

# Indoor Lighting Power Density



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# Executive Summary

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This proposal presents updates to indoor lighting power density (LPD) requirements for consideration in the 2028 California Energy Code (Title 24, Part 6). The proposed measure aims to reduce energy use by updating LPD values and improving consistency in luminaire wattage determination. These updates support California’s long-term energy efficiency, greenhouse gas (GHG) reduction goals, and alignment with national standards such as ASHRAE 90.1-2025. The proposal applies to nonresidential buildings, including new construction, additions, and alterations across all climate zones.

The Statewide CASE Team engaged manufacturers, lighting designers, engineers, and facility operators through workshops, focus groups, and targeted outreach. Stakeholder feedback emphasized challenges with compliance complexity, inconsistencies in luminaire data, and the need for clear wattage determination rules. This feedback directly informed the proposal, including use of maximum selectable wattage, updates to luminaire classification, and simplification of alteration pathways. Only the four applications brought in from the Tailored Method were updated in the 2025 Energy Code, the 75 remaining applications have not been updated since the 2022 Energy Code. Thus, the results detailed in this report represent the advancements in lighting technologies that have occurred in the past six years.

Environmental and social justice (ESJ) impacts were evaluated across cost, health, resiliency, and comfort. The proposal is not expected to negatively impact disadvantaged communities and may improve visual comfort, reduce lighting system costs, and lower utility bills.

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## Measure: Indoor Lighting Power Density (LPD) Updates

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### Proposed Code Change

The proposal would reduce LPD limits for many space types based on advances in LED technology, improved luminaire efficacy, and updated design practices. It also introduces clarified rules for determining luminaire wattage, including requirements for multi-wattage luminaires, line-voltage luminaires, and retrofit LED systems. Additionally, the proposal simplifies the one-to-one luminaire alteration pathway by replacing a floor-area threshold with a wattage-based threshold ( $\leq 3,000$  watts with  $\geq 40\%$  reduction).

## Benefits of Proposed Change

The measure would reduce lighting energy consumption while maintaining illuminance levels aligned with Illuminating Engineering Society recommended practice standards. Updated LPD values reflect modern LED performance and align California standards with national model codes. The proposal improves compliance clarity, supports adoption of high-efficacy lighting technologies, reduces overdesign, and helps maintain Energy Code stringency over time.

## Compliance and Enforcement

The proposal builds on existing compliance structures using the comparison of the Adjusted Indoor Lighting Power to the Allowed Lighting Power. Updates clarify installed wattage determination and improve consistency in compliance documentation. No significant changes to compliance processes or acceptance testing are required, though minor updates to compliance software and training materials are expected.

## Market Assessment

High-efficiency LED lighting products are widely available from multiple manufacturers and distributors. The proposal does not require new technologies but reflects existing market capabilities and performance trends. Manufacturer impacts are limited to labeling and documentation updates, and the measure supports continued innovation in lighting efficiency and controls.

## Cost Effectiveness

The measure is cost effective, as reduced lighting power decreases energy consumption and long-term system costs. In many cases, improved luminaire efficacy results in lower first costs due to reduced wattage requirements while maintaining performance.

## First-Year Statewide Impacts

The proposed LPD reductions are expected to result in significant statewide electricity savings, peak demand reduction, and GHG emissions reductions. Prototype analysis shows meaningful energy savings across many building types. For example, large spaces such as atria and convention spaces demonstrate substantial annual energy savings, while typical spaces such as classrooms, offices, and retail also show consistent reductions in energy use and lifecycle costs. Detailed statewide results, including energy, demand, and GHG impacts, are provided in the report's statewide impact tables.

**Table 1: Market Adjusted Statewide Energy and LSC Impacts—New Construction, Additions, and Alterations**

<b>Metric <sup>a</sup></b>	<b>New Construction and Additions</b>	<b>Alterations</b>	<b>Total</b>
<b>Annual Electricity Savings (GWh)</b>	17.6	61.5	79.1
<b>Peak Demand Reduction (MW)</b>	1.6	5.4	7.0
<b>Annual Natural Gas Savings (Million Therms)</b>	N/A	N/A	N/A
<b>Annual Source Energy Savings (Million kBtu)</b>	20.5	69.0	89.5
<b>30-Year Long-term System Cost Savings (Million 2029 PV\$)</b>	\$135	\$467	\$602
<b>Annual Avoided GHG (Metric Tons CO<sub>2</sub>e/yr)</b>	1,087	3,642	4,729

a. Values represent impacts from buildings permitted during the first year the code is in effect. Positive values indicate savings or reductions. Values correspond to Table 20 (market adjusted energy impacts), and Table 21 (GHG emissions impacts) in the source CASE report.

# Acronyms

Table 2 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a [glossary of terms](#).

**Table 2: List of Acronyms**

Acronym	Definition
<b>ACM</b>	Alternative Calculation Method
<b>ASHRAE</b>	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
<b>BCR</b>	Benefit-to-cost Ratio
<b>Btu</b>	British Thermal Units
<b>CASE</b>	Codes and Standards Enhancement
<b>CBECC</b>	California Building Energy Code Compliance Software
<b>CEC</b>	California Energy Commission
<b>CBO</b>	Community-Based Organization
<b>CPUC</b>	California Public Utilities Commission
<b>CZ</b>	Climate Zone
<b>DAC</b>	Disadvantaged Community
<b>DGS</b>	California Department of General Services
<b>DOSH</b>	Division of Occupational Safety and Health
<b>ECC</b>	Energy Code Compliance
<b>EIR</b>	Environmental Impact Report
<b>EPIC</b>	Electric Program Investment Charge
<b>ESJ</b>	Environmental and Social Justice
<b>FSOR</b>	Final Statement of Reasons
<b>GHG</b>	Greenhouse Gas
<b>GWh</b>	Gigawatt-Hour
<b>HVAC</b>	Heating, Ventilation, and Air Conditioning
<b>IECC</b>	International Energy Conservation Code
<b>IES</b>	Illuminating Engineering Society
<b>IOU</b>	Investor-Owned Utility
<b>ISOR</b>	Initial Statement of Reasons
<b>kWh</b>	Kilowatt-Hour
<b>kWh/year</b>	Kilowatt-Hour Per Year
<b>LED</b>	Light Emitting Diode
<b>LPD</b>	Lighting Power Density
<b>LSC</b>	Long-term System Cost

Acronym	Definition
<b>MeasureSET</b>	CASE Measure Savings Estimation Template
<b>MG</b>	Million Gallons of Water
<b>NAICS</b>	North American Industry Classification System
<b>NPDI</b>	Net Private Domestic Investment
<b>PEP</b>	Public Engagement Plan
<b>PV</b>	Present Value
<b>RCR</b>	Room Cavity Ratio
<b>SOC</b>	Standard Occupational Classification
<b>SRIA</b>	Standardized Regulatory Impact Assessment
<b>UL</b>	Underwriters Laboratories
<b>W</b>	Watt

# 1. Introduction

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This proposal describes energy efficiency code changes (referred to as “measures”) aimed at reducing wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. These measures are submitted to the California Energy Commission (CEC) for consideration and potential inclusion in California’s Energy Code (Title 24, Part 6), which sets statewide energy efficiency requirements for newly constructed buildings and for additions and alterations to existing buildings. Measures may also be considered for inclusion in CALGreen (Title 24, Part 11) as voluntary energy efficiency standards, which would take effect only if adopted by a local jurisdiction seeking to exceed the minimum requirements of the Energy Code. Measures submitted to the CEC will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. To be included in the Energy Code, proposed measures must be both cost-effective and technically feasible.

The CEC is the state agency authorized to adopt revisions to Title 24, Part 6. One way the Statewide CASE Team participates in the development process is by submitting code change proposals to the CEC for consideration. CEC will evaluate proposals that the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. See the [CEC’s 2028 code cycle website](#) for information about the rulemaking schedule and how to participate in the process.

## 1.1 Report Context

This proposal describes specific energy-efficiency code changes (referred to as “measures”) aimed at reducing wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. These measures are submitted to the California Energy Commission (CEC) for consideration and potential inclusion in California’s Energy Code (Title 24, Part 6), which sets statewide energy efficiency requirements for newly constructed buildings and for additions and alterations to existing buildings. Measures may also be considered for inclusion in CALGreen (Title 24, Part 11) as voluntary energy efficiency standards, which would take effect only if adopted by a local jurisdiction seeking to exceed the minimum requirements of the Energy Code. Measures submitted to the CEC will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. To be included in the Energy Code, proposed measures must be both cost effective and technically feasible.

## 1.2 Proposal Sponsors

Three California Investor-Owned Utilities (IOUs)—Pacific Gas & Electric Company, San Diego Gas & Electric, and Southern California Edison jointly sponsored this effort. Where the term “Statewide CASE Team” is used in this report, it refers to the authors and State Building Codes Advocacy activities supported through the Codes and Standards program.

## 1.3 Stakeholder Engagement to Inform Proposal

The Statewide CASE Team engaged a broad set of stakeholders including manufacturers, designers, code experts, and facility operators through a public workshop, targeted outreach, and a designer focus group to inform the proposal.

Key themes from stakeholder input:

**Compliance and design practices:** Current Title 24 compliance can be challenging, particularly for complex projects. Designers rely on typical assumptions (e.g., LLD ~0.90; LLF ~0.80–0.85) and raised questions about alignment between specified and actual performance.

**Wattage and controls:** General support for using the highest selectable wattage for multi-output products and for expanded use of current limiters to manage compliance and prevent post-installation changes.

**Retrofit strategies:** Type B and C retrofits are more commonly used than Type A, though Type A remains relevant for maintenance. Tradeoffs exist across cost, safety, and reliability.

**Programmable Drivers:** Programming of programmable-drivers for multi-wattage luminaires practices are inconsistent and often decentralized. Programming is typically factory-controlled, while labeling may occur post-installation with limited verification infrastructure.

**Technology trends:** Higher-efficacy luminaires are technically feasible with minimal cost or performance tradeoffs but currently represent a small market share driven by demand rather than constraints.

See Appendix F for additional details on the Statewide CASE Team’s stakeholder engagement. See Section 1.1 Report Context.

for a summary, for an explanation of how the stakeholder input informed the LPD analysis. See *Section 2.5.4 Summary of Stakeholder Comments on Luminaire Wattage*, for a summary of how the stakeholder feedback were used to inform luminaire classification and wattage rating.

A more detailed description of the questions asked of stakeholders and a summary of their responses are contained in Appendix F.

## 1.4 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in environmental and social justice (ESJ) communities.<sup>1</sup> These issues persist today. To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences on ESJ communities.

When analyzing impacts for nonresidential buildings, the Statewide CASE Team reviewed each nonresidential building type through the lens of four criteria: cost, health, resiliency, and comfort. The Statewide CASE Team examined which building types are used by ESJ communities most frequently and evaluated the allocation of impacts related to the following areas among all populations. Some building types have unique environmental justice concerns due to their common uses, location, or other factors.

The Statewide CASE Team will continue to build relationships with community-based organizations and other stakeholders to improve the identification of potential impacts for future code cycles and is open to additional resources that can contribute to this effort.

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<sup>1</sup> The CPUC refers to ESJ communities as “low-income or communities of color that have been underrepresented in the policy setting or decision-making process, are subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socioeconomic investments in their communities” (CPUC 2022). ESJ communities also include the CPUC definition for Disadvantaged Communities, which comprises “(1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0 (1,984 tracts); (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores (19 tracts); (3) Census tracts identified in the 2017 DAC designation as disadvantaged, regardless of their scores in CalEnviroScreen 4.0 (307 tracts); and (4) Lands under the control of federally recognized Tribes (OEHHA 2022).

## 2. Measure Description

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### 2.1 Proposed Code Change

This code change proposal aims to update the prescriptive requirements on lighting power density (LPD) for nonresidential indoor spaces. The LPD requirements dictate the maximum lighting power allowed in each building type or space type within a building. The LPD requirements in 2025 Title 24, Part 6, Section 601.3.1 [Section 140.6] will be the base case, and the proposed case has lower LPD values than the base case, although this varies by building and area type. A lower LPD value means that the same maintained level of illumination in a building or an area would be provided while using less lighting power.

The proposed LPD update is based on the following four factors:

1. **Advancements in LED technology** since the 2022 code cycle have resulted in higher maintained luminous efficacies for light sources.
2. **Updated industry practices for lamp lumen depreciation.** Market information on LED products having a 90 percent lamp lumen depreciation (LLD) at an expected life of 50,000 hours is broadly being used in lighting design and is used for calculating reduced LPD requirements in the most recent national model energy codes (ASHRAE 90.1-2025 and the 2027 version IECC). Initial research by the Statewide CASE Team has supported these assumptions.
3. **Alignment with national lighting design standards.** The LPD requirements in Title 24, Part 6 are based upon meeting or exceeding the maintained illuminance recommendations of the Illuminating Engineering Society (IES) contained in either the IES Illuminance Selector or the pertinent current Recommended Practice (RP) by application type.
4. **Alignment with national energy standards.** Lighting power information developed for the national model energy efficiency codes is also compared and considered when developing the updated Title 24, part 6 LPD values. This comparison also forms part of the consideration to add new space types.

Furthermore, to ensure consistent and accurate determination of installed lighting power, the proposal includes updated guidance for luminaire classification and power in Section 601.2.1 [Section 130.0(c)] to more closely align with national model codes and reflect changes to lighting technology. The four primary changes recommended for luminaire classification and power are:

- Allow the wattage of a luminaire with line voltage sockets to be the combined wattage of lamps that are installed in the luminaire.

- For multi-wattage lamps or luminaires to be the maximum field-adjustable wattage that is possible after installation, without removing the luminaire from its installed location.
- Limit the use of LEDs that are installed downstream of a fluorescent or HID (high intensity discharge, high pressure sodium, or metal halide) ballast by treating the wattage of the ballasts and LED combination as the wattage of the ballast when it was driving the legacy fluorescent or HID light source.
- Allow the use of current limiters for any adjustable wattage lighting technology installed wattage to increase design flexibility. Today, current limiters are a compliance option limited to track lighting applications.

In addition, the proposal aims to simplify the indoor lighting alteration provisions by replacing the current 5,000 square foot floor-area limitation for one-to-one luminaire alterations with a cap on the total wattage of altered luminaires. Under the proposed change, the simplified alteration pathway would apply where the total wattage of altered luminaires does not exceed 3,000 watts and the alteration reduces lighting wattage by at least 40 percent relative to the pre-alteration condition. This change maintains comparable stringency while eliminating the need to determine room or tenant space floor area to demonstrate eligibility for the simplified compliance pathway.

The revised LPD requirements do not vary by climate zone and would apply to new construction, additions, and alterations. No changes to the compliance process are anticipated. While no structural or formatting change to the compliance software and documents are expected, the LPD values built into them would need to be updated to reflect the revision.

Table 3 summarizes the scope of the proposed code change.

**Table 3: Scope of Proposed Code Change**

A  indicates the proposed code change is relevant.

Building Type(s)		Construction Type(s)		Type of Change			
<input type="checkbox"/> Single Family		<input checked="" type="checkbox"/> New Construction		<input checked="" type="checkbox"/> Mandatory			
<input type="checkbox"/> Multifamily		<input checked="" type="checkbox"/> Additions		<input checked="" type="checkbox"/> Prescriptive			
<input checked="" type="checkbox"/> Nonresidential (Not Group R uses)		<input checked="" type="checkbox"/> Alterations		<input checked="" type="checkbox"/> Performance			
Application Climate Zones		Energy Code Sections		Compliance Forms		Sections of ACM Reference Manuals	
Climate Zones 1–16		Part 6, Section 601.2.1 [Section 130.0(c)], Section 601.3.1 [Section 140.6], Section 601.5 [Section 141.0]		NRCC-LTI-E, LMCC-LTI-E and NRCC/LMCC-PRF-E		Prescriptive, Section 5.4.4	
Acceptance Tests				Updates to Compliance Software			
<input checked="" type="checkbox"/> No changes to acceptance test				<input type="checkbox"/> No updates			
<input type="checkbox"/> Update existing verification requirements				<input checked="" type="checkbox"/> Update existing feature			
<input type="checkbox"/> Add new acceptance tests				<input type="checkbox"/> Add new feature			

## 2.2 Benefits of Proposed Change

High-efficiency light sources are now widespread, and updating LPD requirements in Title 24, Part 6 ensures that new and altered buildings reflect these advancements. By revising LPDs to reflect the latest recommended practices from the Illuminating Engineering Society (IES) and appropriate illumination levels, this code change maximizes energy savings while supporting the continued effectiveness and modernization of California’s lighting market (Illuminating Engineering Society 2025).

These updates are grounded in multiple improvements:

1. Adoption of updated IES standards.
2. Refined mappings of primary function areas to task requirements.
3. Updated luminaire zonal lumen distributions added to the Inverse Lumen Method model.
4. Updated luminaire data reflecting current design practice and higher maintained efficacy.

Updating LPDs directly impacts energy savings and maintains the efficient design features of compliant lighting designs while using high-efficacy light sources. The Nonresidential ACM Reference Manual relies on LPDs as a baseline for energy modeling. If lighting efficacy increases but LPDs remain fixed, designs may install less

power than allowed, potentially shifting inefficiencies to other building systems such as HVAC or envelope components. Revising LPDs would ensure that lighting designs continue to meet recommended illuminances with current commercially available efficacies, maintaining the stringency and effectiveness of Title 24, Part 6 over time.

These updates would also support broader market and policy goals. Efficient, well-designed lighting reduces building energy use and occupant energy bills, simplifies compliance for designers and code officials, and drives market transformation toward higher-performing luminaires.

By integrating current technologies, good design practices, and updated standards, this code change would reinforce California's leadership in energy efficiency and ensure future building designs maximize performance, sustainability, and affordability.

## 2.3 Background Information

### 2.3.1 Lighting Power Density

Over the past three decades, lighting technology has advanced significantly, particularly with the widespread adoption of light-emitting diodes (LEDs). These high-efficiency light sources have steadily increased in maintained efficacy, producing more light for the same amount of electricity. As a result, the LPD values in Title 24, Part 6 have been updated in previous code cycles to reflect these improvements. Prior to the 2019 code cycle, the allowable LPDs in Section 601.3.1 [*Section 140.6*] were based on a mix of older technologies, including fluorescent, metal halide, and infrared-reflecting halogen lamps. These traditional sources had lower efficacy and limited control over light distribution, which restricted energy savings potential.

The 2019 update of indoor LPD requirements represented a significant shift in approach. The standards moved from legacy lighting technologies to LEDs as the baseline. LEDs not only offer higher efficacy but are also typically dimmable and have more controllable light distribution. These characteristics allow for higher optical efficiency, directing light precisely where it is needed. As a result, the 2019 revision of Title 24, Part 6 significantly reduced allowable LPDs, ensuring energy savings while maintaining appropriate illumination levels for building occupants. Updates in the 2022 revision of Title 24, Part 6, continued to reduce allowable LPDs in appropriate space types reflecting increasing efficacy and optical efficiency of LED luminaires. During the 2025 Title 24 lighting power allowance updates, most lighting applications were unaffected, the only change to lighting power allowances was to move the applications in tailored lighting method into the area category method; with multiple rows of additional allowances for each space type to approximate the layered allowances in the tailored lighting method.

The Statewide CASE Team’s review of LPD requirements in national standards (2025 ASHRAE 90.1) and other model codes (2024 IECC) shows that for certain space types, the LPD values in these national and model codes are already lower than the values in the 2025 Title 24, Part 6. The IECC proposed general lighting values are identical to those adopted in ASHRAE 90.1-2025 for the Space-by-Space Method and for the Building Area Method. Additionally, the national codes do not have the level of complexity as in the tailored lighting method or the space types with multiple rows of additional allowances in Table 140.6-C for the 2025 Title 24 Areas Category Method.

The lighting designers on the lighting and power subcommittee to ASHRAE 90.1 agreed that they use a lamp lumen depreciation factor of 90 percent for designing lighting systems. This higher lamp lumen depreciation (i.e., less light loss over time) resulted in lower LPDs in the ASHRAE 90.1 lighting model and resulted in lower LPDs in the Space-by-Space Method and the Building Area Method. A lighting designer on the Statewide CASE Team interviewed lighting manufacturers and their representatives and confirmed that a 90 percent lamp lumen depreciation at 50,000 hours is a reasonable value and that the equipment cut sheets do not always represent the lamp lumen depreciation of latest products. In prior technical models for ASHRAE 90.1 and Title 24, manufacturers’ reported data were used, resulting in LPDs that were 6.4 percent higher due to this factor alone.

California is experiencing a rapid growth of data center construction to support cloud computing and artificial intelligence. Current Title 24 requirements do not explicitly address LPDs for data centers and their spaces. Updating LPDs for these building types would help ensure that illumination services are delivered efficiently while supporting broader energy savings goals.

### **2.3.2 Luminaire Classification**

Indoor lighting compliance under Title 24 is determined by comparing the Adjusted Indoor Lighting Power, calculated according to Section 601.3.1.1 [*Section 140.6(a)*], to the Allowed Indoor Lighting Power in Sections 601.3.1.2 and 601.3.1.3 [*Sections 140.6(b) and 140.6(c)*]. The Allowed Indoor Lighting Power is based on LPD values in Table 601.3-B [*Table 140.6-B*] (Complete Building Method) and Table 601.3-C [*Table 140.6-C*] (Area Category Method). The Adjusted Indoor Lighting Power is derived from the total installed wattage of luminaires as defined in Section 601.2.1 [*Section 130.0(c)*] (“Luminaire classification and power”) and modified by various exclusions and adjustments.

While this proposal would not change Section 601.3.1.1 [*Section 140.6(a)*], it does propose updates to Section 601.2.1 [*Section 130.0(c)*] to better align with recent guidance on defining installed wattage, including methods adopted in ASHRAE 90.1-2022 Addendum (ASHRAE 2025). These changes would ensure that installed lighting

power is accurately described and increase flexibility to comply with the Title 24 lighting standards with the latest lighting technologies.

The proposed updates to Section 601.2.1 [Section 130.0(c)] include:

**1. New requirements for field-adjustable solid-state lighting (SSL) luminaires**

Wattage must now reflect the highest output setting available from the manufacturer or manufacturer approved representative. The chosen maximum wattage must be marked on a permanent label installed by the manufacturer or their authorized representative. This ensures that installed wattage accounts for the full operational capability of field-adjustable products.

**2. Revised wattage determination for luminaires with line-voltage lamp holders**

Instead of defaulting to the luminaire's maximum relamping wattage, wattage is now based on the installed lamp or SSL light engine. This aligns the rules with ASHRAE practices and provides a more accurate reflection of actual installed power.

**3. Clarification on wattage determination for SSL luminaires using legacy ballasts**

The proposed language explicitly addresses luminaires in which SSL is powered by high-intensity discharge (HID) or fluorescent ballasts. If adopted, the proposed language would establish that the reported wattage must be based on the maximum reported input power under the ballast's rated operating conditions, as documented by the ballast manufacturer (e.g., the highest input watts for any listed lamp configuration). This ensures a conservative and consistent method for power calculations when legacy ballasts remain in place.

These proposed updates have implications for linear LED lamps, including UL Type A, Type B, and Type C architectures.

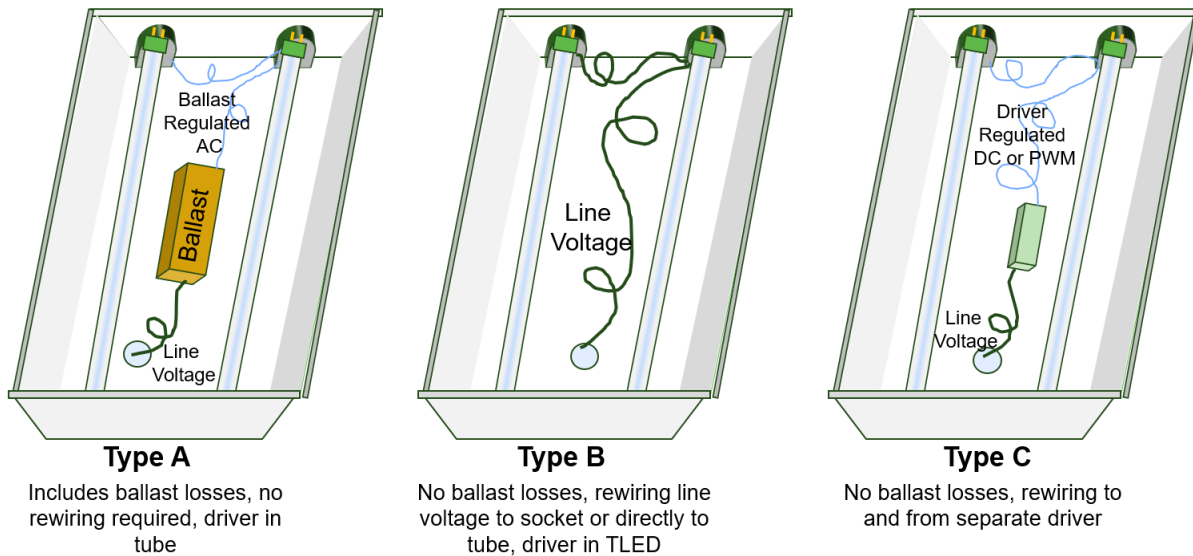


Figure 1: Three types of linear LED lamps.

**4. UL Type A (fluorescent ballast-compatible lamps):**

UL Type A products rely on an existing fluorescent ballast. Under the proposed language, these systems are explicitly covered by Section 601.2.1.4 [Section 130.0c(3)]. Installed wattage for compliance purposes must be based on the maximum rated wattage of the ballast, regardless of the lower rated wattage of the SSL lamp itself. This may result in higher reported installed wattage compared to SSL-only systems.

**5. UL Type B (ballast-bypass, line-voltage lamps):**

Under the current Energy Code and proposed updates, UL Type B lamps fall under the line-voltage lamp-holder provisions. Installed wattage would be based directly on the lamp's labeled wattage or driver-integrated SSL light engine rating, rather than any historical fluorescent lamp rating.

**6. UL Type C (remote-driver systems):**

UL Type C systems operate the same as SSL luminaires with dedicated drivers. Under the current and proposed Section 601.2.1 [Section 130.0(c)], UL Type C systems must use the maximum rated input wattage of the driver/lamp combination and may be subject to the expanded SSL labeling requirements.

**2.3.3 Simplification of One-to-One Luminaire Alteration Pathway**

Under the current requirement in Section 601.5.2.2.4 [Section 141.0(b)2], the one-to-one luminaire alteration pathway is limited to alterations within spaces of 5,000 square foot or less. Determining eligibility therefore requires calculating the floor area of the affected space or tenant area, which can require additional documentation or drawings and therefore increase compliance complexity for relatively small retrofit projects.

