobby
- Stairwell
- Corridor/Hallways
- Lounge/Waiting Room
- Activity/Common Room
- Religious Worship
- Dining
- Restroom/Bathroom

The spaces and LPDs were chosen based on a review and analysis of IES RP-28-2016, Lighting and the Visual Environment for Seniors and the Low Vision Population, as well as ASHRAE/ IES 90.1 documentation relative to provisions for low-vision individuals.

The Statewide CASE Team used the Title 24-2019 VAN modeling spreadsheet to develop the LPDs for Aging Eye/Low-Vision spaces. More details on the Inverted Lumen method are found in Appendix D. Results are shown in Table 71 and includes two options (A & B) for proposed LPDs. The Statewide CASE Team is proposing Option B which sets a lower base LPD and provides use-it-or-lose-it adders as a means of reaching the LPD targets generated by the VAN Title 24-2019 modeling.

Table 72 provides a comparison between the latest ASHRAE/IES 90.1, ASHRAE/IES 189.1, and the new LPDs (both Option A & B) for Aging Eye/Low-Vision spaces. The proposed Title 24, Part 6 2019 baseline is also included as a reference.

Table 71: Low-vision Space Types Modeled using T24-19 VAN

Space Type	FC Target	General LPD (VAN Model)	Task & WW (adjusted) LPD	Total LPD (VAN Model)	Allowed LPD	
					Option A	Option B
Corridors	20 FC	0.54 W	0.37 W	0.91 W	0.90 W	0.80 W + 0.15 W (decorative adder)
Dining	20 FC + (50 FC Task)	.45 W	0.57 W	1.02 W	1.00 W	0.80 W + 0.30 W (ornamental adder)
		.50 W	0.45 W	0.95 W		
		.43 W	0.30 W[a]	0.73 W		
Activity/Common Room	30 FC +	0.98 W	0.21 W	1.19 W	1.20 W	0.95 W + 0.30 W (ornamental adder)
Lounge/Waiting Rooms	20 FC +	0.41 W	032 W	0.73 W	0.90 W	0.75 W + 0.30 W (ornamental adder)
Entry Lobby (daytime)	100 FC	1.67 W	0.10 W	1.77 W	1.80 W	1.65 W + 0.20 W (accent/feature adder)
Religious Worship	30 FC +	0.62 W	0.51 W	1.13 W	1.15 W	1.00 W + 0.30 W (ornamental adder)
Restroom	(5:1 Accent)	0.59 W	0.37 W	0.96 W	1.00 W	0.75 W + 0.35 W (multiple adder)

a. No wall wash component.

Table 72: ASHRAE/IES 90.1 and 189.1 2017 Spaces vs Title 24, Part 6 2019 Proposed

Space Type and/or Area	ASHRAE 90.1-2016	ASHRAE 189.1-2017	T24-2019 Baseline	T24-2019 Low-Vision Option A	T24-2019 Low-Vision Option B
Entry Lobby[a] (Daytime) - visually impaired	2.03	1.59	0.85	1.80 W	1.65 W + 0.20 W (adder)
Stairwell - facility for the visually impaired	NA	0.81	0.50	0.70 W	0.80 W (used 90.1 #)
Corridor - facility for the visually impaired	0.92	0.81	0.60	0.90 W	0.80 W + 0.15 W (adder)
Dining Area - facility for the visually impaired	2.00	1.69	0.40 to 0.55	1.00 W	0.75 W + 0.30 W (adder)
Restroom - facility for the visually impaired	0.96	0.68	0.65	1.00 W	0.80 W + 0.35 W (adders)
Religious Worship - visually impaired	1.06	0.84	0.95	1.15 W	1.10 W + 0.30 W (adders)
Activity/Common Room - visually impaired	1.80	1.59	0.65	1.20 W	0.95 W + 0.30 W (adder)
Lounge/Waiting Rooms - visually impaired	1.80	1.59	0.65	0.90 W	0.75 W + 0.30 W (adder)

a. Baseline 0.85 with balance via daylighting controls.