To maintain comparable stringency while simplifying compliance, the proposed language replaces the floor-area limit with a cap on the total wattage of altered luminaires. The simplified pathway would apply only where the total wattage of all altered luminaires does not exceed 3,000 watts and where the alteration reduces lighting wattage by at least 40 percent compared to the pre-alteration condition.

The 3,000-watt threshold is derived from typical legacy lighting conditions. Assuming a legacy lighting power density of approximately one watt per square foot, a 5,000 square foot space would have approximately 5,000 watts of installed lighting. A 40 percent reduction results in approximately 3,000 watts of post-alteration lighting load.

Anecdotally, this corresponds roughly to a retrofit involving about 100 luminaires at 30 watts each, representing a substantial lighting upgrade while remaining consistent with the scale of projects intended for the simplified pathway.

By using a wattage threshold rather than a floor-area limit, the proposed change preserves the intended scope of the simplified alteration pathway while eliminating the need to calculate room size or provide supporting plans, thereby reducing compliance burden without materially reducing energy savings.

## 2.4 Technical Basis of Lighting Power Densities

The maximum allowed lighting power densities are developed based on multiple layers of analysis, comparison and review. These can be summarized as follows.

1. **Technical model.** This model uses a lumen method calculation to approximate the required lighting power density to light prototypical spaces to maintained light levels recommended by the Illuminating Engineering Society in their Lighting Selector or appropriate Recommended Practice. These models contain assumptions about geometry, reflectances, and types of lighting systems to generate a calculated W/sf.
2. **Interviews with market participants on current design features and current lighting power densities.** This also includes feedback from stakeholders and solicited comments from recognized experts in the lighting design community.
3. **Comparison with Title 24, compliance documentation databases.** These databases summarize the lighting power density for different building types and space types.

### 2.4.1 Technical Model for Calculating LPDs

Most LPDs in previous iterations of ASHRAE standards and Title 24, Part 6 iterations were based on versions of the Inverse Lumen Method calculation, a simplified lighting calculation that's been used since the early 1900s and is documented in the IES Handbook and other publications. An advantage of the Inverse Lumen Method is its simplicity and transparency; all the inputs can be entered into a spreadsheet, simplifying

review. The Inverse Lumen Method is based on a simplified model that calculates the allowable lighting power needed to deliver a targeted design illuminance. This works well based on far-field photometric measurements of luminaires and in rooms that are open rectangular boxes without too much intervening furniture, partitions, or stacks. As spaces deviate from these assumptions, one can use more exacting models that use the radiosity calculation approach. The radiosity calculation approach was used in the prior code cycle for large offices with systems furniture, library stacks, and warehouse areas with racks.<sup>2</sup> For this proposal, new detailed models were not conducted. Instead, the Statewide CASE Team used the previously calculated radiosity calculation models and scaled those using luminaire efficacy.

The updates to LPDs proposed for the 2028 Title 24, Part 6 Standards are based on this same method. The Statewide CASE Team reviewed and refined these calculation results, drawing on their professional experience to ensure accuracy and relevance.

#### **2.4.1.1 Derivation of Inverse Lumen Method**

The average maintained illuminance (luminous flux density),  $\dot{E}_{\text{maintained}}$ , (in units of FC or lux in SI units) in a space is calculated by the following Lumen Method equation:<sup>3</sup>

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

Where,

CU = coefficient of utilization, or fraction of lumens from light sources that reaches the work plane directly or via interreflections. This is a function of luminance distribution of the luminaire, the geometry of the space as described by the Room Cavity Ratio (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.

Historically, the Statewide CASE Team relied on lookup tables for CU values. Beginning with the 2022 version, however, the LPD model has used an Excel User-Defined Function to calculate directly from the space geometry, surface reflectances, and the zonal lumen distribution of the luminaires. The Excel User—Define Function enables the State CASE Team to create a custom Visual Basic function in Excel that performs these calculations directly, eliminating the need for lookup tables. This approach results in a more efficient and lightweight spreadsheet. The Statewide CASE Team collected IES photometric files for all

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<sup>2</sup> <https://title24stakeholders.com/measures/cycle-2022/nonresidential-indoor-lighting/>

<sup>3</sup> Illumination Engineering Society (IES).2011. The Lighting Handbook 10<sup>th</sup> edition. Equation 10.30.

luminaires of interest and extracted the zonal lumens for each file using the Lighting Analysts Photometric Toolbox software.

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 include ballast, thermal, and equipment operating factors such as lamp operating position.

For integral LED luminaires, this equation differs slightly. The LED's light output 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 entire luminaire's output. The equation for integral LED luminaires can more accurately be described as follows:

$$\dot{E}_{maintained,LED} = \frac{(no. luminaires)(luminaire lumens)(CU)(LLF)}{workplane area}$$

Where luminaire lumens represent the lumens leaving the luminaire and account for both the thermal effects of a luminaire and its optical efficiency. As a result, the same luminaire tested with an integral LED would 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 reaches the work plane, whereas the CU for the same fixture fitted with fluorescent lamps represents the light leaving the lamps that reaches the work plane.

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:

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

For the 2022 Title 24, Part 6 update, the Statewide CASE Team developed a database of 68 luminaires based on the averaged results of 488 source luminaires. This database includes:

1. Luminaire description
2. Luminaire lumens
3. Input watts from which luminous efficacy can be calculated
4. Zonal lumens for each 10-degree increment vertical angle, normalized to 1,000 lumens per luminaire to allow averaging across luminaires with different total lumen output
5. CIE Classification, Direct to Indirect, calculated from zonal lumen description

Lumen depreciation is estimated per luminaire type based on multiple interviews and comparisons of product literature to best estimate the actual lamp lumen depreciation. It builds on the ASHRAE 90.1 precedent of using the 90 percent lamp-lumen depreciation, unless a more robust estimate is found.

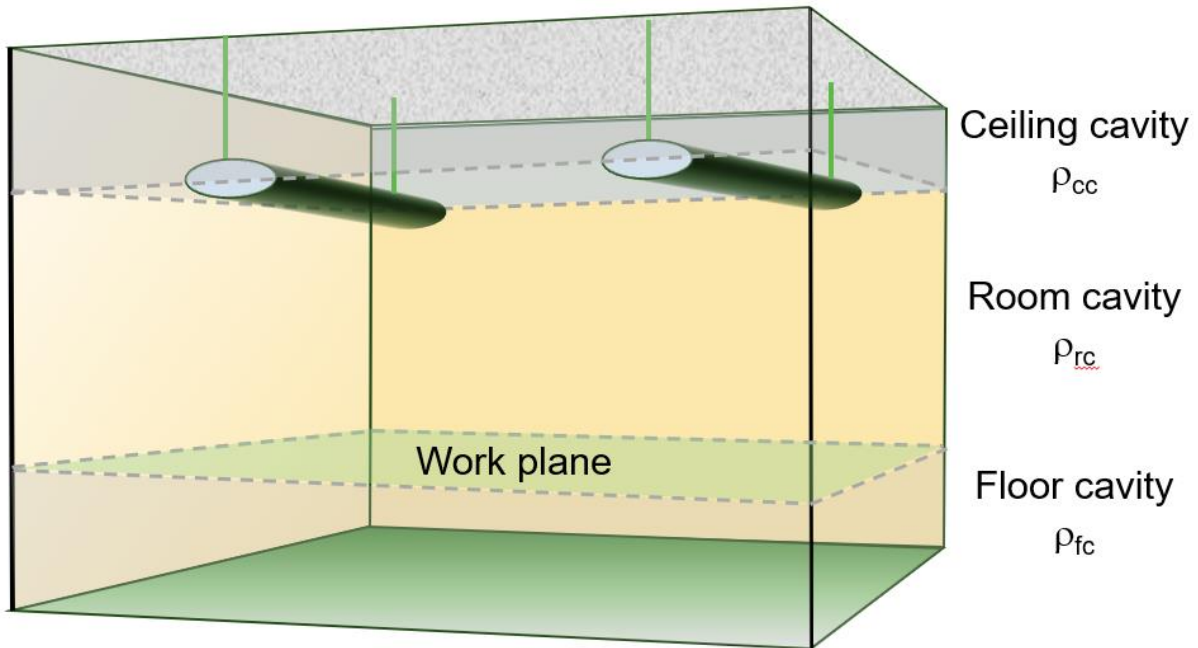
From these components, maintained, delivered luminous efficacies, and  $K_{\text{maint,delivered}}$  are calculated. This proposal added higher-performing luminaires to this database and modified the light loss factors to best represent the performance of the equipment's performance over its expected life and maintenance schedule.

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

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

Where the space fraction indicates what fraction of the space area is being illuminated to a given design illuminance (FC) 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.



**Figure 2: Schematic of sample space light transfer simulated using the Inverse Lumen Method.**

In the past, CUs were provided for each luminaire type at various room cavity ratios in increments of factors of 2 from 2 to 10. Typically, this was for one set of reflectances comprised of 70 percent ceiling, 50 percent wall, and 20 percent floor for most fixtures, but for industrial fixtures it was 50 percent ceiling, 30 percent wall, and 20 percent floor reflectances. Starting with the CASE proposal for LPD for the 2022 standards, a spreadsheet user-defined function calculates the coefficient of utilization for any room cavity ratio (any orthogonal geometry) and any reflectances of the ceiling, walls or floor cavities.

This allows a more accurate estimate of the luminaire lumens needed to illuminate the space to a given design illuminance, regardless of room geometry or surface reflectances.

#### **2.4.1.2 Wall Wash Calculation Method**

Wall wash luminaires are asymmetric or directional luminaires designed to light wall surfaces, increasing the brightness rather than providing horizontal illuminance on the work plane. As a result, the power required for wall washing to achieve a given average illuminance is not directly calculable using the Lumen Method. Starting in the 2019 Indoor Lighting Power Densities report, the Statewide CASE Team developed an approach to calculate wall-washing power densities per square foot of floor area. This approach requires detailed radiosity simulation of prototypical spaces and normalizing

the results for special application of the Inverse Lumen Method. There are two primary outputs for this method:

1. The amount of power required to illuminate the wall areas of the space to a given average vertical illuminance and normalized to an LPD per square foot of floor area.
2. The amount of general lighting power displaced from reflected or “spill” light from the illuminated walls, normalized to negative LPD per square foot of floor area.

The calculations below make use of more complex radiosity calculations (in this case the Statewide CASE Team used the AGi32 software) to quantify these specific lighting and power characteristics of each wall washing luminaire modeled:

$P_{WallWash}$  = Wall wash lighting power, in watts

$Area_{wall}$  = Area of vertical wall being illuminated, ft<sup>2</sup>

$E_{v,wall}$  = Average illuminance of vertical wall, foot candles

WHF = Fraction of wall height inward from wall for horizontal floor illuminance measurements, dimensionless

$E_{H,floor}$  = Average horizontal illuminance of floor plane within the fraction of wall height inward from the wall illuminated by wall wash luminaires, foot candles

The sample spaces are modeled with only the wall illuminated by evenly spaced wall-wash luminaires. The luminaire models include light-loss factors so that calculated footcandles (fc) represent maintained illuminance values. Rooms with walls heights of 12 feet or less have a WHF of 50 percent, whereas spaces with taller walls have a WHF of either 25 percent or 33 percent. Horizontal illuminances are calculated at floor levels because wall-wash lighting displaces circulation lighting, which typically has its design illuminance defined at the floor level. Wall reflectances are varied so that one can accurately model the amount of reflected light, reducing the need for separate general lighting.

For each room type modeled in the Title 24, Part 6 Lumen Method spreadsheet, a geometry is specified. For the purposes of the wall washing calculation the RCR of the space is defined as the full height RCR where the mounting height is at the ceiling levels and the horizontal work plane is at floor level.

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

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

Where,

AreaWall = area of all the walls of the room (ft<sup>2</sup>)

AreaFloor = floor area of the room (ft<sup>2</sup>)

The RCR is directly proportional to the ratio of wall area to floor area. This is a simple conversion of wall washing W/ft<sup>2</sup> of wall area to W/ft<sup>2</sup> of floor area. It should be noted that the heights used for RCR in the wall washing calculation are the heights of the room from the floor to luminaires, all mounted at ceiling level, and not the heights of the cavity between the mounting height of the luminaires and the work plane. As a result, there is a separate RCR calculated for use in the wall washing calculation.

LPDs (W/ft<sup>2</sup> of floor area) can be calculated using the RCR of a given space to convert the W/ft<sup>2</sup> of wall areas needed to wall wash all the perimeter walls in a room to given illuminance level. An LPD<sub>Wall Wash</sub> adder accounts for wall washing all the walls in a given room.

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

Where,

P<sub>WallWash</sub> = Power for wall washing, watts

This approach assumes that the wall washing watts needed would be linearly proportional to wall illuminance levels and wall area. Some adjustment is needed for tall wall heights, because wall washing luminaires for these applications are typically higher output and may have different efficacies. In addition, the ratio of average illuminance to total lumens may differ for tall walls. Thus, specific luminaires are specified for tall wall heights.

The required power for wall washing, P<sub>WallWash</sub>, and the area of the wall, A<sub>Wall</sub>, are inputs for a given detailed (radiosity) simulation. Additionally, a light loss factor is applied to the radiosity simulation so that the luminous flux output of the simulated luminaires is reduced to represent their maintained light output at the end of the 15-year period of analysis. The results from AGI simulations of the average vertical illuminance on the wall, E<sub>v,wall</sub>, are multiplied by the area of the wall to yield the total maintained lumens (luminous flux) delivered to the wall, Φ<sub>maint,v,wall</sub>. Dividing the maintained lumens delivered to the wall by the power for wall washing yields the maintained delivered luminous efficacy of the wall washing luminaires, K<sub>maint,wall</sub>. This luminous efficacy value is significantly less than the luminous efficacy of the luminaire itself because some of the light emitted from the luminaire is lost to spill, interreflections, and other surfaces other than the wall.

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

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

LPD per square foot of wall area required to light the wall to target average illuminance can be calculated by rearranging the formula:

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

As described earlier, the LPD to wall wash all perimeter wall areas in units of watts per square foot of wall area, can be converted to a LPD unit of watts per square foot of floor area, by multiplying the wall wash LPD by 0.4 times RCR. Combining the equation for calculating the wall LPD from design vertical illuminance and delivered, maintained efficacy and the equation to convert from a wall power density to a floor power density is given below.

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

Often wall washing is conducted on a portion of the walls; the following equation proportionately reduces the LPD for wall washing in units of watts per square foot of floor area.

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

Where,

WallFraction = fraction of the wall that is illuminated with wall washing luminaires.

This is a variable (selected by the user) and is similar to the SpaceFraction variable- which is the fraction of the floor area illuminated by the other lighting systems (see prior section on Inverse Lumen Method).

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 general lighting. This is commonly seen in many designs, where the last row of luminaires for general lighting is replaced with wall washing luminaires that provide both wall washing and general lighting.

As previously mentioned, the average horizontal fc on the work plane at the finish floor level was extracted for the room area that is within a defined distance from the wall

illuminated by the simulated wall washer. This defined distance is the wall height multiplied by the wall height fraction, WHF. The ratio of average horizontal illuminance on the work plane 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 the defined fraction of the 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 by spill light from wall washing, the wall height fraction in from walls,  $FGI_{Spill}$ , is given by the following equation:

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

Where,

$E_{Wall,Design}$  = Design (target) illuminance for wall washing (FC)

$E_{Floor,Design}$  = Design (target) general lighting floor illuminance (FC)

The equation is capped at 1 so that no more light or power than is used for providing general lighting for the floor is displaced.

As described earlier, the ratio of total perimeter 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 the wall height fraction multiplied by the wall height, inwards, from the base of the walls. When all walls are illuminated by wall washing, the fraction of floor area where horizontal general lighting is displaced,  $FFA_{Spill}$ , is given by the following:

$$FFA_{Spill} = WHF \times 0.4 \times RCR$$

WHF is the fraction of wall height inward from wall for horizontal floor illuminance measurements and is 50 percent of the wall height for most walls. However, for walls

taller than 12 feet WHF is 25 percent. For evaluating corridor wall washers that can illuminate a corridor without additional lighting, the WHF was 80 percent for a forward-throw wall washer illuminating the entire 8-foot width of a corridor with a 10-foot ceiling height.

In most cases, not all walls in the space are illuminated by wall-washing luminaires. The more general equation that accounts for the portion of floor area adjacent to the fraction of walls being illuminated is given below.

$$FFA_{\text{Spill}} = \text{WallFraction} \times \text{WHF} \times 0.4 \times \text{RCR}$$

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

$$\text{GLRF} = \text{FGL}_{\text{Spill}} \times FFA_{\text{Spill}}$$

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

$$LPD_{\text{Gen,Red}} = LPD_{\text{Gen}} \times \text{GLRF}, \text{ or}$$

$$LPD_{\text{Gen,Red}} = LPD_{\text{Gen}} \times \min \left[ 1, \frac{(E_{\text{Wall,Design}} \times R_{\text{HtoV,L}})}{E_{\text{Floor,Design}}} \right] \times \text{Wall Fraction} \times \text{WHF} \times 0.4 \times \text{RCR}$$

In 2019 Title 24, Part 6 wall wash model, the wall height factor was fixed and from the 2022 code cycle onwards, the wall wash models included a wall height factor that is attached to the different precalculated radiosity models that are normalized using this approach. The wall wash model has different precalculated models for different wall reflectances. This does not affect the vertical fc impinging on the wall, but it does reduce the amount of horizontal illuminance received by work plane near the wall. Thus, reflectance of the wall impacts the General Lighting Power Density Reduction,  $LPD_{\text{Gen,Red}}$ . Thus, for different reflectance walls the amount of displaced general lighting power can be more accurately calculated and less LPD “safety factor” associated with loss of accuracy is needed for the LPD targets. Unless otherwise published, high color rendering index (90 CRI and above) wall washers have their efficacy derated by 20 percent by the authors.

## 2.4.2 Luminaire Efficacy

When comparing the 2022 Inverse Lumen Method model to the 2028 Inverse Lumen Method model, “luminaire efficacy” is the variable with the greatest difference. As shown in Table 4, luminaire efficacy increased significantly, with most luminaires exhibiting efficacy gains of at least 15 percent. Theoretically the LPDs should decrease proportionally; however, this technical inverse lumen method spreadsheet model informs changes to LPDs but is not the sole input. Nonetheless, identifying these

changes in efficacy demonstrates the need to revisit the allowed lighting power allowances. It is clear that over the last six years, luminaire efficacy has increased significantly and updating the 2028 code to keep up with the market would yield significant energy savings.

**Table 4: Comparison of Luminaire Efficacies from 2022 and 2028 LPD models**

Luminaire Description	Average 2028 Efficacy (lm/W)	Average 2022 Efficacy (lm/W)	Ratio 2028 Efficacy to 2022 Efficacy
Cove light asymmetric 80 CRI	117	91	128%
Cove light asymmetric 90 CRI	117	N/A—new	128%
Downlight large 6"+ 80 CRI	97	82	118%
Downlight large 6"+ 80 CRI Hi Output	100	90	111%
Downlight large 6"+ 90 CRI	92	78	117%
Downlight large 6"+ 90 CRI Hi Output	93	81	116%
Downlight large 6"+ 90 CRI Warm	92	66	139%
Downlight large 6"+ 90 CRI Warm Hi Output	93	70	133%
Downlight 4" and less 80 CRI	100	76	132%
Downlight 4" and less 80 CRI Lo Output	97	62	156%
Downlight 4" and less 90 CRI	94	83	113%
Downlight 4" and less 90 CRI Warm	94	69	136%
High Bay 80 CRI	153	128	119%
Low bay 80 CRI	152	145	105%
Pend bowl direct/indirect 80 CRI	107	81	131%
Pendant direct/indirect 80 CRI	126	97	130%
Pendant direct/indirect 90 CRI	110	N/A—new	114%
Parking garage luminaire 70 CRI	127	111	115%
Parking garage luminaire 80 CRI	139	104	134%
Parking garage luminaire 80 CRI Hi Output	139	104	134%
Linear light slot 4" or more 80 CRI	115	104	110%
Linear light slot 4" or less 80 CRI	123	94	131%
Strip Under cabinet 80 CRI	108	63	170%
Strip Under cabinet 80 CRI Hi Output	116	76	152%
Strip Under cabinet 90 CRI	90	46	198%
Industrial strip 80 CRI	141	135	105%
Industrial strip 80 CRI Hi Output	139	122	114%

Luminaire Description	Average 2028 Efficacy (lm/W)	Average 2022 Efficacy (lm/W)	Ratio 2028 Efficacy to 2022 Efficacy
Industrial strip 80 CRI Lo Output	141	121	116%
Troffer Basket 80 CRI	132	116	114%
Troffer Basket 80 CRI Hi Output	132	112	118%
Troffer Basket 80 CRI Lo Output	128	95	134%
Troffer Basket 90 CRI	125	101	124%
Troffer Lensed 80 CRI	125	110	114%
Troffer Lensed 80 CRI Hi Output	125	115	109%
Troffer Lensed 80 CRI Lo Output	125	111	113%
Parking garage luminaire 70 CRI Hi Output	128	112	114%

**2.4.3 Proposed Title 24, Part 6 LPDs Compared with LPDs in Other Energy Codes**

Table 5 compares the allowed lighting power densities of this proposal with the baseline or general lighting power densities of the current 2025 version of Title 24, Part 6 and with the LPDs in the national nonresidential model energy code ASHRAE 90.1-2025. It is anticipated that the 2027 version of the IECC will have the same baseline LPD values as in ASHRAE 90.1. The additional LPDs are not shown in this comparison because ASHRAE 90.1-2025 applies a constant 0.50 W per square foot LPD for additional lighting power associated with decorative and display lighting across all spaces including warehouses spaces and mechanical rooms. The comparison of total power with ASHRAE 90.1 is interesting but not as compelling as the comparison between the baseline LPD allowances.

The first thing to note in Table 5 is in the fifth column, the ratio of 2025 Title 24 LPDs to ASHRAE 90.1 LPDs. Approximately half of these LPDs ratios are greater than 100 percent, that is the 2025 Title 24 LPDs are higher than those in the national minimum energy code. The unweighted average across all space types is that the 2025 Title 24 LPDs are 106 percent of the ASHRAE 90.1-2025 values. This is an indication that there is an opportunity to save energy by reducing LPDs more in line with those in ASHRAE 90.1. These ASHRAE 90.1 values have been vetted through a public process in 2025. In comparison the most of 2025 Title 24 LPDs were vetted in 2020 for the 2022 Title 24, Part 6 energy code.

Table 5: Comparison of 2025 Title 24 and Proposed 2028 Title 24 LPDs to ASHRAE 90.1-2025 LPDs

Primary Function Areas	2025 Title 24 Allowed General LPD (W/sf)	2028 Title 24 Proposed Baseline LPD (W/sf)	ASHRAE 90.1-2025 LPD (W/sf)	Ratio 2025 Title 24 / ASHRAE 90.1-2025 LPD (%)	Ratio 2028 Title 24 / ASHRAE 90.1-2025 LPD (%)
<b>Aging Eye/Low-vision: Corridor Area</b>	0.70	0.70	0.60	117%	117%
<b>Aging Eye/Low-vision: Dining</b>	0.80	0.80	1.08	74%	74%
<b>Aging Eye/Low-vision: Main Entry Lobby</b>	0.85	0.80	1.27	67%	63%
<b>Aging Eye/Low-vision: Lounge/Waiting Area</b>	0.80	0.80	1.06	75%	75%
<b>Aging Eye/Low-vision: Multipurpose Room</b>	0.85	0.80	1.06	80%	75%
<b>Aging Eye/Low-vision: Religious Worship Area</b>	1.00	0.90	0.62	161%	145%
<b>Aging Eye/Low-vision: Restroom</b>	1.00	0.90	0.90	111%	100%
<b>Aging Eye/Low-vision: Stairwell</b>	0.80	0.80	N/A	N/A	N/A
<b>Atria &lt; 20 ft tall <sup>a</sup></b>	0.60	0.30	0.29	207%	103%
<b>Atria 20 to &lt; 40 ft <sup>a</sup></b>	0.60	0.40	0.37	162%	108%
<b>Atria &gt; 40 ft <sup>a</sup></b>	0.60	0.50	0.49	122%	102%
<b>Audience Seating Area</b>	0.50	0.30	0.23	217%	130%
<b>Auditorium Area</b>	0.70	0.50	0.56	125%	89%
<b>Auto Repair / Maintenance Area</b>	0.55	0.55	0.56	98%	98%
<b>Barber, Beauty Salon and Spa Area</b>	0.70	0.65	0.61	115%	107%
<b>Civic Meeting Room</b>	0.90	0.70	0.96	94%	73%
<b>Concourse</b>	0.60	0.45	0.51	118%	88%
<b>Convention Center: Ballroom <sup>a</sup></b>	0.75	0.45	N/A	N/A	N/A
<b>Convention: Exhibit Space <sup>a</sup></b>	0.75	0.45	0.83	90%	54%
<b>Convention: Meeting Room <sup>a</sup></b>	0.75	0.65	0.83	90%	78%
<b>Control room</b>	0.60	0.50	0.65	92%	77%

Primary Function Areas	2025 Title 24 Allowed General LPD (W/sf)	2028 Title 24 Proposed Baseline LPD (W/sf)	ASHRAE 90.1-2025 LPD (W/sf)	Ratio 2025 Title 24 / ASHRAE 90.1-2025 LPD (%)	Ratio 2028 Title 24 / ASHRAE 90.1-2025 LPD (%)
Copy Room	0.50	0.45	0.52	96%	87%
Corridor Area	0.40	0.35	0.43	93%	81%
Data center: Computer room*	N/A	0.70	0.70	N/A	100%
Dining Area: Bar/Lounge and Fine Dining*	0.45	0.70	0.69	65%	101%
Dining Area: Cafeteria/Fast Food	0.45	0.40	0.35	129%	114%
Dining Area: Family and Leisure	0.40	0.35	0.50	80%	70%
Education/Business: Classroom, Training, Educational, civic: Multipurpose room (art, music etc.) <sup>a</sup>	0.60	0.55	0.68	88%	81%
Electrical, Mechanical, Telephone Rooms	0.75	0.60	0.83	90%	72%
Exercise/Fitness Center and Gymnasium Area	0.40	0.40	0.67	60%	60%
Financial Transaction Area	0.50	0.55	0.78	64%	71%
Healthcare: In-patient Corridor <sup>a</sup>	0.70	0.53	0.53	132%	100%
Healthcare: Exam/Treatment Room	N/A	0.55	0.60	N/A	92%
Healthcare: Imaging Room	1.15	1.10	1.26	91%	87%
Healthcare: Medical Supply Room	0.60	0.55	0.88	68%	63%
Healthcare: Nursery	0.55	0.50	0.52	106%	96%
Healthcare: Nurse's Station	0.80	0.80	0.84	95%	95%
Healthcare: Operating Room	0.85	0.75	0.93	91%	81%
Healthcare: Patient Room - Critical care <sup>a</sup>	1.90	1.90	1.99	95%	95%
Healthcare: Patient Room - General	N/A	0.90	N/A	N/A	N/A
Healthcare: Physical Therapy Room	0.70	0.70	0.73	96%	96%
Healthcare: Recovery Room	0.75	0.65	0.86	87%	75%
Kitchen/Food Preparation Area	0.90	0.85	1.13	80%	75%
	0.95	0.85	0.93	102%	91%

Primary Function Areas	2025 Title 24 Allowed General LPD (W/sf)	2028 Title 24 Proposed Baseline LPD (W/sf)	ASHRAE 90.1- 2025 LPD (W/sf)	Ratio 2025 Title 24 / ASHRAE 90.1-2025 LPD (%)	Ratio 2028 Title 24 / ASHRAE 90.1-2025 LPD (%)
Laboratory: Scientific and Teaching	0.90	0.80	1.18	76%	68%
Laundry Area	0.45	0.43	0.48	94%	90%
Library : Reading Area	0.80	0.70	0.80	100%	88%
Library : Stacks Area	1.00	0.91	1.15	87%	79%
Lobby: Main entry	0.70	0.60	0.74	95%	81%
Lobby: Performing Arts	0.70	0.60	1.13	62%	53%
Locker Room	0.45	0.40	0.40	113%	100%
Lounge, Breakroom, or Waiting Area	0.55	0.45	0.50	110%	90%
Manufacturing & Commercial Work Area: Low Bay	0.60	0.60	0.81	74%	74%
Manufacturing & Commercial Work Area: High Bay	0.65	0.65	1.15	57%	57%
Manufacturing & Commercial Work Area: Precision	0.85	0.80	0.71	120%	113%
Motion picture: Theater area	0.50	0.50	0.20	250%	250%
Museum: Exhibition/Display**	0.80	0.60	0.27	296%	222%
Museum Area: Restoration Room	0.70	0.65	1.17	60%	56%
Office Area: ≤ 250 square feet	0.65	0.55	0.69	94%	80%
Office Area: > 250 square feet	0.60	0.50	0.52	115%	96%
Office: Conference Room <sup>a</sup>	0.75	0.60	0.83	90%	72%
Parking Garage Area: Parking Zone and Ramps	0.10	0.08	0.08	125%	100%
Parking Garage Area: Daylight Adaptation Zones*	1.00	0.78	0.79	127%	99%
Performance: Theater area	0.80	0.50	0.97	82%	52%
Performance: Dressing room <sup>a</sup>	N/A	0.50	0.37	N/A	135%
Pharmacy Area	1.00	1.00	1.49	67%	67%
Retail: Grocery Sales	1.00	0.90	0.79	127%	114%

Primary Function Areas	2025 Title 24 Allowed General LPD (W/sf)	2028 Title 24 Proposed Baseline LPD (W/sf)	ASHRAE 90.1-2025 LPD (W/sf)	Ratio 2025 Title 24 / ASHRAE 90.1-2025 LPD (%)	Ratio 2028 Title 24 / ASHRAE 90.1-2025 LPD (%)
Retail: Merchandise Sales	0.95	0.80	0.79	120%	101%
Retail: Fitting Room	0.60	0.50	0.42	143%	119%
Religious Worship Area	0.95	0.75	0.64	148%	117%
Restrooms	0.65	0.65	0.73	89%	89%
Stairwell	0.60	0.60	0.44	136%	136%
Sports Arena – Playing Area: Class I Facility	2.25	2.25	2.65	85%	85%
Sports Arena – Playing Area: Class II Facility	1.45	1.45	1.87	78%	78%
Sports Arena – Playing Area: Class III Facility	1.10	1.05	1.21	91%	86%
Sports Arena – Playing Area: Class IV Facility	0.75	0.71	0.81	93%	88%
Transportation: Baggage Area	0.40	0.30	0.29	138%	103%
Transportation: Ticketing Area	0.45	0.40	0.37	122%	108%
Transportation: Waiting area <sup>a</sup>	0.60	0.40	0.71	85%	56%
Videoconferencing Studio	0.90	0.70	1.11	81%	63%
Warehouse: Storage	0.40	0.40	0.41	98%	98%
Warehouse: Shipping and Handling	0.60	0.60	0.83	72%	72%

a. New function areas or 2025 single primary function areas that were split up into multiple areas.

Table 5 compares the ratio of the baseline LPDs proposed for the 2028 version of Title 24 part 6 with the ASHRAE 90.1-2025 LPDs. The unweighted average of this ratio is 92 percent. The proposal would result in the 2028 Title 24, part 6 LPDs being slightly more stringent than those in ASHRAE 90.1-2025, the minimum national model building energy efficiency code.

The comparison of Title 24 is not exactly an “apples-to-apples” comparison. As an example, ASHRAE 90.1 exempts display lighting in museums, thus the lighting power allowance for museums is very low in ASHRAE 90.1. As a result the ratios of Title 24 to 90.1 LPDs are very high for museums.

Besides the general or baseline LPDs both Title 24 and ASHRAE 90.1 have additional allowances which are use-it-or-lose-it allowances primarily for decorative and display lighting. These additional lighting power allowance can only be used for the type of lighting systems and cannot offset general lighting power. “Left over” additional allowances from one room cannot be applied to another room. However, the baseline allowances may be traded off among rooms. One room can have less than the allowed baseline LPD installed and apply the “leftover” baseline allowance to another room to use the additional lighting power in the other room.

In the primary function area column, several of these areas are in blue font and with a superscripted “a”. They represent new function areas or represent 2025 single primary function areas that were split up into multiple areas. New function areas include the elevator lobby, performing arts lobby, performance arts dressing room, and data centers. Concourse and Atria Area from 2025 Title 24, Part 6 was split into: Atria of different heights to match height bins in ASHRAE 90.1, convention center concourse, retail concourse, and transportation concourse. Convention, Conference, Multipurpose and Meeting Area from 2025 Title 24, Part 6 was split into: Convention Center—Ballroom; Exhibit Space, Meeting Room; Educational, civic—Multipurpose room; Office—Conference Room.

The benefit of separating a broad multiple space primary functional area LPD into more targeted primary function area LPDs is that each LPD is more closely linked to the illumination needs of these individual space types. In the past, the LPD was targeted to the highest lighting power for all space types listed in the multiple space primary function area. As a result, for most of the space types in these groupings, the LPDs were unnecessarily high. By splitting multiple space types into single space types, the LPD is targeted to the needs of each space type. The result from these more targeted LPDs is fairly significant for the wattage reductions. For the remaining areas where the applications and design illuminances are not changing, the wattage reductions are modest, often less than the 15 percent reduction expected from luminaire efficacy alone.

The healthcare primary function area “Patient Room” was split into Patient Room—Critical Care and Patient Room—General. This change resulted from comparing sample LPDs with other standards, including ANSI/ASHRAE/ASHE Standard 189.3: Standard for the Design, Construction, and Operation of Sustainable High-Performance Health Care Facilities. The preexisting patient room LPD was appropriate for general patient rooms, and the recommended LPD value of 0.90 W per square foot from ASHRAE 189.3 for critical care patient rooms was applied to the newly added Patient rooms—critical care primary function area in the proposal.

To simplify the standard, a single value per ATM (automated teller machine) is proposed in parking garages whereas in the past the ATM allowance was 100 watts per first ATM and an additional 50 watts for additional ATMs. This modification removes the ambiguity of whether the ATMs were close together (the original intention) or any additional ATMs in the entire parking garage had the reduced allowance. The wattage needed to illuminate ATMs has decreased with higher efficacy LED sources, so the level of complexity is no longer needed. The California statutory requirements for illumination<sup>4</sup> ATMs require at least 10 fc on the face of the ATM and at least 10 fc on the ground up to 5 feet in front of the machine even when only one machine is present. Additionally at least 2 fc “in that portion of the defined parking area within 60 feet of the automated teller machine,” is required. In parking garages, the 2 fc requirement is already met by the general lighting LPD for parking garages which is sufficient to provide 5 fc average maintained illuminance.

The ratios of the proposed 2028 Title 24, Part 6 allowed baseline LPD allowance and the 2025 Title 24 allowed general lighting LPD indicated the increase in stringency. These range between 50 percent and 110 percent, with an unweighted average of 88 percent, reflecting the change in luminous efficacy of products. The 8 percent ratio for the parking garage daylight adaptation zone reflects that the transition zone lighting is treated as a specialized task with an additional lighting power allowance that is tied to daylight adaptation controls. When additional power is included for the daylight transition zone in parking garages the ratio is 88 percent reflecting the moderate increase in efficacy of LEDs over the past 6 years.

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<sup>4</sup> California Financial Code—Division 4. Automated teller machines: user safety Section 13041. [https://leginfo.legislature.ca.gov/faces/codes\\_displaySection.xhtml?lawCode=FIN&sectionNum=13041](https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=FIN&sectionNum=13041).

Table 6: Comparison of Proposed 2028 Title 24 LPDs with 2025 Title 24 and ASHRAE 90.1-2025

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	Ratio 2028 Title 24/ 2025 T-24 Gen LPD (%)	Ratio 2028 Title 24/ 2025 Title 24 Total LPD (%)
Aging Eye/Low-vision:1 Corridor Area	0.70	0.30	0.70	0.30	100%	100%
Aging Eye/Low-vision:1 Dining	0.80	0.40	0.80	0.40	100%	100%
Aging Eye/Low-vision:1 Main Entry Lobby	0.80	1.10	0.85	1.35	94%	86%
Aging Eye/Low-vision:1 Lounge/Waiting Area	0.80	0.40	0.80	0.40	100%	100%
Aging Eye/Low-vision:1 Multipurpose Room	0.80	0.40	0.85	0.40	94%	96%
Aging Eye/Low-vision:1 Religious Worship Area	0.90	0.40	1.00	0.40	90%	93%
Aging Eye/Low-vision:1 Restroom	0.90	0.30	1.00	0.20	90%	100%
Aging Eye/Low-vision:1 Stairwell	0.80	0.30	0.80	0.30	100%	100%
Atria < 20 ft tall	0.30	0.20	0.60	0.25	50%	59%
Atria 20 to < 40 ft	0.40	0.25	0.60	0.25	67%	76%
Atria > 40 ft	0.50	0.30	0.60	0.25	83%	94%
Audience Seating Area	0.30	0.35	0.50	0.25	60%	87%
Auditorium Area	0.50	0.45	0.70	0.45	71%	83%
Auto Repair / Maintenance Area	0.55	0.20	0.55	0.20	100%	100%
Barber, Beauty Salon and Spa Area	0.65	0.50	0.70	0.55	93%	92%
Civic Meeting Room	0.70	0.30	0.90	0.25	78%	87%
Concourse	0.45	0.25	0.60	0.25	75%	82%
Convention Center: Ballroom	0.45	0.40	0.75	0.25	60%	85%
Convention: Exhibit Space	0.45	0.30	0.75	0.25	60%	75%
Convention: Meeting Room	0.65	0.25	0.75	0.25	87%	90%
Control room	0.50	0.00	0.60	0.00	83%	83%
Copy Room	0.45	0.00	0.50	0.00	90%	90%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	Ratio 2028 Title 24/ 2025 T-24 Gen LPD (%)	Ratio 2028 Title 24/ 2025 Title 24 Total LPD (%)
Corridor Area	0.35	0.30	0.40	0.25	88%	100%
Data center: Computer room (new)	0.45	0.25	N/A	N/A	N/A	N/A
Dining Area: Bar/Lounge and Fine Dining	0.40	0.75	0.45	0.80	89%	92%
Dining Area: Cafeteria/Fast Food	0.40	0.25	0.45	0.25	89%	93%
Dining Area: Family and Leisure	0.35	0.25	0.40	0.25	88%	92%
Education/Business: Classroom, Training,	0.55	0.00	0.60	0.00	92%	92%
Educational, civic: Multipurpose room (art, music etc.)	0.60	0.30	0.75	0.25	80%	90%
Electrical, Mechanical, Telephone Rooms	0.40	0.20	0.40	0.20	100%	100%
Exercise/Fitness Center and Gymnasium Area	0.55	0.00	0.50	0.00	110%	110%
Financial Transaction Area	0.53	0.30	0.70	0.25	76%	87%
Healthcare: Corridor (new)	0.55	0.25	N/A	N/A	N/A	N/A
Healthcare: Exam/Treatment Room	1.10	0.00	1.15	0.00	96%	96%
Healthcare: Imaging Room	0.55	0.35	0.60	0.30	92%	100%
Healthcare: Medical Supply Room	0.50	0.00	0.55	0.00	91%	91%
Healthcare: Nursery	0.80	0.10	0.80	0.10	100%	100%
Healthcare: Nurse's Station	0.75	0.30	0.85	0.30	88%	91%
Healthcare: Operating Room	1.90	0.00	1.90	0.00	100%	100%
Healthcare: Patient Room - Critical care	0.90	0.25	N/A	N/A	N/A	N/A
Healthcare: Patient Room - General	0.70	0.25	0.70	0.25	100%	100%
Healthcare: Physical Therapy Room	0.65	0.10	0.75	0.10	86%	88%
Healthcare: Recovery Room	0.85	0.30	0.90	0.10	94%	115%
Kitchen/Food Preparation Area	0.85	0.00	0.95	0.00	89%	89%
Laboratory: Scientific and Teaching	0.80	0.35	0.90	0.35	89%	92%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	Ratio 2028 Title 24/ 2025 T-24 Gen LPD (%)	Ratio 2028 Title 24/ 2025 Title 24 Total LPD (%)
Laundry Area	0.43	0.00	0.45	0.00	96%	96%
Library : Reading Area	0.70	0.25	0.80	0.25	88%	91%
Library : Stacks Area	0.91	0.00	1.00	0.00	91%	91%
Lobby: Main entry	0.60	0.40	0.70	0.50	86%	83%
Lobby: Performing Arts	0.60	0.40	0.70	0.50	86%	83%
Locker Room	0.40	0.00	0.45	0.00	89%	89%
Lounge, Breakroom, or Waiting Area	0.45	0.25	0.55	0.25	82%	88%
Manufacturing & Commercial Work Area: Low Bay	0.60	0.20	0.60	0.20	100%	100%
Manufacturing & Commercial Work Area: High Bay	0.65	0.20	0.65	0.20	100%	100%
Manufacturing & Commercial Work Area: Precision	0.80	0.70	0.85	0.70	94%	97%
Motion picture: Theater area	0.50	0.25	0.50	0.25	100%	100%
Museum: Exhibition/Display	0.60	0.45	0.80	0.45	75%	84%
Museum Area: Restoration Room	0.65	0.35	0.70	0.35	93%	95%
Office Area: ≤ 250 square feet	0.55	0.25	0.65	0.20	85%	94%
Office Area: > 250 square feet	0.50	0.25	0.60	0.20	83%	94%
Office: Conference Room	0.60	0.25	0.75	0.25	80%	85%
Parking Garage Area: Parking Zone and Ramps	0.08	0.00	0.10	0.00	80%	80%
Parking Garage Area: Daylight Adaptation Zones <sup>8</sup>	0.08	0.70	1.00	0.00	8%	78%
Performance: Theater area	0.50	0.40	0.80	0.25	63%	86%
Performance: Dressing room (new)	0.50	0.00	N/A	N/A	N/A	N/A
Pharmacy Area	1.00	0.35	1.00	0.35	100%	100%
Retail: Grocery Sales	0.90	0.55	1.00	1.05	90%	71%
Retail: Merchandise Sales	0.80	0.95	0.95	0.95	84%	92%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	Ratio 2028 Title 24/ 2025 T-24 Gen LPD (%)	Ratio 2028 Title 24/ 2025 Title 24 Total LPD (%)
Retail: Fitting Room	0.50	0.00	0.60	0.00	83%	83%
Religious Worship Area	0.75	0.25	0.95	0.25	79%	83%
Restrooms	0.65	0.35	0.65	0.35	100%	100%
Stairwell	0.60	0.35	0.60	0.35	100%	100%
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	2.25	0.00	2.25	0.00	100%	100%
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	1.45	0.00	1.45	0.00	100%	100%
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	1.05	0.00	1.10	0.00	95%	95%
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	0.71	0.00	0.75	0.00	95%	95%
Transportation: Baggage Area	0.30	0.10	0.40	0.00	75%	100%
Transportation: Ticketing Area	0.40	0.20	0.45	0.20	89%	92%
Transportation: Waiting area	0.40	0.25	0.60	0.25	67%	76%
Videoconferencing Studio <sup>12</sup>	0.70	1.00	0.90	1.00	78%	89%
Warehouse: Storage	0.40	0.00	0.40	0.00	100%	100%
Warehouse: Shipping and Handling	0.60	0.00	0.60	0.00	100%	100%

## 2.4.4 Summary of Stakeholder Comments

The Statewide CASE Team conducted preliminary outreach to lighting manufacturers, lighting designers, and other stakeholders to solicit input on proposed Title 24 updates related to luminaire classification, wattage determination, and indoor lighting power density (LPD). Feedback collected during the Utility-Sponsored Stakeholder Meeting on September 24, 2025, as well as through follow-up discussions with manufacturers and designers, provided insights into current design practices, luminaire performance assumptions, and compliance considerations associated with the proposed updates.

The Statewide CASE Team assembled a focus group of senior lighting design professionals from major design firms, along with stakeholders representing manufacturers and a university facilities team, as part of these outreach and research efforts. See Section 1.3 for a summary of the input received from these stakeholders, and Appendix F for a detailed list of inputs. Through this engagement, the Statewide CASE Team has incorporated stakeholder feedback into the proposal and supporting analysis.

Specifically, stakeholder input helped evaluate and confirm several key modeling and design assumptions used in the LPD analysis. Lighting designers indicated that lumen depreciation factors around 0.90 are commonly used in lighting calculations for modern LED luminaires, consistent with manufacturer documentation and current industry practice. A higher lumen depreciation factor reflects improved lumen maintenance performance over time and allows designers to assume higher maintained light output, which can result in lower installed wattages needed to meet illuminance targets.

Feedback from both designers and manufacturers also informed the evaluation of compliance approaches for selectable-output luminaires and multi wattage products, which are becoming increasingly common in the market. Stakeholders indicated that using the highest wattage setting for compliance calculations for wattage-selectable luminaires provides a clear and conservative approach that is generally acceptable in practice. Designers noted that if this approach creates compliance challenges in specific applications, fixed-output luminaires can be specified or alternative compliance approaches, such as current limiters, can be used.

Designers also noted that while 90 CRI luminaires typically have lower efficacy than comparable 80 CRI products, the difference has narrowed significantly in recent LED product generations. In addition, stakeholders indicated that manufacturer cut sheet performance data and photometric files are generally reliable for recently introduced luminaires, though updates to documentation may not always occur when incremental product improvements are made.

Organizations and individuals contacted for additional feedback through the Manufacturer Survey are listed in Appendix F.

### **2.4.5 Summary of Compliance Database Lighting Power Densities**

The Statewide CASE Team received data from NORESO's compliance database. The compliance database contains compliance information used to generate Certificates of Compliance (CC) and Certificates of Installation (CI) for permitting Nonresidential (NR) and Low-Rise Multifamily (LM) projects in California. This data is from the EnergyPro building simulation performance approach software, the prescriptive approach Virtual Compliance Assistant (VCA) form-filling software, and provided data from Nonresidential Certificates of Compliance (NRCC) documents specific to the LTI (Indoor Lighting) category.

## **2.5 Technical Basis Luminaire Classification and Wattage Rating**

This proposal includes updates to Section 601.2.1 [*Section 130.0(c)*] to better align with recent guidance on defining installed wattage, including the methods adopted in ASHRAE 90.1-2022 Addendum CK (ASHRAE 2025). These changes are not expected to directly affect luminaire energy use; rather, they are intended to increase flexibility in allowable equipment combinations and in how wattages are rated.

The proposed updates focus on three areas:

- Luminaires with line-voltage lamp holders
- Field-adjustable solid-state lighting (SSL) luminaires
- Clarification on wattage determination for SSL luminaires using legacy ballasts.

These revisions aim to provide more accurate and verifiable wattage reporting while supporting compliance with both code and industry standard testing practices.

### **2.5.1 Luminaires with Line Voltage Lamp Holders**

The proposal would define the wattage of luminaires with line-voltage lamp holders as the sum of the wattages of the installed lamps, rather than relying on the luminaire's factory-applied maximum relamping label. Under the current code, anyone wishing to reuse a luminaire with lower-wattage lamps must remove the luminaire, ship it back to the manufacturer, and obtain a new label. This process is impractical, costly, and often leads to unnecessary luminaire replacement and material waste without providing additional energy savings.

Historically, there has also been concern that high-efficacy lamps installed for inspection could be swapped out afterward. This concern stemmed from the limitations of earlier high-efficacy lamp technologies, which were frequently replaced because of:

- High upfront cost
- Poor color quality
- Limited optical control
- Lack of dimming capability
- Longevity that often fell short of expectations

With today's LED market, these incentives for post-inspection lamp replacement are significantly reduced. Modern LED lamps offer high color quality (CRI 90–97), dimming capability, long life, and reasonable pricing. Because each lamp is individually labeled, inspectors can easily verify installed wattage—often with greater accuracy than relying on a luminaire's maximum relamping label.

Rationale and accuracy considerations include:

1. **More accurate reflection of installed power.** Using the actual lamp wattage eliminates systematic overestimates caused by defaulting to a luminaire's maximum-rated wattage.
2. **Clear, verifiable documentation.** Lamp wattage labeling is standardized and consistently applied across products, making field verification straightforward.
3. **Alignment with industry practices.** The proposed approach aligns with ASHRAE and other national model code practices that base luminaire wattage on installed lamp wattage.

Based on current product characteristics and market data, totaling the wattage of the installed lamps would provide an accurate and representative wattage value for line-voltage luminaires. The proposal would reduce waste, simplify compliance, and maintain confidence in the accuracy of connected-load calculations.

### 2.5.2 Field-adjustable solid-state lighting (SSL) luminaires

The proposal would require that luminaires with multiple wattage or output settings use the highest output setting available from the manufacturer or manufacturer approved representative. The chosen maximum wattage must be marked on a permanent label installed by the manufacturer or their authorized representative. This approach is intended to ensure that code calculations account for the full operational capability of field-adjustable products.

Rationale and accuracy considerations include:

- **More accurate representation of potential power use**  
Multi-wattage and field-adjustable products can vary in power draw across their settings. If compliance were based on a lower setting, connected load could be underestimated. Using the highest accessible setting would provide a conservative and more accurate basis for wattage calculations.

- Balance between design flexibility and energy savings**  
 Multi-wattage products allow for using the same luminaire in multiple ceiling heights without having to change spacing to accommodate similar design illuminances. However, if it were allowed to claim less than maximum wattages this could result in claims of lower wattage settings for initial compliance and then easily setting the adjustable luminaire for higher power consumption after inspection. To retain flexibility for systems where it is highly desirable to make use of multi-output luminaires, it is proposed that the scope of current limiters or dedicated overcurrent protection be expanded from track lighting to any lighting system type.
- Alignment with industry testing and listings**  
 Many products are evaluated and listed (e.g., UL or DLC) across their full output range. Using the highest accessible setting for compliance would better align with how these luminaires are tested, ensuring that wattage assumptions correspond to certified performance.
- Consistency across different adjustment mechanisms**  
 Treating all adjustable luminaires uniformly—whether their settings are changed mechanically or through programmable drivers—would prevent gaps where certain adjustment types could inadvertently allow lower reported wattage than the product is capable of delivering.

### 2.5.3 Clarification on Wattage Determination for SSL Luminaires using Legacy Ballasts

The proposal would clarify how installed wattage is determined for luminaires in which SSL components are powered by existing—or legacy—HID or fluorescent ballasts. Under the proposed language, the wattage of these luminaires would be defined as the maximum reported input power under the ballast’s rated operating conditions, as documented by the ballast manufacturer.

This approach recognizes that, in ballast-powered configurations, the ballast remains the primary electrical power-regulating component of the system. The SSL lamp or light engine may have a lower nominal input rating, but the connected load seen by the electrical system is governed by the ballast’s rated operating characteristics and losses. As a result, relying solely on the SSL product’s labeled wattage can underrepresent the actual installed power and compromise the accuracy of connected-load calculations.

Rationale and accuracy considerations include:

- Accurate representation of connected load**  
 Ballasts introduce fixed and variable losses that are not captured in the labeled wattage of the SSL lamp or module. Using the maximum rated ballast wattage

provides a conservative and more representative estimate of the power draw associated with the installed luminaire.

- **Consistency with legacy system treatment**

Existing code provisions for HID and fluorescent luminaires base wattage on ballast ratings rather than lamp ratings. Applying the same principle to SSL retrofits that retain legacy ballasts maintains continuity across technologies and avoids creating parallel compliance pathways for functionally similar systems.

- **Reduced risk of underreporting installed power**

Because SSL lamps compatible with ballasts are often marketed with low nominal wattage values, basing compliance on lamp labeling alone could systematically underestimate connected load in retrofit scenarios. The proposed method limits this risk by anchoring calculations to the controlling electrical component.

- **Alignment with industry testing and listing practices**

Ballasts are evaluated and listed as complete power-regulating devices, including their electrical losses and operating ranges. Using the ballast's maximum-rated wattage aligns code reporting with how these components are tested and certified.

By defining installed wattage based on the maximum-rated ballast wattage, the proposal provides a clear, enforceable, and technology-neutral method for accounting for SSL luminaires that retain legacy ballasts. This clarification improves the accuracy of connected-load reporting, supports consistent inspection practices, and maintains parity with established treatment of non-SSL luminaires, without restricting allowable equipment combinations.

#### **2.5.4 Summary of Stakeholder Comments on Luminaire Wattage**

The Statewide CASE Team conducted preliminary outreach to lighting manufacturers, lighting designers, and other stakeholders to solicit input on proposed updates to Title 24 related to luminaire classification, wattage determination, and indoor LPD. Feedback collected during the Utility-Sponsored Stakeholder Meeting on September 24, 2025, and through follow-up outreach activities provided insights into current lighting design practices, retrofit approaches, and compliance considerations associated with the proposed updates.

Stakeholders generally expressed support for allowing the continued reuse of existing luminaires with replaceable lamps where appropriate, particularly in retrofit situations where full luminaire replacement may not be feasible due to cost, access limitations, or architectural constraints. Several stakeholders emphasized that flexible retrofit pathways could help facilitate incremental upgrades from legacy fluorescent systems to LED technologies while minimizing material waste and project costs.

Stakeholders also raised questions and concerns regarding compliance treatment for certain retrofit configurations and emerging luminaire technologies. In particular, discussions focused on the treatment of UL Type A LED retrofit lamps, the treatment of selectable-output SSL luminaires, and approaches for determining installed wattage for products with adjustable lumen or wattage settings. Stakeholders highlighted the importance of clearly defining how these products should be treated in compliance calculations to ensure consistent interpretation by designers, manufacturers, and enforcement agencies.

Additional input was provided regarding multi-wattage luminaires, multi-wattage LED retrofit lamps, and the role of luminaire labeling and field verification in supporting compliance. Manufacturers and designers indicated that selectable-output luminaires and lamps are increasingly common in the market because they allow flexibility during installation and simplify product stocking and specification. At the same time, stakeholders emphasized the need for compliance approaches that are straightforward to document and verify in the field.

To supplement feedback gathered during the stakeholder meeting, the Statewide CASE Team also conducted targeted outreach with a small focus group of senior lighting design professionals from major design firms, as well as stakeholders representing manufacturers and a university facilities team. These discussions provided additional insights into real-world retrofit practices, product performance considerations, and compliance documentation responsibilities. Lighting designers reported that installed lighting power in typical projects frequently falls near the allowable power levels, although the need for performance trade-offs or additional power allowances varies depending on project type and design features. Designers also noted that projects incorporating advanced lighting features, such as tunable white or color-changing lighting, can sometimes face greater challenges complying with lighting power limits.

Through these interactions, the Statewide CASE Team began incorporating stakeholder feedback where appropriate and continues outreach to ensure that proposed updates reflect current market conditions and design practices. In general, stakeholders indicated that using the highest wattage setting for compliance calculations for selectable-output luminaires provides a clear and conservative approach that can simplify compliance documentation. Designers also indicated that, when necessary, fixed-output luminaires or other compliance strategies can be specified to address projects that approach lighting power limits.

With respect to retrofit lamp technologies, feedback indicated that UL Type A, B, and C LED retrofit lamps are all used in practice, with project conditions, safety considerations, and cost constraints influencing product selection. While some stakeholders indicated a preference for Type B or Type C retrofit approaches due to efficiency and performance considerations, others emphasized that Type A products remain an important option for

certain retrofit projects where ballast compatibility, installation simplicity, or budget limitations are factors. Based on this feedback, along with input from university facilities staff and broader policy considerations, the Statewide CASE Team determined that limiting the use of UL Type A retrofit lamps would not be pursued as part of this proposal.

Overall, the feedback highlighted the importance of providing clear guidance regarding the eligibility of Type A retrofit lamps, the treatment of selectable-output luminaires and lamps in compliance calculations, and the use of consistent labeling and verification approaches to support accurate compliance determination. A detailed summary of survey responses and stakeholder comments is provided in Appendix F.

## **2.6 Modifications to Energy Code Documents**

This section provides descriptions of how the proposed code change would affect each Energy Code document. See Section 7: Proposed Language of this report for detailed revisions to code language.

### **2.6.1 Energy Code Change Summary**

The primary updates to the code focus on the LPD values in Table 601.3-B [*Table 140.6-B*] and Table 601.3-C [*Table 140.6-C*] of Section 601.3.1 [*Section 140.6*], Title 24, Part 6. Updates to the Luminaire Classification and Power section would be made in Section 601.2.1 [*Section 130.0(c)*].

### **2.6.2 Reference Appendices Change Summary**

No changes are proposed to the Reference Appendices for this proposed measure.

### **2.6.3 Compliance Manuals Change Summary**

Compliance manuals would be updated to describe the changes in how lighting wattage is calculated and how allowed wattage is calculated, especially for retail occupancies. The mechanics of most of the applications stay the same only as the values change but any example that makes use of the allowed wattage would be updated. Additionally, the manual would be updated to describe the additional specificity of building type since nonresidential buildings would be more narrowly defined.

### **2.6.4 Alternative Calculation Method Reference Manual Change Summary**

If adopted, the current LPD values in Appendix 5.4A of the ACM Reference Manual would be updated to reflect the proposed code change. For more details see 7.6 ACM Reference Manual.

## 2.6.5 Compliance Forms Change Summary

If adopted, the compliance forms would differentiate between two building categories: (1) Nonresidential Buildings excluding *Group R Occupancies and Common or Public Use Areas*, and (2) buildings and their *Group R Occupancies and Common or Public Use Areas*.

For Group R buildings, that wattage calculations would remain unchanged. For Nonresidential Buildings, excluding *Group R*, the LPD values in the NRCC-LTI-E form would be updated to reflect the proposed code change. The final implementation may involve two separate forms or tables within the same form.

## 2.7 Measure Context

### 2.7.1 Comparable Model Codes or Standards

The proposed updates to LPD values in Title 24, Part 6, Section 601.3.1 [*Section 140.6*] are informed by recent and relevant national model codes and industry standards. The primary reference is ASHRAE 90.1-2025, which includes updated LPD requirements for nonresidential indoor spaces and reflects contemporary LED lighting technology, optical efficiency, and luminaire design practices. The proposal also considers the draft version of IECC 2027, which is based upon the updates in ASHRAE 90.1-2025 for Space-by-Space Method LPDs and Building Area Method LPDs. These references provide a benchmark that indicates that California's standards are slightly more efficient than the national minimum energy efficiency model codes.

Overall, the proposed Title 24 updates are more stringent than current 2025 Title 24 values for certain space types, primarily based on updates to efficacies of LED luminaires and updates to assumptions of maintained efficacy. The proposed updates also address areas not explicitly covered by national standards, such as data center lighting, ensuring high energy efficiency in rapidly growing building sectors. Overall, this proposal ensures that California's lighting standards remain aligned with industry best practices, maintain technical accuracy, and continue to support energy savings.

### 2.7.2 Interactions with Other Regulations

California Assembly Bill 130 (AB130) prohibits modifications to residential dwellings until 2031. This has been interpreted by the California Building Standards Commission to include GROUP R OCCUPANCIES AND COMMON OR PUBLIC USE AREAS. This is newly defined in the definition section as follows: *GROUP R OCCUPANCIES AND COMMON OR PUBLIC USE AREAS. Group R occupancy as defined by the California Building Code and spaces ancillary to the occupancy that are not part of individual dwelling or sleeping units and are intended for shared, common, or public use, including areas that support occupant use or building operations.*

As a result, there are two area category method tables:

1. A revised Lighting Power Density table for nonresidential buildings not including *Group R occupancies and common use areas* and
2. An unchanged Lighting Power Density table for *Group R occupancies and common use areas*.

The common-use areas of Hotel/Motel buildings were historically combined with nonresidential requirements as many space types in nonresidential buildings are found in the common areas of hotel/motel buildings such as exercise spaces, offices, lounges, parking garages, and more. For the 2028 code cycle, the same application may have different lighting power allowances depending on the type of building in which the space is located.

Besides the consideration above, there are no known federal, state, or local regulations that directly duplicate or conflict with the proposed updates to LPD requirements in Title 24, Part 6. The measure does not require the use of lighting equipment that exceeds federally mandated minimum efficiency standards, ensuring full compliance with applicable federal appliance regulations. At the state level, there are no conflicting requirements related to energy efficiency, occupational safety, or health. The proposed LPD updates are consistent with the California Building Code and do not necessitate changes to other building code sections, such as mechanical, plumbing, or electrical codes. While some local jurisdictions have adopted reach codes with more stringent lighting requirements, these complement the proposed measure and would not pose a conflict. Overall, the proposal is designed to harmonize with existing regulatory frameworks while advancing statewide energy efficiency goals.

## 3. Compliance and Enforcement

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### 3.1 Compliance Considerations

The proposed updates to LPD values in Tables 601.3-B and 601.3.-C [Tables 140.6-B and 140.6-C], along with the refinements to Section 601.2.1 [Section 130.0(c)] regarding luminaire classification and installed wattage, are designed to be feasible for compliance and enforcement without imposing significant new burdens. Compliance with the measure would continue to rely on the standard calculation of Adjusted Indoor Lighting Power under Section 601.3.1.1 [Section 140.6(a)], ensuring that installed wattages do not exceed the Allowed Indoor Lighting Power. The updates clarify how installed wattage should be determined for multi-wattage luminaires, linear LED lamps, and line-voltage luminaires, aligning Title 24, Part 6 with recent guidance from ASHRAE 90.1-2025. This harmonization reduces ambiguity for designers, inspectors, and code compliance staff, supporting accurate and consistent application of the standards.

Field verification is not expected to be required beyond standard lighting inspections. Compliance professionals, including building inspectors and plan checkers, would rely on modified existing procedures for reviewing luminaire schedules, lighting layouts, and calculated power densities. No specialized training beyond familiarization with the updated wattage definitions in Section 601.2.1 [Section 130.0(c)] is anticipated, though inspection staff may benefit from brief guidance on identifying multi-wattage luminaires and LED configurations in accordance with the updated code language.

By clarifying how installed wattage should be reported and how LPDs are applied across different luminaires, the measure reduces the risk of errors or misinterpretations during plan review or field inspections. The language has been adjusted to improve clarity, reduce ambiguity, and ensure consistent application across project types. For example, updates to definitions in Section 601.2.1 [Section 130.0(c)] are harmonized with existing Title 24 terminology, avoiding conflicts or confusion with other code sections.

### 3.2 Impact on Market Actors

Table 7 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

**Table 7: Impacts on Market Actors and Suggested Training and Education Opportunities**

Market Actor	Impact(s)	Suggested Outreach and Education
<b>Owner/ Developer</b> <sup>a</sup>	Verify luminaire selections match updated LPD values.	Additional outreach likely unnecessary.
<b>Design Professional</b> <sup>b</sup>	Must ensure lighting designs comply with updated LPDs and account for updated installed wattage calculations. Review substitutions and confirm they are code equivalent. This is part of the larger substitution review process that evaluates code compliance, including energy, as well as meeting design intent.	Offer webinars or reference guides explaining the revised LPD tables and luminaire classification rules. Include calculation examples for multi-wattage and linear LED luminaires. Evaluation of substitutions is an ongoing task and requires understanding of code as described above.
<b>Construction Team</b> <sup>c</sup>	Limited impact: primary responsibility is verifying that specified luminaires are installed. Contractors may propose substitutions and need to understand what constitutes a code-compliant equivalent.	Training on what can be a valid substitution and what needs to be in place to support the requirements documented in the compliance forms as part of the submittal process.
<b>Building Department</b> <sup>d</sup>	Plan review and inspection procedures are unchanged but require understanding of updated Section 601.2.2.3 [Section 130.0(c)] and LPD tables.	Provide checklist updates and brief training on new wattage calculation methods to streamline review and inspection.
<b>Acceptance Tester</b> <sup>e</sup>	Not applicable, Acceptance Testers do not verify wattage. They verify correct operation of controls.	Not applicable
<b>Manufacturers and Distributors</b>	Must label products or provide documentation reflecting lumen output and multi-wattage configurations in alignment with updated Section 601.2.2.3 [Section 130.0(c)].	Educational outreach explaining new classification requirements, including examples of compliant labeling and luminaire documentation.

- a. Owner/Developer is funding the project and is the primary decision-maker.
- b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
- c. Construction team includes general contractors, home builders, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.

- d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.
- e. Acceptance testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The [2028 CASE Methodology Report](#) presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on owner/developer, design professional, construction team, building department, acceptance tester, and manufacturers and distributors, since these market actors are expected to experience the most direct impacts from lighting power density reductions. The following provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

**Builders.** The proposed change would affect commercial builders; however, it would not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the residential and commercial building industries equally; instead, it would primarily affect industry subsectors. Table 8 shows the commercial building subsectors the Statewide CASE Team expects would be impacted by the changes proposed in this report.

**Building occupants (owners and tenants).** The proposed code change would have incremental costs and would reduce building owners' utility bills throughout the measure lifetime. See the [2028 CASE Methodology Report](#) for a description of how LSC savings relate to occupant utility bill savings.

The subsectors that are most relevant include general commercial building construction firms, nonresidential electrical contractors, and finishing trades that frequently coordinate fixture installation, lighting controls, and interior system integration. These trades would interact with the revised LPD values and updated installed-wattage rules, but the changes represent modest adjustments to design documentation rather than shifts in construction practices.

**Table 8: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code or Standard by Subsector in 2025 (Estimated)**

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
Commercial Building Construction	5,491	87,450	\$10.6
Nonresidential Electrical Contractors	3,245	72,794	\$7.8
Other Nonresidential Finishing Contractors	492	7,241	\$0.6

Source: Analysis by the Statewide CASE Team of QCEW data from the California Employment Development Department

<https://labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry>

\*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. <https://www.bls.gov/opub/hom/cew/concepts.htm> (State of California n.d.).

**Manufacturers.** Manufacturers of luminaires and lighting components are impacted market actors, as the proposal clarifies installed-wattage definitions and updates LPD values that inform product specification and documentation. Most major luminaire and LED manufacturers serving the California market are national or global companies, though several maintain sales, distribution, or product configuration facilities in California. The proposed updates are not expected to impose significant new manufacturing burdens; rather, they may encourage clearer labeling and documentation for multi-wattage luminaires and LED lamp types, which align with existing national practices. Any potential effects on California-based operations or jobs are expected to be minimal. Additional discussion of statewide economic impacts is provided in Section 4.4.

### 3.3 Compliance Software Updates

If this proposal is adopted, CBECC would require updates, but only minor adjustments to existing rulesets. The primary change is to incorporate the revised LPD values in Tables 601.3-B and 601.3-C [Tables 140.6-B and 140.6-C] into NRACM Appendix 5.4A, for nonresidential buildings, excluding the defined building types—*Group R Occupancies and Common or Public Use Areas*. The rulesets do not change; only the values in Appendix 5.4A change. However, consideration of LPDs are based on both building type and space type, so there would be a slight modification to the ACM to reflect the prescriptive wattage allowances. With the change to the NRACM, this not only affects CBECC, but also third-party software designed to meet the specification in the NRACM. These updates do not require new EnergyPlus functionality; existing

objects and modeling approaches already support lighting power calculations and luminaire wattage inputs.

If the CEC determines that more substantial changes are required during rulemaking, the Statewide CASE Team can provide more detailed recommendations.

### 3.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

The Statewide CASE Team expects modest additional costs to state or local governments associated with the enforcement of the proposed measure. However this is in the context of AB 130 resulting in a dual path in the code to specifically carve out nonresidential space types within R occupancy buildings.

The current enforcement framework already accounts for LPD requirements, and the proposed measure only decreases the values being enforced. Changes to deemed wattages are either increased clarity (Type A wattage is based on ballast wattage), increased scope of existing criteria (current limiter or supplementary overcurrent protection can be applied to all lighting types) or for luminaires with line voltage lamp holders the wattage rating shifted from the label on the fixture to the sum of the labelled wattage of the installed lamps. This incremental adjustment does not require the development of new programs or significant changes to existing enforcement protocols. Training is required to stay current with all codes updated during the triennial cycle, and the changes associated with this proposal are small.

No new training programs for enforcement officials are anticipated, as the existing training infrastructure is sufficient to support the minor increase in enforcement activity. Similarly, no additional workforce training is expected for the construction industry, as the proposed measure does not introduce new design or installation practices beyond those already covered under current guidelines.

As such, the state would incur relatively modest additional costs for compliance assurance, enforcement, or training associated with this proposal as compared to the ongoing training required to stay current with the remainder of the triennial code changes and the development of new building officials.

With the passage of AB 130, where code requirements for *Group R Occupancies and Common or Public Use Areas*, are to match the 2025 code requirements during the 2028 code cycle, and only nonresidential occupancies are to be updated for the 2028 building code cycle, energy code compliance forms would either be duplicated to have nonresidential versus a *Group R Occupancies and Common or Public Use Areas*

version, or sections of the forms would be segmented by building occupancy. To date, it appears that the interpretation and implementation of this legislation adds complexity to the compliance process for the duration of the moratorium on including Group R occupancies in code updates.

The process of code enforcement does not change. Plan review would include reviewing NRCC/LMCC-LTI-E Indoor Lighting Certificate of Compliance and NRCC-PRF-E and ensuring that it meets the new code requirement and is consistent with the drawings and specifications. The allowed wattage calculations would be modified to correspond to the updates to the LPDs.

Inspection review would include reviewing NRCI/LMCI-LTI-E Indoor Lighting Certificate of Installation and ensuring that the information on the forms is consistent with the approved NRCC/LMCC-LTI-E Indoor Lighting Certificate of Compliance forms and with what is actually installed.

## 4. Market and Economic Analysis

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### 4.1 Market Structure and Availability

#### 4.1.1 Current Market Structure and Availability

The principal manufacturers that supply luminaires and LED light engines to the California commercial market include Signify (Philips Lighting), Acuity Brands (including Lithonia Lighting), Hubbell, Cree, Osram Green Creative, and several European/global players such as Zumtobel. Nationally, Signify, Acuity Brands, Hubbell, Cree Lighting, and Osram combined share in the percentages of the mid-40s of the commercial lighting market.<sup>5</sup> These firms produce the vast majority of commercial luminaires, fixture families, and LED modules that designers specify and contractors install; Signify, Acuity Brands and Current (including Columbia, Prescolite, and GE lamps ) are particularly prominent in North American commercial projects.

Major electrical and lighting distributors that serve California projects — and that routinely stock and deliver these manufacturers' products to contractors and building owners — include All-Phase, Graybar, Platt, Rexel, among others (and their regional branches). These distributors maintain warehouses and sales/service centers throughout California, which support timely local availability and logistics for commercial construction schedules.

Manufacture, supply, and installation of the affected products can be provided by multiple parties. Luminaires and LED replacement lamps are commodity products available from many competing manufacturers and distributed through multiple national and regional distributors, providing strong redundancy in the supply chain and minimal risk of single-vendor bottlenecks. Where corporate consolidation has occurred (for example, Signify's acquisition of Cooper Lighting), product lines continue to be supplied under familiar brands and remain widely available through distributors.

Because this proposal focuses on updating LPD tables and clarifying how installed wattage is determined, it does not require manufacturers to introduce new luminaire technologies or retool production lines. The updated LPD allowances are in response to increased luminaire efficacy in commercially available products.

This proposal also clarifies that lamps and luminaires with user-selectable wattage settings shall have installed wattage determined using the highest selectable setting. This aligns with ASHRAE 90.1-2025. It also aligns with about half of the responses from the design community that using the maximum wattage seemed reasonable. Surveyed

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<sup>5</sup> <https://www.mordorintelligence.com/industry-reports/north-america-commercial-led-lighting-market>

manufacturers also indicated limited interest in developing a user-selectable product with mechanisms that permanently disable wattage adjustment after installation.

As a result, manufacturer impacts are expected to be limited primarily to routine product and documentation updates, including luminaire labeling revisions, product literature updates, linear LED lamp configurations, and inseparable SSL modules to align with the revised definitions. There are two major changes and two major clarifications:

- **Change:** For line-voltage fixtures, fixture wattage is not based on the label on the fixture, but the sum of the installed maximum wattages as labeled on the lamps or SSL light engines.
- **Clarification:** For lamps or luminaires with user-selectable wattage, the rated wattage is the maximum rated wattage.
- **Change:** To accommodate where the design might use a lower user-selectable wattage, the scope of where a current limiter or supplementary overcurrent protection is allowed to define the installed wattage has been expanded from modular lighting and track lighting to all system types. This increased scope would rarely be used as it increases costs but expands the flexibility to use lower user selectable wattage settings and claim a lower installed wattage.
- **Clarification:** For UL Type A LED retrofits, where the legacy fluorescent or HID ballast is still connected and drawing power in addition to the LED source, the rated power for the luminaire is the total input ballast power as rated in combination with the legacy fluorescent or HID lamps.

Overall, these adjustments are within the scope of normal product documentation updates and are already familiar to major lighting manufacturers.

There are no known patents or exclusive supply restrictions that would limit multiple vendors from providing compliant luminaires or LED modules for the California market. The commercial LED and luminaire markets are mature and competitive; product types (linear LED lamps, recessed troffers, high-bay fixtures, downlights, and integrated SSL fixtures) are produced by many manufacturers, so the measure would not create a single-source dependency.

Emerging trends in the lighting market—connected lighting controls, tunable-white systems, power-over-Ethernet (PoE) solutions, and integrated sensor networks—are complementary to this proposal. By tightening LPD allowances and clarifying how installed wattage is counted, the measure incentivizes use of optically efficient luminaires and encourages integrated control strategies that reduce installed power while preserving or improving illuminance quality. Where the design strategy requires greater use of controls or optically efficient fixtures, Section 3.2 recommends targeted outreach to designers and controls contractors. No negative impacts on innovation are anticipated; on the contrary, clearer wattage accounting rewards product innovations

that deliver more lumens per input watt and better optical performance. (See Section 3.2 of this report for workforce training recommendations.)

The required design strategies for compliance — selecting luminaires with documented installed wattages that meet the revised Section 601.2.1 [*Section 130.0(c)*] definitions and designing to the updated LPD tables — are already common practice among experienced commercial lighting designers and electrical contractors. Typical commercial design-build teams regularly specify fixture wattages, submit luminaire schedules, and coordinate with distributors for product submittals; the proposal tightens how those wattages are defined and reported. For less experienced teams, the training and outreach described in Section 3.2 (webinars, sample luminaire schedules, calculation examples) would be sufficient to close knowledge gaps.

High-efficacy luminaires are standard practice in the California commercial market. Compliant products are already widely available from multiple manufacturers and stocked by major distributors. Absent regulations, the industry would continue moving toward higher efficacy and better optical performance; however, the code change accelerates uniform market adoption and eliminates ambiguity in wattage reporting.

For statewide energy savings estimates, the CASE analysis conservatively discounts free market adoption rates—assumes some portion of the market would have adopted higher performance in the absence of the code—and counts only the incremental savings attributable to the code change. Given the complexity of evaluating the impact of lower LPDs on future behavior, this proposal relies on prior CPUC evaluations of measured savings from changes in stringency of lighting efficiency standards and applies a methodology for projecting market-wide changes in distribution of installed power.

#### **4.1.2 Market Challenges and Solutions**

The greatest market challenge is the wide range of efficacy and lamp lumen depreciation (LLD) stated on specification cut sheets for similar products from different manufacturers—and, in some cases, from the same manufacturer.

In the analysis of luminaires (refer to Appendix J), luminaire efficacy differences between similar luminaires in any given category are as much as 150 percent to 200 percent.

Also, the LLD stated manufacturer specification cut sheets varied significantly. Some manufacturers stated the IES L70 at 50,000 hours, while others stated lumen maintenance as high as at 60,000 hours with estimated extended LLD at L70 to L90 at 100,000+ hours.

The ideal solution would be the industry standardization of documented luminaire specifications on product cut sheets. The practical solution is for specifiers to review

and analyze luminaire specifications (especially efficacy and LLD) and to validate the accuracy of the specifications with the manufacturer and/or manufacturers' representatives.

## 4.2 Design and Construction Practices

### 4.2.1 Current Design and Construction Practices

Currently, lighting designers select LED luminaires that balance lumen output, optical distribution, and dimmability to optimize energy efficiency while maintaining occupant comfort. Designers also consider lamp lumen depreciation (LLD) assumptions when calculating LPDs, ensuring installed wattages remain within code limits throughout the expected life of the system.

The proposed updates to LPD values and the clarifications to luminaire classification would reinforce these practices by aligning allowable lighting power with modern LED performance, task-based lighting strategies, and industry-standard luminaire classification methods. Designers would continue to specify luminaires according to the intended application, but updated Tables 601.3-B and 601.3-C [*Table 140.6-B and 140.6-C*] values may encourage more widespread use of higher-efficacy luminaires or improved optical efficiency to meet stricter power allowances. This may slightly shift design decisions, such as fixture spacing or selection of integrated LED systems versus traditional lamp-and-ballast configurations, but it does not fundamentally alter electrical service requirements, space planning, or aesthetic considerations.

### 4.2.2 Health and Safety Considerations

The proposed updates to LPDs and luminaire classification do not introduce any changes to structural or seismic design, indoor air quality, moisture management, fire-resistance ratings, or other health and safety factors. The measure continues to rely on existing luminaire installation practices, electrical safety standards, and manufacturer guidance.

All current federal, state, and local safety regulations, including rules enforced by the California Division of Occupational Safety and Health, remain fully applicable.

Compliance with the updated LPDs and luminaire classification is not anticipated to create any adverse impacts on the health or safety of building occupants, installers, or maintenance personnel.

A potential benefit of the measure is improved lighting quality and consistency, which may enhance visual comfort and reduce the risk of eye strain or accidents in poorly illuminated spaces. No stakeholder feedback raised health or safety concerns relevant to this proposal.

### 4.2.3 Design and Construction Challenges and Solutions

A major design and construction challenge is the discrepancies found among cut sheets of what are essentially the same product. The Statewide CASE Team hypothesizes that luminaire cut sheets are not updated as quickly as products are changing. The same product with a 90 CRI is sometimes listed as having a higher efficacy than the same luminaire with an 80 CRI. Historically, an 80 CRI product has a higher efficacy than a 90 CRI product, which contain spectra with lower photopic efficiencies. It is hypothesized that the 90 CRI product is a new release and the data for the 80 CRI product has not been updated.

Thus, to meet more demanding LPDs while providing sufficient illumination, specifiers must confirm that the luminaire selection process is conducted with the latest and accurate data. Given our findings of increased efficacies over the last 6 years, this challenge may turn into an opportunity to expand the range of luminaires that are available to provide enhanced lighting quantity and quality with reduced wattages.

Furthermore, this due diligence must also apply when bid alternate and substitute luminaires are submitted to ensure luminaire performance, quality and efficacy, and meet or exceed the specified luminaire.

Additionally, Table 7 in Section 3.2 *Impact on Market Actors* has recommendations for a description of workforce training that could support effective design, installation, and commissioning.

## 4.3 Energy Equity and Environmental Justice

Each measure in this CASE Report was evaluated for ESJ impacts using 4 criteria: cost, health, resiliency, and comfort. The details of that evaluation can be found in Section 1.4 and the [2028 CASE Methodology Report](#).

Based on a preliminary review, the measures in this proposal are unlikely to have significant impacts on ESJ outside of any impacts mentioned in the [2028 CASE Methodology Report](#), therefore reducing the impacts of disparities on ESJ communities.

The Statewide CASE Team does not expect any impact on the health and safety of ESJ communities, or on their disaster preparedness. The comfort of ESJ communities is unlikely to be negatively impacted by the proposed code changes, rather, visual comfort may be enhanced by the proposed code changes. The Statewide CASE Team does not expect negative economic or cost impacts to ESJ communities as on average the first cost is less expensive than a system minimally compliant with the 2025 standard and has lower operational utility bill costs.

## 4.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 9,

Table 10, and Table 11 outline the statewide implications for these job categories. For more information on the Statewide CASE Team’s economic impacts methodology, see the [2028 CASE Methodology Report](#).

The Statewide CASE Team does not anticipate that the proposed changes would lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, the Statewide CASE Team’s proposed change would not result in economic disruption to any sector of the California economy. Rather, it would lead to modest changes in the employment of existing jobs.

**Table 9: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector**

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
<b>Direct Effects (Additional spending by Commercial Builders)</b>	467	\$37	\$51	\$102
<b>Indirect Effect (Additional spending by firms supporting Commercial Builders)</b>	213	\$17	\$29	\$51
<b>Total Economic Impacts</b>	<b>680</b>	<b>\$54</b>	<b>\$80</b>	<b>\$153</b>

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.<sup>6</sup>

<sup>6</sup> IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 [www.IMPLAN.com](http://www.IMPLAN.com)

**Table 10: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors**

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
<b>Direct Effects (Additional spending by building designers and energy consultants)</b>	0	0	0	0
<b>Indirect Effect (Additional spending by firms supporting building designers and energy consultants)</b>	0	0	0	0
<b>Total Economic Impacts</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

Table 10 above shows zero impact across all categories. Economic impacts for building designers and energy consultants are driven by how the proposed code change would affect the amount of time that designers and consultants spend per project. The Statewide CASE Team expects that in some ways the proposed code changes would decrease designer and consultant time requirements, because of clarifications and streamlining of requirements. However, there also might be increased time spent to understand and design to the more stringent code. Overall, the Statewide CASE Team does not have reason to expect a significant net change in designer and consultant hours per project. As a result, the Statewide CASE Team does not estimate any economic impacts for this sector.

**Table 11: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors**

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
<b>Direct Effects (Additional spending by building inspectors)</b>	390	\$44,330,872	\$52,570,992	\$63,884,235
<b>Indirect Effect (Additional spending by firms supporting building inspectors)</b>	50	\$4,105,586	\$6,394,435	\$11,136,952
<b>Total Economic Impacts</b>	<b>439</b>	<b>\$48,436,457</b>	<b>\$58,965,427</b>	<b>\$75,021,187</b>

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

The proposed change represents a modest adjustment, which is not expected to excessively burden or competitively disadvantage California businesses, nor is it expected to lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.<sup>7</sup> Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have advantageous or adverse effects on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling resulted in an estimated \$14,338,208 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.<sup>8</sup>

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).<sup>9</sup> As Table 12 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of incremental income that business owners would reinvest into expanding their capital stock.

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<sup>7</sup> Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

<sup>8</sup> 23 percent of proprietor income was assumed to be allocated to net business investment (investment that expands the capital stock, rather than updates or replaces existing capital stock); see Table 11.

<sup>9</sup> Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

**Table 12: Net Domestic Private Investment and Corporate Profits, U.S.**

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2020	389	2,212	18
2021	545	2,888	19
2022	825	2,951	28
2023	836	3,069	27
2024	885	3,441	26
<b>5-Year Average</b>	Intentionally blank	Intentionally blank	23

Source: (Federal Reserve Economic Data (FRED) n.d.)

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a \$3,365,736 increase in net private investment by California businesses.

## 4.5 Economic and Fiscal Impacts

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to a significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California’s economy. The proposed change would not result in economic disruption to any sector of the California economy. For more information on the Statewide CASE Team’s economic and fiscal impacts methodology, see the [2028 CASE Methodology Report](#).

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry, architects, energy consultants, and building inspectors. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2028 code cycle regulations would result in additional spending by those businesses.

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

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

**Cost to State:** The state government already has a budget for code development, education, and compliance enforcement. While the state government would 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 for the state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals. On average the code change results in changes to the design of lighting systems in state buildings that will reduce energy consumption and reduce utility costs. When compared to a building designed to the current California energy standard designed with lighting representing efficacies of 6 years ago, a building designed to the proposed 2028 standard with higher efficacy lighting representative of the current average efficacy, the proposed lighting system will cost less than the currently allowed higher wattage design.

**Cost to Local Governments:** All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 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 Statewide Codes and Standards program (such as Energy Code Ace). As noted in Section 3.2, 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.

#### **4.5.2 Mandates on Local Agencies or School Districts**

This proposal imposes a mandate on local agencies or school districts to comply with the updated lighting power density requirements in Title 24 part 6. The fiscal impacts of this measure reduces lighting system cost and reduces energy costs, financially benefiting these local agencies and school districts. However, note the proposed requirements are widely applicable and not specific to local agencies or school districts.

#### **4.5.3 Costs to Local Agencies or School Districts**

There are no costs to local agencies or school districts because this measure reduces lighting system cost and reduces energy costs, financially benefiting these local agencies and school districts.

#### **4.5.4 Costs or Savings to Any State Agency**

There are no costs or savings to any state agencies beyond what's already described in Section 4.5.1. However, this measure reduces lighting system cost and reduces energy costs, which could financially benefit state agencies.

#### **4.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies**

There are no added nondiscretionary costs or savings to local agencies because the adoption of this proposal reduces lighting system cost and reduces energy costs, which could financially benefit local agencies.

#### **4.5.6 Costs or Savings in Federal Funding to the State**

There are no costs or savings to federal funding to the state because this proposal largely provides updates to lighting wattage allowances for indoor spaces. Therefore, there are no expected impacts to federal funding for the state.

## 5. Cost Effectiveness

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### 5.1 Cost-Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The [2028 CASE Methodology Report](#) and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on Long-term System Cost (LSC), which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

### 5.2 Energy and Energy Cost Savings Results

Energy and energy cost savings results are developed from differences in allowed installed wattage as follows:

Annual energy savings per square foot are calculated by taking the difference in lighting power density between the 2025 LPDs and the proposed 2028 LPD and multiplying the difference by the annual full load hours of lighting system operation for each space type.

The decreased cooling loads and increased heating loads associated with reduced lighting electrical consumption is not calculated due to its small impact, relative to the primary impact of less lighting load. Nonresidential buildings are primarily cooling load dominated, each unit of reduction in lighting internal gains save an additional 15 percent in electricity savings but also result in an increase of around 7 percent in gas consumption. The net effect of heating and cooling interaction effects are small and, in most applications, increases savings. For more details and references see Appendix A.

Full load hours are calculated from the lighting power fractions in the lighting schedules in Appendix 5.4B of the Nonresidential Alternative Calculation Method (ACM) Reference

Manual which describes the whole building simulation calculation methods used in the performance approach. These lighting power fractions vary by hour of day during weekdays, Saturdays and Sundays. The day-of-week values line up with the assumptions embedded in the economic factors, and the lighting profiles are aligned to be formatted to the 2009 calendar year, where January 3 and 4 are the first weekend of the year. This reference year ensures that the day of week in the computer simulations align with the day of week used for the development of the hourly metrics for life cycle systemwide cost (LSC), energy demand, source energy, and carbon emissions.

When the LPD reduction (W per square foot) is multiplied by the lighting schedule and divided by 1,000 W/kW conversion factor, this results in a kWh/sf reduction for each hour. The sum of the value results in the kWh/sf-y savings.

When these hourly energy savings are multiplied by the hourly demand factors, this yields the kW of demand for each W per square foot reduction in the LPD.

When these hourly energy savings are multiplied by the hourly LSC values and summed this results in the present value dollars over 30 years per square foot of systemwide life cycle savings. The units are present valued dollars.

The same approach of multiplying hourly factors by the hourly energy savings values results in similar calculations of nominal undiscounted 30-year energy cost savings in units of 30-year dollars, annual Greenhouse Gas Emission reductions in tonnes of CO<sub>2</sub> equivalent, and source energy reductions in kBtu/y.

Since the base case and proposed systems have identical load shapes and HVAC interaction effects are ignored, there is no climate zone dependency for demand, GHG emission, and source energy reductions. For LSC and nominal energy cost savings over 30 years, the variability of maximum to minimum value divided by the average was less than 5 percent for all the ACM lighting load profiles. Thus, the average LSC and Nominal savings values with little loss in accuracy across all climate zones.

Negative savings values (shown in red and enclosed in parentheses) indicate cases where the proposed allowance for general lighting power, combined with any additional lighting power, results in an overall increase in lighting energy use relative to the current requirements.

Table 14 reports the savings per prototypical space for each primary function area that minimally complies with the proposed lighting power allowances relative to minimal compliance with the 2025 Title 24, part 6 lighting power densities (LPDs). Most of the 2025 LPDs are unchanged since the 2022 version of Title 24, Part 6. The savings per prototypical space are proved for electrical energy (kWh/y), peak electrical demand in watts, 30-year life cycle systemwide energy cost (LSC) in 30 years present valued 2029 dollars, and source energy savings in kBtu per year. The GHG emissions reductions

associated with energy savings are presented in units of metric tons of carbon dioxide equivalent per year.

Table 13: Reduction in Allowed Power

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	2028 Total LPD Reduction (W/sf)	2028 Total Power Reduction (%)
Aging Eye/Low-vision:1 Corridor Area	0.70	0.30	0.70	0.30	0.00	0%
Aging Eye/Low-vision:1 Dining	0.80	0.40	0.80	0.40	0.00	0%
Aging Eye/Low-vision:1 Main Entry Lobby	0.80	1.10	0.85	1.35	0.30	14%
Aging Eye/Low-vision:1 Lounge/Waiting Area	0.80	0.40	0.80	0.40	0.00	0%
Aging Eye/Low-vision:1 Multipurpose Room	0.80	0.40	0.85	0.40	0.05	4%
Aging Eye/Low-vision:1 Religious Worship Area	0.90	0.40	1.00	0.40	0.10	7%
Aging Eye/Low-vision:1 Restroom	0.90	0.30	1.00	0.20	0.00	0%
Aging Eye/Low-vision:1 Stairwell	0.80	0.30	0.80	0.30	0.00	0%
Atria < 20 ft tall	0.30	0.20	0.60	0.25	0.35	41%
Atria 20 to < 40 ft	0.40	0.25	0.60	0.25	0.20	24%
Atria > 40 ft	0.50	0.30	0.60	0.25	0.05	6%
Audience Seating Area	0.30	0.35	0.50	0.25	0.10	13%
Auditorium Area	0.50	0.45	0.70	0.45	0.20	17%
Auto Repair / Maintenance Area	0.55	0.20	0.55	0.20	0.00	0%
Barber, Beauty Salon and Spa Area	0.65	0.50	0.70	0.55	0.10	8%
Civic Meeting Room	0.70	0.30	0.90	0.25	0.15	13%
Concourse	0.45	0.25	0.60	0.25	0.15	18%
Convention Center: Ballroom	0.45	0.40	0.75	0.25	0.15	15%
Convention: Exhibit Space	0.45	0.30	0.75	0.25	0.25	25%
Convention: Meeting Room	0.65	0.25	0.75	0.25	0.10	10%
Control room	0.50	0.00	0.60	0.00	0.10	17%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	2028 Total LPD Reduction (W/sf)	2028 Total Power Reduction (%)
Copy Room	0.45	0.00	0.50	0.00	0.05	10%
Corridor Area	0.35	0.30	0.40	0.25	0.00	0%
Data center: Computer room (new)	0.45	0.25	0.55	0.25	0.10	13%
Dining Area: Bar/Lounge and Fine Dining	0.40	0.75	0.45	0.80	0.10	8%
Dining Area: Cafeteria/Fast Food	0.40	0.25	0.45	0.25	0.05	7%
Dining Area: Family and Leisure	0.35	0.25	0.40	0.25	0.05	8%
Education/Business: Classroom, Training, Educational, civic: Multipurpose room (art, music etc.)	0.55	0.00	0.60	0.00	0.05	8%
Electrical, Mechanical, Telephone Rooms	0.60	0.30	0.75	0.25	0.10	10%
Electrical, Mechanical, Telephone Rooms	0.40	0.20	0.40	0.20	0.00	0%
Exercise/Fitness Center and Gymnasium Area	0.40	0.20	0.40	0.20	0.00	0%
Exercise/Fitness Center and Gymnasium Area	0.55	0.00	0.50	0.00	(0.05)	(10%)
Financial Transaction Area	0.53	0.30	0.70	0.25	0.12	13%
Healthcare: Corridor (new)	0.55	0.25	0.40	0.25	(0.15)	(23%)
Healthcare: Exam/Treatment Room	1.10	0.00	1.15	0.00	0.05	4%
Healthcare: Imaging Room	0.55	0.35	0.60	0.30	0.00	0%
Healthcare: Medical Supply Room	0.50	0.00	0.55	0.00	0.05	9%
Healthcare: Nursery	0.80	0.10	0.80	0.10	0.00	0%
Healthcare: Nurse's Station	0.75	0.30	0.85	0.30	0.10	9%
Healthcare: Operating Room	1.90	0.00	1.90	0.00	0.00	0%
Healthcare: Patient Room - Critical care	0.90	0.25	0.70	0.25	(0.20)	(21%)
Healthcare: Patient Room - General	0.70	0.25	0.70	0.25	0.00	0%
Healthcare: Physical Therapy Room	0.65	0.10	0.75	0.10	0.10	12%
Healthcare: Recovery Room	0.85	0.30	0.90	0.10	(0.15)	(15%)
Kitchen/Food Preparation Area	0.85	0.00	0.95	0.00	0.10	11%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	2028 Total LPD Reduction (W/sf)	2028 Total Power Reduction (%)
Laboratory: Scientific and Teaching	0.80	0.35	0.90	0.35	0.10	8%
Laundry Area	0.43	0.00	0.45	0.00	0.02	4%
Library : Reading Area	0.70	0.25	0.80	0.25	0.10	9%
Library : Stacks Area	0.91	0.00	1.00	0.00	0.09	9%
Lobby: Main entry	0.60	0.40	0.70	0.50	0.20	17%
Lobby: Performing Arts	0.60	0.40	0.70	0.50	0.20	17%
Locker Room	0.40	0.00	0.45	0.00	0.05	11%
Lounge, Breakroom, or Waiting Area	0.45	0.25	0.55	0.25	0.10	13%
Manufacturing & Commercial Work Area: Low Bay	0.60	0.20	0.60	0.20	0.00	0%
Manufacturing & Commercial Work Area: High Bay	0.65	0.20	0.65	0.20	0.00	0%
Manufacturing & Commercial Work Area: Precision	0.80	0.70	0.85	0.70	0.05	3%
Motion picture: Theater area	0.50	0.25	0.50	0.25	0.00	0%
Museum: Exhibition/Display	0.60	0.45	0.80	0.45	0.20	16%
Museum Area: Restoration Room	0.65	0.35	0.70	0.35	0.05	5%
Office Area: ≤ 250 square feet	0.55	0.25	0.65	0.20	0.05	6%
Office Area: > 250 square feet	0.50	0.25	0.60	0.20	0.05	6%
Office: Conference Room	0.60	0.25	0.75	0.25	0.15	15%
Parking Garage Area: Parking Zone and Ramps	0.08	0.00	0.10	0.00	0.02	20%
Parking Garage Area: Daylight Adaptation Zones8	0.08	0.70	1.00	0.00	0.22	22%
Performance: Theater area	0.50	0.40	0.80	0.25	0.15	14%
Performance: Dressing room (new)	0.50	0.00	0.55	0.00	0.05	9%
Pharmacy Area	1.00	0.35	1.00	0.35	0.00	0%
Retail: Grocery Sales	0.90	0.55	1.00	1.05	0.60	29%

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/sf)	2028 Additional Lighting Power (W/sf)	2025 Title 24 Allowed General LPD (W/sf)	2025 Title 24 Additional Lighting Power (W/sf)	2028 Total LPD Reduction (W/sf)	2028 Total Power Reduction (%)
Retail: Merchandise Sales	0.80	0.95	0.95	0.95	0.15	8%
Retail: Fitting Room	0.50	40 <sup>a</sup>	0.60	40 <sup>a</sup>	0.10	17%
Religious Worship Area	0.75	0.25	0.95	0.25	0.20	17%
Restrooms	0.65	0.35	0.65	0.35	0.00	0%
Stairwell	0.60	0.35	0.60	0.35	0.00	0%
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	2.25	0.00	2.25	0.00	0.00	0%
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	1.45	0.00	1.45	0.00	0.00	0%
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	1.05	0.00	1.10	0.00	0.05	5%
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	0.71	0.00	0.75	0.00	0.04	5%
Transportation: Baggage Area	0.30	0.10	0.40	0.00	0.00	0%
Transportation: Ticketing Area	0.40	0.20	0.45	0.20	0.05	8%
Transportation: Waiting area	0.40	0.25	0.60	0.25	0.20	24%
Videoconferencing Studio <sup>12</sup>	0.70	1.00	0.90	1.00	0.20	11%
Warehouse: Storage	0.40	0.00	0.40	0.00	0.00	0%
Warehouse: Shipping and Handling	0.60	0.00	0.60	0.00	0.00	0%

a. Watts per mirror

Table 14: Unit Savings per Prototype Space: Electricity, Demand, LSC, Source Energy and GHG Emissions

Primary Function Area	Prototype Area (sf)	Prototype Annual Energy Savings (kWh/yr)	Prototype Demand Savings (W)	Prototype Energy Cost Savings (PV\$)	Prototype Source Energy Savings (kBtu/yr)	GHG Savings Tonnes CO <sub>2</sub> e/yr
Aging Eye/Low-vision:1 Corridor Area	640	0	0.0	\$0	0	0.000

Primary Function Area	Prototype Area (sf)	Prototype Annual Energy Savings (kWh/yr)	Prototype Demand Savings (W)	Prototype Energy Cost Savings (PV\$)	Prototype Source Energy Savings (kBtu/yr)	GHG Savings Tonnes CO2e/yr
Aging Eye/Low-vision:1 Dining	1,600	0	0.0	\$0	0	0.000
Aging Eye/Low-vision:1 Main Entry Lobby	600	606	58.8	\$4,869	794	0.042
Aging Eye/Low-vision:1 Lounge/Waiting Area	900	0	0.0	\$0	0	0.000
Aging Eye/Low-vision:1 Multipurpose Room	900	152	14.7	\$1,217	199	0.011
Aging Eye/Low-vision:1 Religious Worship Area	504	170	16.5	\$1,363	222	0.012
Aging Eye/Low-vision:1 Restroom	216	0	0.0	\$0	0	0.000
Aging Eye/Low-vision:1 Stairwell	160	0	0.0	\$0	0	0.000
Atria < 20 ft tall	6,000	7,382	608.2	\$53,700	7262	0.384
Atria 20 to < 40 ft	10,000	7,031	579.2	\$51,143	6916	0.366
Atria > 40 ft	7,776	1,367	112.6	\$9,942	1345	0.071
Audience Seating Area	3,200	1,077	104.5	\$8,657	1412	0.075
Auditorium Area	5,400	3,636	352.6	\$29,216	4764	0.252
Auto Repair / Maintenance Area	4,800	0	0.0	\$0	0	0.000
Barber, Beauty Salon and Spa Area	1,440	506	41.7	\$3,682	498	0.026
Civic Meeting Room	540	273	26.4	\$2,191	357	0.019
Concourse	12,000	6,060	587.6	\$48,693	7940	0.420
Convention Center: Ballroom	5,625	2,841	275.4	\$22,825	3722	0.197
Convention: Exhibit Space	10,000	8,417	816.1	\$67,629	11028	0.583
Convention: Meeting Room	520	175	17.0	\$1,407	229	0.012
Control room	600	170	13.5	\$1,217	159	0.008
Copy Room	200	23	1.9	\$170	23	0.001
Corridor Area	640	0	0.0	\$0	0	0.000
Data center: Computer room	350	99	7.9	\$710	93	0.005

Primary Function Area	Prototype Area (sf)	Prototype Annual Energy Savings (kWh/yr)	Prototype Demand Savings (W)	Prototype Energy Cost Savings (PV\$)	Prototype Source Energy Savings (kBtu/yr)	GHG Savings Tonnes CO2e/yr
Dining Area: Bar/Lounge and Fine Dining	1,800	862	87.0	\$7,067	1202	0.064
Dining Area: Cafeteria/Fast Food	1,200	287	29.0	\$2,356	401	0.021
Dining Area: Family and Leisure	2,400	574	58.0	\$4,711	801	0.042
Education/Business: Classroom, Training, Educational, civic: Multipurpose room (art, music etc.)	1,064	112	10.0	\$850	123	0.006
Electrical, Mechanical, Telephone Rooms	1,064	224	20.0	\$1,701	246	0.013
Exercise/Fitness Center and Gymnasium Area	1,200	0	0.0	\$0	0	0.000
Exercise/Fitness Center and Gymnasium Area	2,400	(422)	(34.8)	(\$3,069)	(415)	(0.022)
Financial Transaction Area	720	201	16.7	\$1,473	203	0.011
Healthcare: Corridor	1,000	(433)	(36.9)	(\$3,240)	(459)	(0.024)
Healthcare: Exam/Treatment Room	120	17	1.5	\$130	18	0.001
Healthcare: Imaging Room	224	0	0.0	\$0	0	0.000
Healthcare: Medical Supply Room	1,200	173	14.8	\$1,296	183	0.010
Healthcare: Nursery	800	0	0.0	\$0	0	0.000
Healthcare: Nurse's Station	200	58	4.9	\$432	61	0.003
Healthcare: Operating Room	900	0	0.0	\$0	0	0.000
Healthcare: Patient Room - Critical care	256	(148)	(12.6)	(\$1,106)	(157)	(0.008)
Healthcare: Patient Room - General	192	0	0.0	\$0	0	0.000
Healthcare: Physical Therapy Room	1,200	351	29.9	\$2,625	372	0.020
Healthcare: Recovery Room	192	(83)	(7.1)	(\$622)	(88)	(0.005)
Kitchen/Food Preparation Area	450	215	21.7	\$1,767	300	0.016
Laboratory: Scientific and Teaching	672	255	23.6	\$1,949	298	0.016
Laundry Area	1,200	84	7.0	\$614	83	0.004
Library : Reading Area	720	162	13.5	\$1,190	164	0.009

Primary Function Area	Prototype Area (sf)	Prototype Annual Energy Savings (kWh/yr)	Prototype Demand Savings (W)	Prototype Energy Cost Savings (PV\$)	Prototype Source Energy Savings (kBtu/yr)	GHG Savings Tonnes CO2e/yr
Library : Stacks Area	360	78	6.5	\$570	79	0.004
Lobby: Main entry	4,800	3,232	313.4	\$25,970	4235	0.224
Lobby: Performing Arts	2,400	1,616	156.7	\$12,985	2117	0.112
Locker Room	200	35	2.9	\$256	35	0.002
Lounge, Breakroom, or Waiting Area	480	162	15.7	\$1,298	212	0.011
Manufacturing & Commercial Work Area: Low Bay	4,800	0	0.0	\$0	0	0.000
Manufacturing & Commercial Work Area: High Bay	12,000	0	0.0	\$0	0	0.000
Manufacturing & Commercial Work Area: Precision	4,800	679	54.1	\$4,866	635	0.034
Motion picture: Theater area	1,560	0	0.0	\$0	0	0.000
Museum: Exhibition/Display	2,184	1,471	142.6	\$11,816	1927	0.102
Museum Area: Restoration Room	2,400	404	39.2	\$3,246	529	0.028
Office Area: ≤ 250 square feet	140	16	1.4	\$119	16	0.001
Office Area: > 250 square feet	600	70	5.8	\$511	70	0.004
Office: Conference Room	600	209	17.4	\$1,534	211	0.011
Parking Garage Area: Parking Zone and Ramps	7,200	973	105.1	\$8,179	1488	0.079
Parking Garage Area: Daylight Adaptation Zones8	1,980	2,942	317.9	\$24,741	4500	0.238
Performance: Theater area	16,000	8,080	783.4	\$64,924	10587	0.560
Performance: Dressing room	80	13	1.3	\$108	18	0.001
Pharmacy Area	480	0	0.0	\$0	0	0.000
Retail: Grocery Sales	4,800	10,124	834.1	\$73,646	9959	0.527
Retail: Merchandise Sales	4,800	2,531	208.5	\$18,411	2490	0.132
Retail: Fitting Room	60	21	1.7	\$153	21	0.001
Religious Worship Area	8,000	5,394	523.0	\$43,343	7068	0.374

Primary Function Area	Prototype Area (sf)	Prototype Annual Energy Savings (kWh/yr)	Prototype Demand Savings (W)	Prototype Energy Cost Savings (PV\$)	Prototype Source Energy Savings (kBtu/yr)	GHG Savings Tonnes CO2e/yr
Restrooms	150	0	0.0	\$0	0	0.000
Stairwell	360	0	0.0	\$0	0	0.000
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	5,000	0	0.0	\$0	0	0.000
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	5,000	0	0.0	\$0	0	0.000
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	5,000	946	78.0	\$6,884	931	0.049
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	5,000	645	53.2	\$4,694	635	0.034
Transportation: Baggage Area	5,400	0	0.0	\$0	0	0.000
Transportation: Ticketing Area	2,000	337	32.6	\$2,705	441	0.023
Transportation: Waiting area	4,000	2,693	261.1	\$21,641	3529	0.187
Videoconferencing Studio <sup>12</sup>	828	385	32.1	\$2,823	389	0.021
Warehouse: Storage	800	0	0.0	\$0	0	0.000
Warehouse: Shipping and Handling	1,800	0	0.0	\$0	0	0.000

### 5.3 Incremental First Cost

Incremental first cost represents the difference in upfront cost between the proposed 2028 code requirement and an equivalent 2025 design and is an input to overall cost-effectiveness. The Statewide CASE Team relied on cost data collected at a defined point in time and did not speculate about future market shifts, including potential tariff impacts. All prices cited in this analysis were collected in February and March of 2026.

To determine equipment cost, luminaire pricing was collected from a distributor with access to over 1,000 manufacturers' products they were serving. Sample project sizes were used to obtain consistent pricing across luminaires selected. To ensure consistent comparison between the 2022/2025 reference case and the proposed 2028 design, the analysis used the same grade of luminaire for both cases. Product costing was based on products from 44 manufacturers (representing the three high and low efficacy performers for each luminaire type) from the surveyed luminaires. All prices are presented in 2026 dollars to maintain internal consistency and avoid mixing cost assumptions from different periods.

Incremental first cost is based only on cost differences in luminaires and does not include installation costs as the installation costs are essentially the same for the 2022/2025 reference case and the 2028 proposed case. In many cases, the products selected for the proposed designs required to meet the 2028 code with higher efficacies representative of the current market were less expensive than a lower efficacy luminaire that is more representative of those available six years ago when the 2022 Energy Code analysis was conducted.

In Table 15, the descriptive average efficacy, luminous flux, and input wattage reflect simple averages of the multiple luminaires sampled within each prototype luminaire category. Average efficacy is the mean of individual product efficacy, rather than being calculated by dividing average lumens by average watts.

**Table 15: Luminaire Costs**

Representative Year Luminaire Type	Size	Avg Watts	Avg Lumens	Avg Efficacy (Lm/W)	Avg Luminaire Cost (\$)	Cost per Watt (\$/W)
2022 - Basket Troffer	2X2	32	3,523	110	\$306	\$9.49
2028 - Basket Troffer	2X2	26	3,374	130	\$146	\$5.62
2022 - Basket Troffer	2X4	63	6,897	110	\$329	\$5.26
2028 - Basket Troffer	2X4	49	6,638	135	\$127	\$2.58
2022 - Lensed panel troffers	2X2	31	3,487	114	\$51	\$1.67
2028 - Lensed panel troffers	2X2	29	3,608	125	\$65	\$2.24
2022 - Lensed panel troffers	2X4	54	5,864	108	\$90	\$1.65
2028 - Lensed panel troffers	2X4	53	6,890	129	\$106	\$1.98
2022 - Linear Light Slots	4-inch	23	2,233	94	\$340	\$14.59
2028 - Linear Light Slots	4-inch	14	1,679	123	\$392	\$28.81
2022 - Linear Light Slots	6-inch	36	4,004	110	\$421	\$11.58
2028 - Linear Light Slots	6-inch	50	5,803	116	\$401	\$7.99
2022 - Linear Cove Lights	4-ft Section	39	4,124	105	\$676	\$17.34
2028 - Linear Cove Lights	4-ft Section	26	3,075	118	\$382	\$14.69
2022 - Linear Indirect/Direct	4-ft Section	49	5,665	116	\$506	\$10.32
2028 - Linear Indirect/Direct	4-ft Section	26	3,429	131	\$550	\$20.99
2022 - Indirect/Direct Pendant Bowl	36" to 60" dia.	140	11,705	85	\$3,489	\$24.92
2028 - Indirect/Direct Pendant Bowl	36" to 60" dia.	131	16,370	122	\$4,715	\$36.13
2022 - Downlight	4-inch (low)	22	1,622	75	\$240	\$11.12
2028 - Downlight	4-inch (low)	25	2,520	98	\$229	\$9.02
2022 - Downlight	4-inch (med)	32	2,458	77	\$250	\$7.81
2028 - Downlight	4-inch (med)	27	2,706	100	\$232	\$8.59
2022 - Downlight	6-inch (med)	15	1,238	81	\$201	\$13.22

Representative Year Luminaire Type	Size	Avg Watts	Avg Lumens	Avg Efficacy (Lm/W)	Avg Luminaire Cost (\$)	Cost per Watt (\$/W)
2028 - Downlight	6-inch (med)	35	3,235	94	\$286	\$8.16
2022 - Downlight	6-inch (high)	54	4,785	89	\$161	\$2.97
2028 - Downlight	6-inch (high)	56	5,836	104	\$245	\$4.34
2022 - Under counter strip	4ft Standard	17	1,224	73	\$169	\$10.12
2028 - Under counter strip	4ft Standard	15	1,671	109	\$221	\$14.48
2022 - Under counter strip	4ft High Output	29	2,856	100	\$311	\$10.82
2028 - Under counter strip	4ft High Output	20	2,308	113	\$259	\$12.67
2022 - Low bay	Various	88	12,870	146	\$276	\$3.14
2028 - Low bay	Various	101	15,353	151	\$252	\$2.49
2022 - High Bay	Various	242	35,600	147	\$162	\$0.67
2028 - High Bay	Various	220	33,059	151	\$178	\$0.81
2022 - Strip Luminaires	Low output 4ft	41	4,458	114	\$218	\$5.37
2028 - Strip Luminaires	Low output 4ft	32	4,678	148	\$165	\$5.23
2022 - Strip Luminaires	High output 8ft	107	12,582	119	\$275	\$2.57
2028 - Strip Luminaires	High output 8ft	76	11,047	146	\$241	\$3.17
2022 - Parking garage	Low output	32	3,454	111	\$585	\$18.58
2028 - Parking garage	Low output	31	4,222	136	\$484	\$15.61
2022 - Parking garage	High Output	62	6,866	112	\$633	\$10.20
2028 - Parking garage	High Output	54	7,406	137	\$520	\$9.63

To convert the lighting manufacturers contractor's pricing to the total cost seen by the new construction or retrofit project, the contractors' pricing was multiplied by the average local sales tax and contractor's mark-up. The statewide population weighted average county sales tax of 8.56 percent (effective April 1, 2026) was applied to calculate after-tax costs.<sup>10</sup>

RS Means online costing database makes use of a 10.5 percent contractor mark-up for luminaires. Note that the luminaire mark-up is significantly less than labor mark-up. This evaluation does not include labor as the same labor is used in the 2022/2025 reference design and the 2028 proposed design and thus labor drops out when considering incremental costs associated with allowed lighting power density code change.

Combining these two factors results in a total combined sales tax and mark-up factor of 120 percent that is multiplied by the incremental costs of the 2022 luminaire costs for the 2022 design models versus the 2028 luminaire costs for the 2028 design models.

## 5.4 Incremental Maintenance and Replacement Costs

The incremental cost of materials reflects the price of luminaires capable of meeting the proposed LPD requirements while still achieving the intended illumination levels. No incremental labor cost is anticipated because installation practices are the same as those under current code. Based on industry publications and practitioner input, LED luminaires have an estimated useful life (EUL) of 50,000 hours. Replacement costs are calculated as the discounted value at a 3 percent real discount rate on the year 50,000-hour full load hours are achieved.

For the purposes of this assessment, the Statewide CASE Team compared LED products collected in 2025 by the Statewide CASE Team with those evaluated for the 2022 cycle. Because both the 2022/2025 reference case and 2028 proposed conditions rely on long-life LED technologies, the expected maintenance profiles are fundamentally similar. As a result, differences in relamping, repair, or other scheduled maintenance are negligible, and no incremental maintenance cost is assigned.

Persistence of energy savings is expected to remain stable through the analysis period. Performance verification at turnover and adherence to typical facility-management practices are sufficient to maintain performance.

## 5.5 Cost Effectiveness

Results of the cost-effectiveness analyses for each space type are presented in Table 16.

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<sup>10</sup> Sales tax: <https://cdtfa.ca.gov/taxes-and-fees/rates.aspx> and county population: <https://dof.ca.gov/forecasting/demographics/estimates-e1/>

All incremental equipment cost values are presented in 2026 present value dollars while the systemwide energy cost savings benefit is provided in 2026 present value dollars. Benefits represent 30-year LSC savings and other savings, including incremental first-cost savings if the proposed first cost is less than the current first cost, incremental maintenance cost savings if the proposed maintenance costs are less than the current maintenance costs, and incremental residual value if the proposed residual value is greater than the current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including incremental equipment, replacement, and maintenance costs over the period of analysis. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero or negative, the benefit-to-cost ratio (BCR) is considered infinite. In a few cases energy consumption increases. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate.

Table 16: 30-Year Cost-Effectiveness Summary Per Space Type

Primary Function Areas	Wattage Reduction (W)	30 Year PV Savings LSC (2029 PV\$)	Incremental Cost Including Replacements and Negative Residual Cost (\$)	BCR ratio
Aging Eye/Low-vision:1 Corridor Area	54	\$912	-\$779	Infinite
Aging Eye/Low-vision:1 Dining	157	\$6,155	-\$4,754	Infinite
Aging Eye/Low-vision:1 Main Entry Lobby	171	\$4,622	-\$5,887	Infinite
Aging Eye/Low-vision:1 Lounge/Waiting Area	108	\$2,920	-\$2,460	Infinite
Aging Eye/Low-vision:1 Multipurpose Room	93	\$2,520	-\$1,615	Infinite
Aging Eye/Low-vision:1 Religious Worship Area	44	\$1,202	-\$1,533	Infinite
Aging Eye/Low-vision:1 Restroom	34	\$576	-\$735	Infinite
Aging Eye/Low-vision:1 Stairwell	18	\$302	-\$360	Infinite
Atria < 20 ft tall (used to be atria concourse)	389	\$9,948	\$1,289	7.72
Atria 20 to < 40 ft (used to be atria concourse)	387	\$9,900	\$9,705	1.02
Atria > 40 ft (used to be atria concourse)	-530	-\$13,542	\$32,035	Increased Energy
Audience Seating Area	141	\$3,805	-\$832	Infinite
Auditorium Area	875	\$23,677	-\$5,174	Infinite
Auto Repair / Maintenance Area	1,355	\$27,476	-\$12,078	Infinite
Barber, Beauty Salon and Spa Area	343	\$8,773	-\$5,563	Infinite
Civic Meeting Room	37	\$1,014	-\$943	Infinite
Concourse (used to be atria concourse)	394	\$10,647	-\$1,929	Infinite
Convention Center: Ballroom (used to be multipurpose)	697	\$18,853	-\$29,392	Infinite
Convention: Exhibit Space (used to be multipurpose)	2,834	\$76,676	-\$59,336	Infinite
Convention: Meeting Room (used to be multipurpose)	-92	-\$2,478	\$2,440	Increased Energy
Control room (new)	56	\$1,135	-\$794	Infinite

Primary Function Areas	Wattage Reduction (W)	30 Year PV Savings LSC (2029 PV\$)	Incremental Cost Including Replacements and Negative Residual Cost (\$)	BCR ratio
Copy Room	8	\$131	-\$112	Infinite
Corridor Area	13	\$216	-\$226	Infinite
Data center: Computer room (new) <sup>a</sup>	29	\$585	-\$650	Infinite
Dining Area: Bar/Lounge and Fine Dining	317	\$12,426	-\$9,193	Infinite
Dining Area: Cafeteria/Fast Food	87	\$3,422	-\$2,128	Infinite
Dining Area: Family and Leisure	63	\$2,462	-\$1,841	Infinite
Education/Business: Classroom, Training,	29	\$466	-\$396	Infinite
Educational, civic: Multipurpose room (art, music etc.) <sup>a</sup>	125	\$1,991	-\$2,314	Infinite
Electrical, Mechanical, Telephone Rooms	35	\$419	-\$230	Infinite
Exercise/Fitness Center and Gymnasium Area	-187	-\$4,791	\$640	Increased Energy
Financial Transaction Area	81	\$1,378	-\$1,451	Infinite
Healthcare: Corridor (new) <sup>a</sup>	-432	-\$9,329	\$6,512	Increased Energy
Healthcare: Exam/Treatment Room	24	\$519	-\$485	Infinite
Healthcare: Imaging Room	14	\$308	-\$311	Infinite
Healthcare: Medical Supply Room	108	\$2,325	-\$1,825	Infinite
Healthcare: Nursery	87	\$1,869	-\$1,602	Infinite
Healthcare: Nurse's Station	18	\$380	-\$283	Infinite
Healthcare: Operating Room	319	\$6,895	-\$5,413	Infinite
Healthcare: Patient Room - Critical care (new) <sup>a</sup>	-24	-\$522	-\$2,176	Increased Energy
Healthcare: Patient Room - General	13	\$271	-\$596	Infinite
Healthcare: Physical Therapy Room	59	\$1,279	-\$1,201	Infinite
Healthcare: Recovery Room	43	\$939	-\$674	Infinite
Kitchen/Food Preparation Area	39	\$1,523	-\$171	Infinite

Primary Function Areas	Wattage Reduction (W)	30 Year PV Savings LSC (2029 PV\$)	Incremental Cost Including Replacements and Negative Residual Cost (\$)	BCR ratio
Laboratory: Scientific and Teaching	41	\$1,190	-\$150	Infinite
Laundry Area	-26	-\$660	\$506	Increased Energy
Library : Reading Area	58	\$996	-\$851	Infinite
Library : Stacks Area	40	\$687	-\$717	Infinite
Lobby: Main entry	566	\$15,310	-\$11,650	Infinite
Lobby: Performing Arts	156	\$4,227	-\$1,471	Infinite
Locker Room	17	\$431	-\$58	Infinite
Lounge, Breakroom, or Waiting Area	-13	-\$355	-\$564	Increased Energy
Manufacturing & Commercial Work Area: Low Bay	137	\$2,768	-\$1,068	Infinite
Manufacturing & Commercial Work Area: High Bay	828	\$16,795	-\$7,356	Infinite
Manufacturing & Commercial Work Area: Precision	749	\$15,183	-\$4,212	Infinite
Motion picture: Theater area	-160	-\$4,324	\$3,171	Increased Energy
Museum: Exhibition/Display	38	\$1,018	-\$584	Infinite
Museum Area: Restoration Room	334	\$9,028	-\$6,117	Infinite
Office Area: ≤ 250 square feet	10	\$174	-\$192	Infinite
Office Area: > 250 square feet	46	\$784	-\$670	Infinite
Office: Conference Room	122	\$2,081	-\$3,328	Infinite
Parking Garage Area: Parking Zone and Ramps	105	\$5,949	-\$6,990	Infinite
Parking Garage Area: Daylight Adaptation Zones8	176	\$9,970	-\$6,432	Infinite
Performance: Theater area	1,727	\$46,707	-\$26,806	Infinite
Performance: Dressing room <sup>a</sup>	5	\$135	-\$77	Infinite
Pharmacy Area	54	\$1,378	-\$777	Infinite
Retail: Grocery Sales	715	\$18,283	-\$19,437	Infinite

Primary Function Areas	Wattage Reduction (W)	30 Year PV Savings LSC (2029 PV\$)	Incremental Cost Including Replacements and Negative Residual Cost (\$)	BCR ratio
Retail: Merchandise Sales	146	\$3,735	-\$1,480	Infinite
Retail: Fitting Room	10	\$245	-\$154	Infinite
Religious Worship Area	1,486	\$40,201	-\$11,077	Infinite
Restrooms	-23	-\$393	\$190	Increased Energy
Stairwell	10	\$169	-\$82	Infinite
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	2,359	\$60,314	-\$3,255	Infinite
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	1,572	\$40,209	-\$2,170	Infinite
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	279	\$7,137	-\$1,808	Infinite
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	186	\$4,758	-\$1,205	Infinite
Transportation: Baggage Area	162	\$4,373	-\$9,754	Infinite
Transportation: Ticketing Area	174	\$4,717	-\$3,797	Infinite
Transportation: Waiting area (new) <sup>a</sup>	272	\$7,351	-\$5,989	Infinite
Videoconferencing Studio <sup>12</sup>	136	\$2,310	-\$1,973	Infinite
Warehouse: Storage	63	\$766	-\$246	Infinite
Warehouse: Shipping and Handling	57	\$695	-\$236	Infinite

a. New functional area.

The ratio of proposed (2028 design) equipment costs to the reference case (2022 design) equipment costs ranged from 42 percent to 250 percent (where task criteria changed) with an average cost ratio of 92 percent. Thus, achieving 2022 reference case lighting (non-decorative) levels with luminaires that are of the average efficacy found in the 2028 market costs 8 percent less than complying with lower efficacy luminaires that were representative of the market in 2022, but which can still be specified today.

It is worth noting that there are several space types which originally were combined in the building use type “Convention, Conference, Multipurpose and Meeting Area” these now have specific prototypes and design illuminance tailored to their application. These include Convention Center: ballroom, exhibit space, meeting room, Educational and Civic: Multipurpose room (music, art etc.), and Office: conference room. Some of these spaces have greater lighting needs and thus increased energy. Others had lower needs and not only saved energy but also saved on first costs. This same pattern is seen for reallocating the model from a single “concourse/atria” primary function areas to separate function areas for: atria < 20 ft, atria 20 to 40 ft and atria > 40 ft. The shorter atria required less lighting power and saves both energy and first costs whereas the taller atria used more energy and had a higher first cost.

## 6. Statewide Impacts

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### 6.1 Statewide Energy and Energy Cost Savings

The [2028 CASE Methodology Report](#) contains details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

The tables below present the technical potential of the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 17) and alterations (Table 18).

**Table 17: Technical Potential of First Year Statewide Energy and LSC Impacts—New Construction and Additions**

<b>Primary Function Area</b>	<b>Statewide New Construction &amp; Additions (Million sf/yr)</b>	<b>First-year Electricity Savings (GWh/yr)</b>	<b>Peak Electrical Demand Saving (kW)</b>	<b>Source Energy Savings (Million kBtu/yr)</b>	<b>30-Year LSC Savings (Million 2029 PV\$)</b>
<b>Aging Eye/Low-vision:1 Corridor Area</b>	0.04	0.00	0.0	0.0	\$0.00
<b>Aging Eye/Low-vision:1 Dining</b>	0.04	0.00	0.0	0.0	\$0.00
<b>Aging Eye/Low-vision:1 Main Entry Lobby</b>	0.04	0.04	3.6	0.0	\$0.29
<b>Aging Eye/Low-vision:1 Lounge/Waiting Area</b>	0.04	0.00	0.0	0.0	\$0.00
<b>Aging Eye/Low-vision:1 Multipurpose Room</b>	0.04	0.01	0.6	0.0	\$0.05
<b>Aging Eye/Low-vision:1 Religious Worship Area</b>	0.04	0.01	1.2	0.0	\$0.10
<b>Aging Eye/Low-vision:1 Restroom</b>	0.04	0.00	0.0	0.0	\$0.00
<b>Aging Eye/Low-vision:1 Stairwell</b>	0.04	0.00	0.0	0.0	\$0.00
<b>Atria &lt; 20 ft tall</b>	0.35	0.43	35.3	0.4	\$3.11
<b>Atria 20 to &lt; 40 ft</b>	0.17	0.12	10.0	0.1	\$0.89
<b>Atria &gt; 40 ft</b>	0.02	0.00	0.3	0.0	\$0.03
<b>Audience Seating Area</b>	1.63	0.55	53.2	0.7	\$4.41
<b>Auditorium Area</b>	1.04	0.70	68.1	0.9	\$5.64
<b>Auto Repair / Maintenance Area</b>	2.36	0.00	0.0	0.0	\$0.00
<b>Barber, Beauty Salon and Spa Area</b>	0.25	0.09	7.2	0.1	\$0.64
<b>Civic Meeting Room</b>	0.08	0.04	4.1	0.1	\$0.34
<b>Concourse</b>	2.11	1.06	103.1	1.4	\$8.55
<b>Convention Center: Ballroom</b>	0.03	0.02	1.5	0.0	\$0.12
<b>Convention: Exhibit Space</b>	0.16	0.14	13.2	0.2	\$1.10
<b>Convention: Meeting Room</b>	0.16	0.05	5.3	0.1	\$0.44
<b>Control room</b>	0.15	0.04	3.3	0.0	\$0.30

Primary Function Area	Statewide New Construction & Additions (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Copy Room	1.20	0.14	11.6	0.1	\$1.02
Corridor Area	6.07	0.00	0.0	0.0	\$0.00
Data center: Computer room	2.80	0.79	63.2	0.7	\$5.69
Dining Area: Bar/Lounge and Fine Dining	0.28	0.14	13.7	0.2	\$1.11
Dining Area: Cafeteria/Fast Food	2.06	0.49	49.9	0.7	\$4.05
Dining Area: Family and Leisure	0.65	0.15	15.6	0.2	\$1.27
Education/Business: Classroom, Training, Educational, civic: Multipurpose room (art, music etc.)	7.01	0.74	65.7	0.8	\$5.60
Educational, civic: Multipurpose room (art, music etc.)	1.01	0.21	18.9	0.2	\$1.61
Electrical, Mechanical, Telephone Rooms	3.28	0.00	0.0	0.0	\$0.00
Exercise/Fitness Center and Gymnasium Area	2.69	(0.47)	(39.0)	(0.5)	(\$3.44)
Financial Transaction Area	1.46	0.41	33.8	0.4	\$2.98
Healthcare: Corridor	0.40	(0.17)	(14.8)	(0.2)	(\$1.30)
Healthcare: Exam/Treatment Room	1.93	0.28	23.8	0.3	\$2.08
Healthcare: Imaging Room	0.10	0.00	0.0	0.0	\$0.00
Healthcare: Medical Supply Room	0.07	0.01	0.9	0.0	\$0.07
Healthcare: Nursery	0.08	0.00	0.0	0.0	\$0.00
Healthcare: Nurse's Station	0.13	0.04	3.2	0.0	\$0.28
Healthcare: Operating Room	0.20	0.00	0.0	0.0	\$0.00
Healthcare: Patient Room - Critical care	0.11	(0.06)	(5.4)	(0.1)	(\$0.48)
Healthcare: Patient Room - General	0.28	0.00	0.0	0.0	\$0.00
Healthcare: Physical Therapy Room	0.16	0.05	3.9	0.0	\$0.34
Healthcare: Recovery Room	0.08	(0.03)	(3.0)	(0.0)	(\$0.26)
Kitchen/Food Preparation Area	2.24	1.07	108.1	1.5	\$8.79

Primary Function Area	Statewide New Construction & Additions (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Laboratory: Scientific and Teaching	0.52	0.20	18.3	0.2	\$1.51
Laundry Area	0.39	0.03	2.3	0.0	\$0.20
Library : Reading Area	0.29	0.07	5.4	0.1	\$0.48
Library : Stacks Area	0.24	0.05	4.4	0.1	\$0.38
Lobby: Main entry	4.44	2.99	289.7	3.9	\$24.01
Lobby: Performing Arts	0.28	0.19	18.5	0.2	\$1.53
Locker Room	0.99	0.17	14.3	0.2	\$1.27
Lounge, Breakroom, or Waiting Area	2.85	0.96	93.0	1.3	\$7.71
Manufacturing & Commercial Work Area: Low Bay	3.81	0.00	0.0	0.0	\$0.00
Manufacturing & Commercial Work Area: High Bay	1.43	0.00	0.0	0.0	\$0.00
Manufacturing & Commercial Work Area: Precision	0.29	0.04	3.2	0.0	\$0.29
Motion picture: Theater area	0.50	0.00	0.0	0.0	\$0.00
Museum: Exhibition/Display	0.22	0.15	14.1	0.2	\$1.17
Museum Area: Restoration Room	0.04	0.01	0.6	0.0	\$0.05
Office Area: ≤ 250 square feet	11.93	1.39	115.6	1.4	\$10.17
Office Area: > 250 square feet	13.32	1.55	128.9	1.6	\$11.35
Office: Conference Room	1.50	0.52	43.5	0.5	\$3.83
Parking Garage Area: Parking Zone and Ramps	18.49	2.50	269.8	3.8	\$21.00
Parking Garage Area: Daylight Adaptation Zones8	0.82	1.21	131.2	1.9	\$10.21
Performance: Theater area	0.50	0.25	24.6	0.3	\$2.04
Performance: Dressing room	0.03	0.01	0.5	0.0	\$0.04
Pharmacy Area	0.26	0.00	0.0	0.0	\$0.00
Retail: Grocery Sales	0.56	1.18	96.8	1.2	\$8.55

Primary Function Area	Statewide New Construction & Additions (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
<b>Retail: Merchandise Sales</b>	16.63	8.77	722.7	8.6	\$63.81
<b>Retail: Fitting Room</b>	0.41	0.15	12.0	0.1	\$1.06
<b>Religious Worship Area</b>	0.99	0.67	65.0	0.9	\$5.39
<b>Restrooms</b>	4.26	0.00	0.0	0.0	\$0.00
<b>Stairwell</b>	1.86	0.00	0.0	0.0	\$0.00
<b>Sports Arena – Playing Area: Class I Facility<sup>11</sup></b>	0.07	0.00	0.0	0.0	\$0.00
<b>Sports Arena – Playing Area: Class II Facility<sup>11</sup></b>	0.00	0.00	0.0	0.0	\$0.00
<b>Sports Arena – Playing Area: Class III Facility<sup>11</sup></b>	0.00	0.00	0.0	0.0	\$0.00
<b>Sports Arena – Playing Area: Class IV Facility<sup>11</sup></b>	0.00	0.00	0.0	0.0	\$0.00
<b>Transportation: Baggage Area</b>	0.02	0.00	0.0	0.0	\$0.00
<b>Transportation: Ticketing Area</b>	0.04	0.01	0.7	0.0	\$0.05
<b>Transportation: Waiting area</b>	0.08	0.05	5.3	0.1	\$0.44
<b>Videoconferencing Studio<sup>12</sup></b>	0.35	0.16	13.5	0.2	\$1.18
<b>Warehouse: Storage</b>	17.35	0.00	0.0	0.0	\$0.00
<b>Warehouse: Shipping and Handling</b>	4.00	0.00	0.0	0.0	\$0.00
<b>Totals</b>	<b>152.84</b>	<b>30.33</b>	<b>2,753.8</b>	<b>35.4</b>	<b>\$233.14</b>

**Table 18: Technical Potential of Statewide Energy and LSC Impacts—Alterations**

Primary Function Area	Statewide Alterations (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Aging Eye/Low-vision:1 Corridor Area	0.14	0.00	0.0	0.0	\$0.00
Aging Eye/Low-vision:1 Dining	0.14	0.00	0.0	0.0	\$0.00
Aging Eye/Low-vision:1 Main Entry Lobby	0.14	0.14	13.4	0.2	\$1.11
Aging Eye/Low-vision:1 Lounge/Waiting Area	0.14	0.00	0.0	0.0	\$0.00
Aging Eye/Low-vision:1 Multipurpose Room	0.14	0.02	2.2	0.0	\$0.19
Aging Eye/Low-vision:1 Religious Worship Area	0.14	0.05	4.5	0.1	\$0.37
Aging Eye/Low-vision:1 Restroom	0.14	0.00	0.0	0.0	\$0.00
Aging Eye/Low-vision:1 Stairwell	0.14	0.00	0.0	0.0	\$0.00
Atria < 20 ft tall	1.31	1.61	133.0	1.6	\$11.74
Atria 20 to < 40 ft	0.69	0.49	40.1	0.5	\$3.54
Atria > 40 ft	0.09	0.02	1.3	0.0	\$0.12
Audience Seating Area	6.59	2.22	215.0	2.9	\$17.81
Auditorium Area	4.16	2.80	271.3	3.7	\$22.49
Auto Repair / Maintenance Area	14.14	0.00	0.0	0.0	\$0.00
Barber, Beauty Salon and Spa Area	1.39	0.49	40.1	0.5	\$3.54
Civic Meeting Room	0.67	0.34	32.7	0.4	\$2.71
Concourse	13.40	6.77	656.1	8.9	\$54.37
Convention Center: Ballroom	0.12	0.06	6.0	0.1	\$0.50
Convention: Exhibit Space	0.66	0.56	54.1	0.7	\$4.48
Convention: Meeting Room	0.66	0.22	21.6	0.3	\$1.79
Control room	0.37	0.10	8.3	0.1	\$0.75
Copy Room	4.27	0.50	41.3	0.5	\$3.64

Primary Function Area	Statewide Alterations (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Corridor Area	25.11	0.00	0.0	0.0	\$0.00
Data center: Computer room	9.62	2.72	216.7	2.5	\$19.50
Dining Area: Bar/Lounge and Fine Dining	1.01	0.49	49.0	0.7	\$3.98
Dining Area: Cafeteria/Fast Food	8.58	2.05	207.3	2.9	\$16.85
Dining Area: Family and Leisure	2.26	0.54	54.5	0.8	\$4.43
Education/Business: Classroom, Training,	27.38	2.89	256.7	3.2	\$21.89
Educational, civic: Multipurpose room (art, music etc.)	3.83	0.81	71.8	0.9	\$6.12
Electrical, Mechanical, Telephone Rooms	13.52	0.00	0.0	0.0	\$0.00
Exercise/Fitness Center and Gymnasium Area	10.25	(1.80)	(148.5)	(1.8)	(\$13.11)
Financial Transaction Area	5.04	1.41	117.2	1.4	\$10.31
Healthcare: Corridor	1.70	(0.74)	(62.8)	(0.8)	(\$5.51)
Healthcare: Exam/Treatment Room	8.24	1.19	101.4	1.3	\$8.90
Healthcare: Imaging Room	0.42	0.00	0.0	0.0	\$0.00
Healthcare: Medical Supply Room	0.30	0.04	3.6	0.0	\$0.32
Healthcare: Nursery	0.34	0.00	0.0	0.0	\$0.00
Healthcare: Nurse's Station	0.55	0.16	13.5	0.2	\$1.19
Healthcare: Operating Room	0.85	0.00	0.0	0.0	\$0.00
Healthcare: Patient Room - Critical care	0.47	(0.27)	(23.0)	(0.3)	(\$2.02)
Healthcare: Patient Room - General	1.19	0.00	0.0	0.0	\$0.00
Healthcare: Physical Therapy Room	0.67	0.20	16.7	0.2	\$1.47
Healthcare: Recovery Room	0.34	(0.15)	(12.6)	(0.2)	(\$1.10)
Kitchen/Food Preparation Area	9.30	4.45	449.2	6.2	\$36.51
Laboratory: Scientific and Teaching	2.48	0.94	86.9	1.1	\$7.19

Primary Function Area	Statewide Alterations (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Laundry Area	2.31	0.16	13.4	0.2	\$1.18
Library : Reading Area	1.08	0.24	20.3	0.2	\$1.79
Library : Stacks Area	0.90	0.20	16.3	0.2	\$1.43
Lobby: Main entry	18.11	12.20	1,182.4	16.0	\$97.99
Lobby: Performing Arts	1.15	0.78	75.2	1.0	\$6.24
Locker Room	4.48	0.79	64.9	0.8	\$5.73
Lounge, Breakroom, or Waiting Area	13.75	4.63	449.0	6.1	\$37.21
Manufacturing & Commercial Work Area: Low Bay	27.30	0.00	0.0	0.0	\$0.00
Manufacturing & Commercial Work Area: High Bay	13.00	0.00	0.0	0.0	\$0.00
Manufacturing & Commercial Work Area: Precision	2.60	0.37	29.3	0.3	\$2.64
Motion picture: Theater area	2.05	0.00	0.0	0.0	\$0.00
Museum: Exhibition/Display	0.89	0.60	58.3	0.8	\$4.83
Museum Area: Restoration Room	0.15	0.03	2.5	0.0	\$0.21
Office Area: ≤ 250 square feet	47.56	5.52	460.4	5.6	\$40.53
Office Area: > 250 square feet	47.58	5.52	460.7	5.6	\$40.55
Office: Conference Room	5.27	1.84	153.2	1.9	\$13.48
Parking Garage Area: Parking Zone and Ramps	38.02	5.14	554.9	7.9	\$43.19
Parking Garage Area: Daylight Adaptation Zones8	1.68	2.50	269.8	3.8	\$21.00
Performance: Theater area	2.04	1.03	99.7	1.3	\$8.26
Performance: Dressing room	0.12	0.02	2.0	0.0	\$0.17
Pharmacy Area	1.43	0.00	0.0	0.0	\$0.00
Retail: Grocery Sales	3.42	7.21	593.9	7.1	\$52.44
Retail: Merchandise Sales	110.66	58.35	4,807.6	57.4	\$424.48

Primary Function Area	Statewide Alterations (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
Retail: Fitting Room	2.72	0.96	78.8	0.9	\$6.96
Religious Worship Area	4.11	2.77	268.4	3.6	\$22.24
Restrooms	18.63	0.00	0.0	0.0	\$0.00
Stairwell	7.66	0.00	0.0	0.0	\$0.00
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	0.29	0.00	0.0	0.0	\$0.00
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	0.00	0.00	0.0	0.0	\$0.00
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	0.00	0.00	0.0	0.0	\$0.00
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	0.00	0.00	0.0	0.0	\$0.00
Transportation: Baggage Area	0.08	0.00	0.0	0.0	\$0.00
Transportation: Ticketing Area	0.17	0.03	2.7	0.0	\$0.22
Transportation: Waiting area	0.33	0.22	21.6	0.3	\$1.79
Videoconferencing Studio <sup>12</sup>	1.26	0.59	48.8	0.6	\$4.30
Warehouse: Storage	83.02	0.00	0.0	0.0	\$0.00
Warehouse: Shipping and Handling	19.15	0.00	0.0	0.0	\$0.00
<b>Totals</b>	<b>666.07</b>	<b>142.97</b>	<b>12,673.2</b>	<b>160.4</b>	<b>\$1,084.91</b>

Table 19 summarizes the technical potential of first-year statewide savings from new construction, additions, and alterations.

**Table 19: Technical Potential of First-Year Statewide Energy and LSC Impacts—New Construction, Additions, and Alterations**

Construction Type	Annual Construction (Million sf/y)	First-year Electricity Savings (GWh/y)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/y)	30-Year LSC Savings (Million 2029 PV\$)
<b>New Construction</b>	153	30.3	2,754	35	\$233
<b>Additions and Alterations</b>	666	143.0	12,673	160	\$1,085
<b>Total</b>	<b>819</b>	<b>173.3</b>	<b>15,427</b>	<b>196</b>	<b>\$1,318</b>

After applying the statewide market probability adjustment factors described in Appendix C, the technical potential savings are derated to 58 percent for new construction and derated to 43 percent for alterations. Table 20 summarizes the market adjusted first-year statewide savings from new construction, additions, and alterations.

**Table 20: Market Adjusted Statewide Energy and LSC Impacts—New Construction, Additions, and Alterations**

Construction Type	Annual Construction (Million sf/yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	Source Energy Savings (Million kBtu/yr)	30-Year LSC Savings (Million 2029 PV\$)
<b>New Construction</b>	88.6	17.6	1,597	20.5	\$135
<b>Additions and Alterations</b>	286.4	61.5	5,449	69.0	\$467
<b>Total</b>	<b>375.1</b>	<b>79.1</b>	<b>7,047</b>	<b>89.5</b>	<b>\$602</b>

## 6.2 Statewide Greenhouse Gas Emissions Reductions

Table 21 presents the market adjusted estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 5,427 metric tons of carbon dioxide equivalent (CO<sub>2</sub>e) emissions per year. These reductions for this first year, along with their associated monetary value, at \$162.45 per metric ton, were calculated using hourly annualized GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC’s 2028 Metrics Report. See the [2028 CASE Methodology Report](#) for additional information. On average the statewide total GHG emission reduction is 60 metric tons CO<sub>2</sub> equivalent per GWh

saved from the LPD reduction. This is about two-thirds of the 90 tons per GWh from a 24/7 continuous load reduction would be saving. The lower tons per GWh reflects that many of the loads reduced are during daytime, which has higher levels of renewable generation and less carbon emissions per unit of electricity.

**Table 21: Market Adjusted First-Year Statewide GHG Emissions Impacts**

Construction Type	Electricity Savings (GWh/y)	Reduced GHG Emissions (Metric Ton CO <sub>2</sub> e/y)	Annualized Cost GHG Reduction (\$/y)
<b>New Construction</b>	17.6	1,087	\$176,626
<b>Additions and Alterations</b>	61.5	3,642	\$591,570
<b>Total</b>	<b>79.1</b>	<b>4,729</b>	<b>\$768,197</b>

### 6.3 Statewide Water Use Impacts

The proposed code change would not result in water use impacts.

### 6.4 Statewide Material Impacts

Statewide material impacts were evaluated for two measures:

- Changes in LPD requirements, and
- Changes in equipment replacement practices associated with the proposed code language.

#### LPD Changes

The Statewide CASE Team evaluated whether reduced LPD allowances would result in fewer luminaires installed per square foot. While lower LPDs can theoretically reduce fixture counts, the analysis assumes that lighting design requirements, including illuminance levels and uniformity constraints, limit the extent to which fixture counts can be reduced across most space types.

As a result, the Statewide CASE Team does not assume a material reduction pathway associated with fewer installed luminaires due solely to LPD changes. Instead, LPD reductions are assumed to be achieved primarily through improvements in luminaire efficacy and lighting design optimization rather than reductions in fixture quantity.

Therefore, material impacts associated with LPD changes are assumed to be negligible.

## Lamp Replacement and Luminaire Retention

The primary material impact reduction is the avoidance of full luminaire replacement during alterations. The proposed code change clarifies wattage determination for luminaires and supports the continued use of existing luminaires when linear LED lamp replacements are installed. This approach further supports compliance through lamp replacement rather than requiring full luminaire replacement in applicable scenarios.

As a result, fewer new luminaires are manufactured and installed, reducing demand for associated materials. Consistent with U.S. Department of Energy (DOE) guidance on LED retrofit strategies in their *Upgrading Troffer Luminaires to LED* fact sheet, lamp replacement and retrofit approaches can retain existing luminaire housings when they remain in good condition, reducing material waste compared to full luminaire replacement.

## Material Composition and Estimation Approach

The Statewide CASE Team developed representative material composition values for luminaires using the same approach and values presented in the 2022 Nonresidential Indoor Lighting CASE Report. These values were originally derived from a study on various lighting technologies (Lim, et al. 2013), which quantified the metal content of LED lighting products, including aluminum, copper, and lead associated with lamps and electronic components. Because the study primarily characterizes lamp-level and electronic materials, the Statewide CASE Team supplemented this data with manufacturer environmental product declarations (EPDs) to account for additional luminaire components, including housings, heat sinks, optics, and other structural materials.

Manufacturer EPDs and product specification sheets for representative indoor luminaires indicate that luminaire housings are predominantly steel or aluminum, while optical components are typically composed of polycarbonate (PC), polymethyl methacrylate (PMMA/acrylic), or polystyrene materials.

For a representative 2x4 troffer-class luminaire, which is assumed to be the dominant indoor fixture type, total fixture mass is approximately 11.6 pounds per luminaire, including roughly 8.8 pounds of steel, 2.4 pounds of plastic (optics and housing components), and 0.4 pounds of electronic components.

For downlights, the representative material composition was informed by manufacturer EPD data for a commercially available recessed downlight product, which indicates a substantially lower total fixture mass and a different material distribution compared to troffer luminaires. The downlight has an approximate fixture-only weight of 1.9 pounds, with materials primarily composed of polycarbonate and other plastics used in optical components and housings, along with aluminum associated with the heat sink and structural elements. The assumed composition includes approximately 1.05 pounds of

plastic materials, 0.43 pounds of electronics, 0.35 pounds of aluminum, and minimal steel content (approximately 0.03 pounds). Electronic components, including the driver and printed circuit board, represent a smaller portion of total mass, with minor contributions from steel and wiring materials. This distribution reflects the more compact form factor of downlights, where plastics and aluminum dominate and steel content is minimal relative to larger recessed luminaires.

These fixture-level values were converted to per-unit material intensities using typical fixture densities of approximately 0.01 to 0.02 luminaires per square foot where fixture densities were estimated based on typical lighting power densities and representative luminaire wattages (i.e., fixture density  $\approx$  LPD divided by fixture wattage). Using these representative material composition values, the Statewide CASE Team estimated per-unit material impacts and applied them to statewide construction forecasts. Material impacts were calculated based on the change in luminaire counts and replacement practices between the 2025 baseline and the proposed 2028 code.

This results in estimated material intensities of approximately 0.05 to 0.15 pounds per square foot for steel and 0.02 to 0.06 pounds per square foot for plastics, with aluminum present at lower but variable levels depending on fixture type. These ranges are consistent with manufacturer EPD data (e.g., Signify, Acuity, and Cooper Lighting).

## **Material Categories**

Material impacts were calculated for typical material categories found in luminaires, including aluminum, steel, copper, plastics, and trace metals such as lead. Aluminum and steel, which comprise the majority of luminaire mass due to housings and heat sinks, are the primary drivers of total material impacts. Plastics used in lenses, diffusers, and optical components represent a significant secondary material category.

Trace metals, including copper, lead, and other elements identified in Lim, et al. (2013), are present in smaller quantities associated with wiring, drivers, and printed circuit boards. These materials are orders of magnitude smaller in mass compared to structural materials but are included due to their environmental relevance. Consistent with the 2022 CASE Report, the direction of impact for these materials is a decrease. Per-unit values for trace metals are kept low to reflect their limited contribution to total fixture mass and are based on the relative concentrations identified in Lim et al. (2013).

Mercury impacts are assumed to be unchanged, as LED lighting does not contain mercury and the proposal does not increase the use of legacy lighting technologies.

## **Assumptions**

The analysis assumes that luminaires retained under the proposed code have sufficient remaining useful life and that compatible LED lamp replacement options are available. It also assumes that avoided luminaire replacements directly translate to avoided material

production and disposal, thereby reducing both upstream material demand and downstream waste generation.

**Table 22: First-Year Statewide Impacts on Material Use**

Material	Pounds per troffer	Pounds per downlight	Reduced troffer housing/yr	Reduced Downlight Housing/yr	Reduced Statewide Materials Impact (lbs/yr)
Plastic	2.40	1.05	119,320	428,845	735,325
Steel	8.80	0.03	119,320	428,845	1,061,354
Aluminum	0.00	0.35	119,320	428,845	148,392

For more information on the Statewide CASE Team’s methodology and assumptions used to calculate embodied GHG emissions, see the [2028 CASE Methodology Report](#).

## 6.5 Environmental Impacts

The proposed measure is expected to yield positive environmental benefits. By reducing LPDs, the measure lowers energy use, which in turn reduces associated greenhouse gas emissions and upstream generation impacts as documented in Table 21. By encouraging the use of LED replacement lamps, the proposed measure is expected to reduce the number of luminaire housings replaced during alteration projects.

No significant adverse environmental effects are anticipated. The measure does not introduce new materials, hazardous substances, or processes that would increase environmental burden. Any indirect impact, such as changes in product selection or procurement, are expected to be minimal and consistent with current industry practice.

Reasonable alternatives—such as maintaining current LPD values—were considered but would not achieve the same energy-use reductions or emissions benefits. These alternatives offer no environmental advantage and would not meet the purpose of the proposal. For these reasons, the proposed measure represents the most effective approach with the least environmental effect.

## 6.6 Other Non-Energy Impacts

The measure may offer minor benefits related to visual comfort and lighting quality where more efficient luminaires can provide improved distribution or reduced glare, but these effects are expected to vary by project and are not central to the proposal. No adverse effects on comfort, safety, or productivity are anticipated, and the measure is not expected to influence property valuation.

In evaluating equipment efficacy, the models used to inform this proposal made use of an increasing fraction of 90+ CRI (color rendering index) equipment. This reflects market trends that have increased the use of 90+ CRI sources, often as the default color rendition. Increased color rendition assists in color discrimination and visibility.

At this time, the Statewide CASE Team has not identified any additional non-energy impacts that would require consideration in the CEC's California Environmental Quality Act analysis for this rulemaking action.

# 7. Proposed Language Code

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## 7.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents are marked with dark blue underlining (new language) and ~~striketroughs~~ (deletions). New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics*.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.<sup>11</sup> New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “**Section 601.1** [Section 130.0(a)] **General**” contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from the requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

## 7.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to the administrative code.

## 7.3 Energy Code (Title 24, Part 6)

### 7.3.1 Proposed Changes to Definitions Section

#### SECTION 201 [100.1] DEFINITIONS

...

*This definition identifies which applications are prohibited from having their code requirements changed during the 2028 code cycle by AB130. This definition was*

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<sup>11</sup> <https://www.energy.ca.gov/media/12153> for more details see the docket log for docket number 24-BSTD-05 <https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=24-BSTD-05>

*proposed by the CEC to support the implementation of AB130 by the California Building Standards Commission.*

GROUP R OCCUPANCIES AND COMMON OR PUBLIC USE AREAS: Group R occupancy as defined by the California Building Code and spaces ancillary to the occupancy that are not part of individual dwelling or sleeping units and are intended for shared, common, or public use, including areas that support occupant use or building operations.

#### **LIGHTING definitions:**

...

**Decorative (Lighting/Luminaires)** is lighting or luminaires installed only for aesthetic purposes and that does not serve as display lighting, or general lighting. Decorative luminaires are chandeliers, sconces, lanterns, neon or cold cathode, light emitting diodes, theatrical projectors, moving lights, and light color panels, not providing general lighting or task lighting.

**LED Light Engine** is an integrated assembly composed of light emitting diode (LED) packages (components) or LED arrays (modules), as well as an LED driver and other optical, thermal, mechanical, and electrical components. The device is intended to connect directly to the branch circuit through a custom connector compatible with the LED luminaire for which it was designed. It does not use an ANSI standard base.

**LED Retrofit Kit** is a solid state lighting product intended to replace existing light sources and systems, including incandescent and fluorescent light sources, in previously installed luminaires that already comply with safety standards. These kits replace the existing light source and related electrical components and are classified or certified to UL 1598C. They may employ an ANSI standard lamp base, either integral or connected to the retrofit by wire leads. LED retrofit kit does not include self-ballasted lamps as defined by UL1993 such as UL Type A tubular LEDs where the ballast is not bypassed.

**Very Valuable Display Case Lighting** is lighting contained inside of a locked display case containing rare or precious objects, including, but not limited to, jewelry, coins, small art objects, crystal, ceramics, or silver.

#### **NONRESIDENTIAL BUILDING TYPES:**

...

**Commercial and Industrial (C&I) Storage Building** is a building with building floor areas used for storing items.

**Data Center Building** is a specialized building designed to house computer systems, storage devices, and networking equipment, providing the infrastructure needed to store, process, and manage data. *Data center buildings* contain *computer rooms*.

**Retail Store Building** is a building with building floor areas used for the display and sale of merchandise except food.

~~[Healthcare Facility \(inpatient\) is a building used as diagnostic and treatment facilities for inpatient care.](#)~~

~~[Healthcare Facility \(outpatient\) is a building used for outpatient diagnostic care and treatment. Medical offices are included if they use any type of diagnostic medical equipment. Otherwise, they are categorized as an office building.](#)~~

[Service Facility](#) is a building in which some type of service is provided, other than food service or retail sales of goods such as: vehicle service or repair, barber, beauty salon, spa, laundromat, post office, copy center, kennel etc.

...

**NONRESIDENTIAL FUNCTION AREAS** are those areas, rooms, and spaces within Nonresidential Buildings that fall within the following particular definitions, and are defined according to the most specific definition:

[Ballroom](#) is a large room inside a building, typically designed for dancing, formal parties, or social gatherings such as balls, banquets, or ceremonies

*Consider which of two options are desired: either move the definition of computer room into this section or as reference to the definition of computer room in the main definitions section. Both options are shown below*

[Computer room](#) see defined term for *computer room*.

[Computer room](#) is a room within a building whose primary function is to house electronic equipment and that has a design information technology equipment (ITE) equipment power density exceeding 20 watts/ft<sup>2</sup> (215 watts/m<sup>2</sup>) of conditioned floor area.

[Concourse](#) is a large, open space or hall in public buildings, such as convention centers, transportation buildings, or stadiums, designed for crowds to gather and walk through.

**Convention, Conference, Multipurpose and Meeting Area** are rooms or areas that are designed or used for meetings, conventions, or events, and that have neither fixed seating nor fixed staging.

[Dressing room](#) is a backstage space where actors prepare for a performance, such as dressing, applying makeup, and accessing costumes and props.

Exhibit Space is an area specifically designed in a convention venue that is allocated of displaying goods or services or information during an event.

**Healthcare Facilities** may have a room or area as follows:

Patient Room (Critical care) is a specialized hospital space for treating patients with life-threatening illnesses or injuries, featuring advanced technology and continuous monitoring by specialized staff.

**Patient Room (General)** is a room or area that is occupied by one or more patients during a stay in a healthcare facility or hospital that is not a critical care room.

Meeting Room is a designated space within a conference center, or other venue designed for gatherings, presentations, or discussions.

Multipurpose room (educational, civic) is a flexible learning or activity space designed to serve multiple functions throughout the school year, rather than being dedicated to a single use. These spaces can also serve as performance classrooms.

**Server Room** is a room smaller than 500 square feet, within a larger building, in which networking equipment and Information Technology (IT) server equipment is housed, and a minimum of five IT servers are installed in frame racks.

**Server Aisle** is an aisle of racks of Information Technology (IT) server equipment in a Server Room. While networking equipment may also be housed on these racks, it is largely a room to manage server equipment.

## 7.3.2 Proposed Changes to Lighting Classification and Power for New Construction and Alterations

### SECTION 601

#### NONRESIDENTIAL AND HOTEL/MOTEL OCCUPANCIES

#### (NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)

##### 601.1 [Section 130.0(a)] General.

The design and installation of all *lighting* systems and *equipment* in *nonresidential* and *hotel/motel buildings*, *outdoor lighting*, and *electrical power distribution systems* within the scope of Section 100.3 [Section 100.0(a)], shall comply with the applicable provisions of Section 601.

**NOTE:** The requirements of Sections 601.2 through 601.4 apply to *newly constructed buildings*. Section 601.5 applies to *additions* or *alterations* to existing *buildings*.

### **601.1.1 [Section 130.0(b)] Functional areas where compliance with the single-family residential lighting standards is required.**

The design and installation of all *lighting* systems, *lighting* controls and *equipment* in the following functional areas shall comply with the applicable residential *lighting* requirements of Section 602.2.1 [Section 150.0(k)]. In *buildings* containing these functional areas, all other functional areas, such as common areas, shall comply with the applicable nonresidential *lighting* and controlled receptacle requirements.

1. *Outdoor lighting* attached to a *hotel/motel building* and separately controlled from the inside of a guest room.
2. Fire station *dwelling* accommodations.
3. Hotel and motel guest rooms. Additionally, hotel and motel guest rooms shall meet the requirements of Section 601.2.2.3.7 [Section 130.1(c)8] and Section 601.2.6.4.1 [Section 130.5(d)4].

### **601.2 Mandatory requirements (Newly Constructed, Additions, Alterations).**

**Note:** *This section below splits the changed new requirements for nonresidential occupancies in Section 601.2.1.1 and its subsections from the unchanged requirements in Section 601.2.1.2 and its subsections*

#### **601.2.1 [Section 130.0(c)] Luminaire classification, and power.**

*Luminaires* shall be classified, and their wattage shall be determined and labeled **as follows:** in accordance with Section 601.2.1.2 for *Group R occupancies and common or public use areas* and in accordance with Section 601.2.1.1 for all other Nonresidential Occupancies

##### **601.2.1.1 Luminaire classification, and power in Nonresidential Occupancies Not Including *Group R occupancies and common or public use areas*.**

Luminaires shall be classified, and their wattage shall be determined and labeled as follows:

###### 601.2.1.1.1. ~~[Section 130.0(c)1A]~~ Rated wattage label.

The maximum rated wattage or 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.

###### 601.2.1.1.2 ~~[Section 130.0(c)1B]~~ Permanent label.

The factory installed maximum rated wattage or 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 601.2.1.2: 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.~~

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

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

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

**601.2.1.3 601.2.1.1.1 [Section 130.0(c)2] Luminaires with line voltage lamp holders not served by drivers, ballasts or transformers removable line voltage lamps or removable line voltage LED light engines.**

~~For luminaires with line voltage lamp holders not served by drivers, ballasts, or transformers removable line voltage lamps or removable line voltage LED light engines; the wattage of such luminaires shall be determined as the maximum relamping rated wattage as labeled in accordance with Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1]. the labeled maximum wattage of the specified and installed lamps, LED light engines or LED retrofit kits.~~

**601.2.1.5 601.2.1.1.2 [Section 130.0(c)4] Inseparable Solid State Lighting (SSL) luminaires and SSL luminaires with remotely mounted drivers.**

~~For inseparable SSL luminaires and SSL luminaires with remotely mounted drivers, including luminaires where the light output or wattage is field-adjustable, the maximum rated wattage of the SSL luminaire shall be the maximum rated wattage of the luminaire as specified in Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1] when tested in accordance with UL 1598, 2108 or 8750, or IES LM-79. listed on a permanent, preprinted, label installed by the manufacturer or manufacturer's authorized representative, as specified by UL 1574, 1598, 2108 or 8750, as applicable .~~

**601.2.1.4 601.2.1.1.3 [Section 130.0(c)3] Luminaires with permanently installed or remotely installed ballasts.**

~~For luminaires with permanently installed or remotely installed ballasts, the wattage of such luminaires shall be the operating input wattage of the rated lamp/ballast combination published in the ballast manufacturer's catalogs based on independent testing lab reports as specified by UL 1598.~~

**Note:** The following covers UL Type A retrofits

#### **601.2.1.1.4 [new] Luminaires with ballasts powering SSL lighting.**

Wattage of luminaires containing HID or fluorescent ballasts powering solid state lighting shall be the maximum rated wattage of the ballast published in the ballast manufacturer's catalogs when powering the HID or fluorescent light source. When ballast catalog information is not available, the wattage for the applicable HID or fluorescent lamp/ballast combination from Reference Appendix NA8 shall be used.

#### **601.2.1.6 601.2.1.1.5 [Section 130.0(c)5] LED tape lighting.**

For *LED tape lighting* and *LED linear lighting* with *LED tape lighting* components, the maximum rated wattage shall be the sum of the installed length of the *tape lighting* times its rated linear power density in watts per linear feet, or the maximum rated input wattage of the *driver* or power supply providing power to the *lighting* system, with *tape lighting* tested in accordance with *UL 2108 or 8750*, or *IES LM-79*.

#### **601.2.1.7 601.2.1.1.6 [Section 130.0(c)6] Modular lighting systems.**

For modular *lighting* systems that allow the addition or relocation of *luminaires* without altering the wiring of the system, shall be determined as follows:

1. The wattage shall be the greater of:
  - 1.1 30 watts per linear foot of track or plug-in busway; or
  - 1.2 the rated wattage of all of the *luminaires* included in the system, where the *luminaire* wattage is determined as specified in Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1].

~~2. For line-voltage lighting track and plug-in busway served by a track lighting integral current limiter or a dedicated track lighting supplementary overcurrent protection panel, the wattage shall be determined as follows:~~

~~2.1 The volt-ampere rating of the current limiter as specified by UL 1077;  
or~~

~~2.2 The sum of the ampere (A) rating of all of the current protection devices times the branch circuit voltages for track lighting supplementary overcurrent protection panel.~~

- ~~2~~ 3. For other modular *lighting* systems with power supplied by a *driver*, power supply or transformer, including but not limited to low-voltage *lighting* systems, the wattage of the system shall be the maximum rated input wattage of the *driver*, power supply or transformer published in the manufacturer's catalogs, as specified by *UL 2108 or 8750*.

**Exception to Section ~~601.2.1.7~~ 601.2.1.1.6 :** For power-over-Ethernet *lighting* systems, power provided to installed nonlighting devices may be subtracted from the total power rating of the power-over-Ethernet system.

**Note:** The following allows the deemed wattage all lighting system types (not just track lighting) to be the maximum wattage allowed by a current limiter or supplementary overcurrent protection control

#### **601.2.1.1.7 [new] Lighting controlled by current limiters or supplementary overcurrent protection.**

For any lighting system controlled by a current limiter or supplementary overcurrent protection panel, the wattage shall be determined as follows:

1. The volt-ampere rating of the current limiter as specified by UL 1077; or
2. The sum of the ampere (A) rating of all of the current protection devices times the branch circuit voltages for the lighting supplementary overcurrent protection panel.

#### **601.2.1.1.8 [Section 130.0(c)7] All other lighting equipment.**

For all other *lighting equipment* not addressed by Sections 601.2.1.1.1 through 601.2.1.1.7 [Sections 130.0(c)2 through 6], the wattage of the *lighting equipment* shall be the maximum rated wattage of the *lighting equipment*, or operating input wattage of the system, labeled on a permanent, preprinted, factory installed label, as specified by UL 1574, 1598, 2108 or 8750, as applicable, or published in manufacturer's catalogs, based on independent testing lab reports as specified by *UL 1574, 1598, 2108 or 8750*, or *IES LM-79*.

**Note:** this section is unchanged from the requirements in the restructured 2025 Title 24 part 6 energy code outside of numbering

#### **601.2.1.2 Group R occupancies and common or public use areas: classification, and power.**

Luminaires shall be classified, and their wattage shall be determined and labeled as follows:

##### **601.2.1.2.1 601.2.1.2.1 [Section 130.0(c)1A] Rated wattage label.**

The maximum rated wattage or 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.

##### **601.2.1.2.2 601.2.1.2.2 [Section 130.0(c)1B] Permanent label.**

The factory-installed maximum rated wattage or 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 601.2.1.2 601.2.1.2.2:** 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.

1. High-intensity discharge *luminaires*, having an integral electronic ballast, with a maximum relamping rated wattage of 150 watts.
2. Low-voltage *luminaires* (except *low voltage* track systems),  $\leq 24$  volts, with a maximum relamping rated wattage of 50 watts.
3. Compact fluorescent *luminaires*, having an integral electronic ballast, with a maximum relamping rated wattage of 42 watts.

**601.2.1.3 601.2.1.2.3 [Section 130.0(c)2] Luminaires with line voltage lamp holders not served by drivers, ballasts or transformers.**

For *luminaires* with line voltage *lamp* holders not served by *drivers*, ballasts, or transformers; the wattage of such *luminaires* shall be determined as the maximum relamping rated wattage as labeled in accordance with Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1].

**601.2.1.4 601.2.1.2.4 [Section 130.0(c)3] Luminaires with permanently installed or remotely installed ballasts.**

For *luminaires* with permanently installed or remotely installed ballasts, the wattage of such *luminaires* shall be the operating input wattage of the rated *lamp*/ballast combination published in the ballast manufacturer's catalogs based on independent testing lab reports as specified by *UL 1598*.

**601.2.1.5 601.2.1.2.5 [Section 130.0(c)4] Solid State Lighting (SSL).**

For inseparable *SSL luminaires* and *SSL luminaires* with remotely mounted *drivers*, the maximum rated wattage shall be the maximum rated input wattage of the *SSL luminaire* as specified in Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1] when tested in accordance with *UL 1598, 2108 or 8750*, or *IES LM-79*.

**601.2.1.6 601.2.1.1.6 [Section 130.0(c)5] LED tape lighting.**

For *LED tape lighting* and *LED linear lighting* with *LED tape lighting* components, the maximum rated wattage shall be the sum of the installed length of the *tape lighting* times its rated linear power density in watts per linear feet, or the maximum rated input wattage of the *driver* or power supply providing power to the *lighting* system, with *tape lighting* tested in accordance with *UL 2108 or 8750*, or *IES LM-79*.

**601.2.1.7 601.2.1.2.7 [Section 130.0(c)6] Modular lighting systems.**

For modular *lighting* systems that allow the addition or relocation of *luminaires* without altering the wiring of the system, shall be determined as follows:

1. The wattage shall be the greater of:
  - 1.1 30 watts per linear foot of track or plug-in busway; or
  - 1.2 the rated wattage of all of the *luminaires* included in the system, where the *luminaire* wattage is determined as specified in Sections 601.2.1.1 and 601.2.1.2 [Section 130.0(c)1].
2. For line-voltage lighting track and plug-in busway served by a track lighting integral current limiter or a dedicated track lighting supplementary overcurrent protection panel, the wattage shall be determined as follows:
  - 2.1 The volt-ampere rating of the current limiter as specified by UL 1077; or
  - 2.2 The sum of the ampere (A) rating of all of the current protection devices times the branch circuit voltages for *track lighting supplementary overcurrent protection panel*.
3. For other modular *lighting* systems with power supplied by a *driver*, power supply or transformer, including but not limited to low-voltage *lighting* systems, the wattage of the system shall be the maximum rated input wattage of the *driver*, power supply or transformer published in the manufacturer's catalogs, as specified by *UL 2108 or 8750*.

**Exception to Section 601.2.1.7 601.2.1.2.7:** For power-over-Ethernet *lighting* systems, power provided to installed nonlighting devices may be subtracted from the total power rating of the power-over-Ethernet system.

**601.2.1.8 601.2.1.2.8 [Section 130.0(c)7] All other lighting equipment.**

For all other *lighting equipment* not addressed by Sections 601.2.1.3 601.2.1.2.3 through 601.2.1.7 601.2.1.2.7 [Sections 130.0(c)2 through 6], the wattage of the *lighting equipment* shall be the maximum rated wattage of the *lighting equipment*, or operating input wattage of the system, labeled in accordance with Sections 601.2.1.4 601.2.1.2.1 and 601.2.1.2 601.2.1.2.2 [Section 130.0(c)1], or published in manufacturer's catalogs, based on independent testing lab reports as specified by *UL 1574, 1598, 2108 or 8750*, or *IES LM-79*.

**Note:** *The following change to the alterations section streamlines the use of one-to-one luminaire alterations in nonresidential buildings by limiting its use to post alteration total wattages of no greater than 3,000 Watts which simplifies the use of the Type B and Type C alterations as compared to specifying the total floor area. When floor area is defines the scope, this may require the expense of drawing plans to document the coverage area.*

## 601.5.2.2 [Section 141.0(b)2] Prescriptive requirements (Alterations).

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### 601.5.2.2.4 [Section 141.0(b)2I] Altered indoor lighting systems.

*Alterations* to indoor *lighting* systems that include 10% or more of the *luminaires* serving an *enclosed space* shall meet the requirements of 1, 2, ~~or~~ 3, or 4 below:

**1. Comply with Section 601.3.1 and Table 601.5-A.** The *alteration* shall comply with the indoor lighting power requirements specified in Section 601.3.1 [Section 140.6] and the *lighting* control requirements specified in Table 601.5-A [Table 141.0-F];

**2. 80% of power requirements and Table 601.5-A.** The *alteration* shall not exceed 80% of the indoor lighting power requirements specified in Section 601.3.1 [Section 140.6], and shall comply with the lighting control requirements specified in Table 601.5-A [Table 141.0-F]; or

**3. One-to-one alterations for Nonresidential Buildings not Including Group R occupancies and common or public use areas.** The *alteration* shall be a one-to-one alteration, the total wattage of the altered *luminaires* shall be no greater than 3,000 watts per alteration project, and the total wattage of the altered *luminaires* shall be at least 40% lower compared to their total pre-alteration wattage, and the *alteration* shall comply with the lighting control requirements specified in Table 601.5-A [Table 141.0-F].

**3. 4. One-for-one luminaire alterations One-to-one alterations for Group R occupancies and common use or public use areas** . The *alteration* shall be a ~~one-for-one luminaire alteration~~ one-to-one alteration within a *building* or *tenant space* of 5,000 square feet or less, the total wattage of the altered *luminaires* shall be at least 40% lower compared to their total pre-alteration wattage, and the *alteration* shall comply with the lighting control requirements specified in Table 601.5-A [Table 141.0-F].

*Alterations* to indoor *lighting* systems shall not prevent the operation of existing, unaltered controls, and shall not alter controls to remove functions specified in Section 601.2.2 [Section 130.1].

*Alterations* to *lighting* wiring are considered *alterations* to the *lighting* system. *Alterations* to indoor *lighting* systems are not required to separate existing general, floor, wall, display, or *decorative lighting* on shared circuits or controls. New or completely replaced lighting circuits shall comply with the control separation requirements of Section 601.2.2.1.3 [Section 130.1(a)3].

**Exception 1 to Section 601.5.2.2.4:** *Alteration of portable luminaires, luminaires affixed to moveable partitions, or lighting excluded as specified in Section 601.3.1.1.3 [Section 140.6(a)3].*

**Exception 2 to Section 601.5.2.2.4:** *Any enclosed space with only one luminaire.*

**Exception 3 to Section 601.5.2.2.4:** *Any alteration that would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.*

**Exception 4 to Section 601.5.2.2.4:** *Acceptance testing requirements of Section 601.2.5 [Section 130.4] are not required for alterations where lighting controls are added to control 20 or fewer luminaires.*

**Exception 5 to Section 601.5.2.2.4:** *Any alteration limited to adding lighting controls or replacing lamps, ballasts, or drivers.*

**Exception 6 to Section 601.5.2.2.4:** *One-for-one luminaire alteration of up to 50 luminaires either per complete floor of the building or per complete tenant space, per annum.*

**TABLE 601.5-A [Table 141.0-F]—CONTROL REQUIREMENTS FOR INDOOR LIGHTING SYSTEM ALTERATIONS**

Control Specifications	Coded Section	Projects complying with Section 601.5.2.2.4 item 1	Projects complying with 601.5.2.2.4. item 2, <del>or 3, or 4</del>
Manual Area Controls	601.2.2.1.1 [130.1(a)1]	Required	Required
Manual Area Controls	601.2.2.1.2 [130.1(a)2]	Required	Required
Manual Area Controls	601.2.2.1.3 [130.1(a)3]	Only required for new or completely replaced circuits	Only required for new or completely replaced circuits
Multilevel Controls	601.2.2.2 [130.1(b)]	Required	Not Required
Automatic Shut-Off Controls	601.2.2.3.1 [130.1(c)1]	Required	Required
Automatic Shut-Off Controls	601.2.2.3.2 [130.1(c)2]	Required	Required

Control Specifications	Coded Section	Projects complying with Section 601.5.2.2.4 item 1	Projects complying with 601.5.2.2.4. item 2, <del>or 3,</del> or 4
Automatic Shut-Off Controls	601.2.2.3.3 <i>[130.1(c)3]</i>	Required	Required
Automatic Shut-Off Controls	601.2.2.3.4 <i>[130.1(c)4]</i>	Required	Required
Automatic Shut-Off Controls	601.2.2.3.5 <i>[130.1(c)5]</i>	Required	Required
Automatic Shut-Off Controls	601.2.2.3.6 <i>[130.1(c)6]</i>	Required	Required; except for 601.2.2.3.6.4 <i>[130.1(c)6D]</i>
Automatic Shut-Off Controls	601.2.2.3.7 <i>[130.1(c)8]</i>	Required	Required
Daylight Responsive Controls	601.2.2.4 <i>[130.1(d)]</i>	Required	Not Required
Demand Responsive Controls	600.4.1 <i>[110.12(a)]</i> and 600.4.2 <i>[110.12(c)]</i>	Required	Not Required

...

### 7.3.3 Proposed Changes to Lighting Power Density (LPD)

**Note to reviewers:** State Law AB130 prohibits modifications to residential dwellings until 2031. This has been interpreted to include GROUP R OCCUPANCIES AND COMMON OR PUBLIC USE AREAS. This is newly defined in the definition section as follows:

[GROUP R OCCUPANCIES AND COMMON OR PUBLIC USE AREAS. Group R occupancy as defined by the California Building Code and spaces ancillary to the occupancy that are not part of individual dwelling or sleeping units and are intended for shared, common, or public use, including areas that support occupant use or building operations.](#)

There is only one Complete Building Method table, Table 601.3-B [Table 140.6-B], as this table does not include residential or hotel/motel building types.

However, there are two area category method tables:

1. Table 601.3-C1 [Table 140.6-C1] A revised Lighting Power Density table for nonresidential buildings not including *Group R occupancies and common use areas*. Almost all of the values in this table have been updated and the table is presented in a simpler format
2. Table 601.3-C2 [Table 140.6-C2] An unchanged Lighting Power Density table for *Group R occupancies and common use areas*.

The common use areas of hotel/motel buildings were historically combined with nonresidential requirements as many space types in nonresidential buildings are found in the common areas of hotel/motel buildings such as exercise spaces, offices, lounges, parking garages etc. For the 2028 code cycle, the same application may have different lighting power allowances depending upon the type of building the space is located.

Note that there are two additional building types than can use the simpler (but more stringent) complete building method allowances: data centers and service facilities. Unlike grocery or retail sales service buildings which sell products and are occupancy group M (mercantile) buildings, service buildings are selling services such as hair care, auto repair, tax preparation etc. and are typically in occupancy group B (business) buildings.

601.3 Prescriptive requirements (Newly Constructed).

### **601.3.1 [Section 140.6] Indoor Lighting.**

A building complies with this section if :

~~1. The calculation of adjusted indoor lighting power Adjusted Indoor Lighting Power of all proposed *building* areas combined, calculated under Section 601.3.1.1 is no greater than the calculation of allowed indoor lighting power Allowed Indoor Lighting Power , specific methodologies calculated under in accordance with Section 601.3.1.2 and Section 601.3.1.3; ~~and~~~~

~~2. The calculation of allowed indoor lighting power, general rules comply with Section 601.3.1.2.~~

The prescriptive limits on indoor *lighting* power are the smaller of the adjusted and allowed indoor *lighting* power values determined in accordance with this section.  
~~Item 1 .~~

...

**601.3.1.2 [Section 140.6(b)1 and 2] Calculation of allowed indoor lighting power Allowed Indoor Lighting Power:** general rules.

The ~~allowed indoor lighting power allotment~~ Allowed Indoor Lighting Power allotment for conditioned areas shall be calculated separately from the ~~allowed indoor lighting power allotment~~ Allowed Indoor Lighting Power allotment for unconditioned areas. ~~Each allotment is applicable solely to the area to which it applies, and there~~ There shall be no trade-offs between conditioned and unconditioned area ~~allotments~~ Allowed Indoor Lighting Power.

~~Allowed indoor lighting power allotment~~ Allowed Indoor Lighting Power shall be calculated separately from the ~~allowed outdoor lighting power allotment~~ Allowed Outdoor Lighting Power. ~~Each allotment is applicable solely to the area to which it applies, and there~~ There shall be no trade-offs between ~~the separate indoor~~ Indoor Allowed Lighting Power and ~~Outdoor Allowed Lighting Power~~ Outdoor Allowed Lighting Power ~~allotments~~.

**601.3.1.2.1 [Section 140.6(b)3] General Rules for Calculation methodologies: general lighting.**

The ~~allowed indoor lighting power density allotment for general lighting~~ Allowed Indoor Lighting Power shall be calculated as follows:

1. **Complete Building Method.** The complete building method, as described in Section 601.3.1.3.1 [Section 140.6(c)1], shall be used only for an entire building, except as permitted by Section 601.3.1.3.1 [Section 140.6(c)1]. As described more fully in Section 601.3.1.3.1 [Section 140.6(c)1], and subject to the adjustments listed there, the Allowed Indoor Lighting Power ~~allowed indoor lighting power allotment for general lighting~~ for the entire building shall be calculated as follows:
  - 1.1. For a conditioned building, the product of the square feet of conditioned space of the building times the applicable ~~allotment of watts per square foot~~ Allowed Lighting Power Density described in Table 601.3-B [Table 140.6-B].
  - 1.2. For an unconditioned building, the product of the square foot of unconditioned space of the building times the applicable ~~allotment of watts per square foot~~ Allowed Lighting Power Density described in Table 601.3-B [Table 140.6-B].
2. **Area Category Method.** The area category method, as described in Section 601.3.1.3.2 [Section 140.6(c)2], shall be used for all areas in the building. Under the area category method as described more fully in Section 601.3.1.3.2 [Section 140.6(c)2], separate compliance for the entire conditioned portion and the entire unconditioned portion of the building shall be calculated as follows:
  - 2.1. ~~and subject to the adjustments listed there, the allowed indoor lighting power allotment for general lighting shall be calculated for each area in the building as follows:~~ All installed wattages, general lighting power allowances, and additional lighting power allowances

shall be allocated separately to the conditioned and unconditioned portions of the building with no trade-off allowed between the conditioned and unconditioned compliance calculation.

- 2.2. Compliance for the conditioned portion of the building is achieved if the total Adjusted Installed Lighting Power in the conditioned portions of the building is no greater than the sum of Allowed Lighting Power for all the primary function areas in the conditioned portions of the building.
- 2.3. Compliance for the unconditioned portion of the building is achieved if the total Adjusted Installed Lighting Power in the unconditioned portions of the building is no greater than the sum of Allowed Lighting Power for all the primary function areas in the conditioned portions of the building.
- 2.4. Area Category Method compliance does not require that the adjusted installed lighting in a given lighting space be no greater than Allowed Lighting Power for that space. Instead the building total Adjusted Installed Lighting Power is no greater than the total Adjusted Installed Lighting Power for the given space conditioning categories described in items 2.2 and 2.3.
- 2.5. ~~For conditioned areas, by multiplying the conditioned square feet of the area times the applicable allotment of watts per square foot for the area shown in Table 601.3-C [Table 140.6-C].~~
- 2.6. ~~For unconditioned areas, by multiplying the unconditioned square feet of the area times the applicable allotment of watts per square foot for the area shown in Table 601.3-C [Table 140.6-C].~~
- 2.7. ~~The allowed indoor lighting power allotment for general lighting for one area for which the area category method was used may be increased up to the amount that the allowed indoor lighting power allotment for general lighting for another area using the area category method is decreased, except that such increases and decreases shall not be made between conditioned and unconditioned space.~~

**601.3.1.2.2 [Section 140.6(b)4] Calculation methodologies: lighting other than general lighting.**

~~Allowed Indoor Lighting Power allotments for all *lighting* power allotments other than *general lighting* shall be restricted as follows:~~

~~**Area Category Method.** When using the Area Category Method, allowed Indoor Lighting Power allotments for specialized task work, *precision* commercial and industrial work, white board or chalk board, accent, display *decorative*, *Videoconferencing Studio*, wall display, floor display, task, or very valuable display case, may not be increased as a result of, or otherwise traded off against, decreasing any other allotment.~~

**601.3.1.3 [Section 140.6(c)] Calculation of Allowed Indoor Lighting Power ~~allowed indoor lighting power~~:** specific methodologies.

The ~~allowed indoor lighting power~~ Allowed Indoor Lighting Power for each *building* type, or each primary function area shall be calculated using only one of the methods in Section 601.3.1.3.1 or Section 601.3.1.3.2 below as applicable.

**601.3.1.3.1 [Section 140.6(c)1] Complete Building Method.**

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

1. The Complete Building Method shall be used only for *building* types, as defined in Section 200 [Section 100.1], that are specifically listed in Table 601.3-B [TABLE 140.6-B]. (For example, retail and wholesale stores, *hotel/motel*, and *high-rise residential buildings* shall not use this method.)
2. The Complete Building Method shall be used only on projects involving:
  - 2.1. *Entire buildings* with one type of use *occupancy*; or
  - 2.2. *Mixed occupancy buildings* where one type of use makes up at least 90 percent of the *entire building* (in which case, when applying the Complete Building Method, it shall be assumed that the primary use is 100 percent of the *building*); or
  - 2.3. A *tenant space* where one type of use makes up at least 90 percent of the *entire tenant space* (in which case, when applying the Complete Building Method, it shall be assumed that the primary use is 100 percent of the *tenant space*).
3. The Complete Building Method shall be used only when the applicant is applying for a *lighting* permit and submits plans and specifications for the *entire building* or the *entire tenant space*.
4. Under the Complete Building Method, the ~~allowed indoor lighting power allotment~~ Allowed Indoor Lighting Power is the ~~lighting power density value~~ Lighting Power Density Allowance listed in Table 601.3-B [TABLE 140.6-B] times the floor area of the *entire building*.
5. For *buildings* including a parking *garage* plus another type of use listed in Table 601.3-B [TABLE 140.6-B], the parking *garage* portion of the *building* and other type of use portion of the *building* shall each separately use the Complete Building Method.

**TABLE 601.3-B [TABLE 140.6-B] COMPLETE BUILDING METHOD LIGHTING POWER DENSITY VALUES**

TYPE OF BUILDING	ALLOWED LIGHTING POWER DENSITY ALLOWANCE (WATTS PER SQUARE FOOT)
Assembly Building	<del>0.65</del> <u>0.55</u>
Bank or Financial Institution Building	<del>0.65</del> <u>0.55</u>
<u>Data Center Building</u>	<u>0.40</u>
Grocery Store Building	<del>0.90</del> <u>0.80</u>
Gymnasium Building	<del>0.60</del> <u>0.55</u>
Healthcare Facility	<del>0.90</del> <u>0.80</u>
Industrial/Manufacturing Facility Building	0.60
Library Building	<del>0.70</del> <u>0.65</u>
Motion Picture Theater Building	<del>0.60</del> <u>0.55</u>
Museum Building	<del>0.65</del> <u>0.60</u>
Office Building	<del>0.60</del> <u>0.55</u>
Parking Garage Building	<del>0.13</del> <u>0.11</u>
Performing Arts Theater Building	<del>0.75</del> <u>0.60</u>
Religious Facility Building	<del>0.70</del> <u>0.65</u>
Restaurant Building	<del>0.65</del> <u>0.60</u>
Retail Store Building	<del>0.90</del> <u>0.75</u>
School Building	<del>0.60</del> <u>0.55</u>
Sports Arena Building	<del>0.75</del> <u>0.70</u>
<u>Service Facility (including auto repair)</u>	<u>0.55</u>
All Other Buildings	0.40

**Note:** Table 601.3-C1 [Table 140.6-C1] is a new proposed table for the 2028 code cycle. in Section 2.4.3 of this report to see a comparison of updated Primary Function Areas and Allowed Base LPD values in Table 601.3-C1 [Table 140.6-C1] and 601.3-C2 [Table 140.6-C2].

**601.3.1.3.2 [Section 140.6(c)2A-FD] Area Category Method.**

Under the Area Category Method, the Allowed Indoor Lighting Power is the sum of the Allowed Baseline Lighting Power calculated in accordance with Section 601.3.1.3.2.1 and the Allowed Additional Lighting Power calculated in accordance with Section 601.3.1.3.2.2. Requirements for using the Area Category Method include all of the following:

1. The Area Category Method shall be used only for primary function areas, as defined in Section 200 [Section 100.1], that are *listed* in Table 601.3-C [Table 140.6-C]. For primary function areas not listed, selection of a reasonably equivalent type shall be permitted.
2. Primary function areas in Table 601.3-C [Table 140.6-C] shall not apply to a complete *building*. Each primary function area shall be determined as a separate area.
3. For purposes of compliance with Section 601.3.1.3.2 [Section 140.6(c)2], an “area” shall be defined as all contiguous areas that accommodate or are associated with a single primary function area listed in Table 601.3-C [Table 140.6-C].
4. Where areas are bounded or separated by interior partitions, the floor area occupied by those interior partitions may be included in primary function area.

**601.3.1.3.2.1 [Section 140.6(c)2E&F] Area Category Method – Allowed Baseline Lighting Power**

The Allowed Baseline Lighting Power for the building is the sum of the Allowed Baseline Lighting Power for all areas in the building as follows:

~~1.6.~~ Under the Area Category Method, the ~~allowed indoor lighting power~~ Allowed Baseline Lighting Power for each primary function area is the baseline lighting power density ~~value~~ allowance in Table 601.3-C [Table 140.6-C] times the square feet of the primary function area. ~~The total allowed indoor lighting power density for the building is the sum of all allowed indoor lighting powers densities for all areas in the building.~~

~~2.5.~~ If at the time of permitting for a *newly constructed building*, a tenant is not identified for a multitenant area, a maximum of 0.4 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.

**601.3.1.3.2.2 601.3.1.3.3 [Section 140.6(c)2G] Area Category Method – Allowed Additional Lighting Power lighting power allowances for qualifying lighting systems.**

In addition to the ~~allowed indoor lighting power~~ Allowed Baseline Lighting Power calculated according to ~~Section 601.3.1.3.2 601.3.1.3.2.1 [Sections 140.6(c)2A E through F]~~, the *building* may add the allowed additional lighting power allowances for qualifying lighting systems as specified in the Qualifying Lighting Systems column in Table 601.3-C [Table 140.6-C] under the following conditions:

1. **Qualifying lighting systems.** Only primary function areas having a *lighting* system as specified in the Qualifying Lighting Systems columns in

Table 601.3-C [Table 140.6-C] and in accordance with the corresponding footnote of the Table shall qualify for the additional lighting power allowances; and

2. **Task areas and lighting equipment shown on plans.** 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
3. **Tasks not eligible.** 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
4. **Luminaire types not eligible.** The additional lighting power allowances shall not utilize ~~any type of luminaires~~ that are used for *general lighting* or if there is no general lighting system in the area, the lighting used to illuminate the area in the building; and
5. **Area Category Method only.** The additional lighting power allowances shall not be used when using the Complete Building Method; and
6. **Additional lighting power allowed.** The additional lighting power allowed in each space is the smaller of:
  - 6.1. the lighting power density listed in the “Allowed Additional Lighting LPD” columns in Table 601.3-C [Table 140.6-C], times the square feet of the primary function area, or
  - 6.2. the adjusted indoor lighting power of the applicable *lighting in the space*; and
7. **Videoconferencing studios.** Additional lighting power for videoconferencing as specified in Table 601.3-C [Table 140.6-C] shall be allowed in a *videoconferencing studio*, as defined in Section 200 [Section 100.1], provided the following conditions are met:
  - 7.1. A completed and signed installation certificate is prepared and submitted in accordance with Section 601.2.5.2 [Section 130.4(b)], specifically detailing compliance with the applicable requirements of Section 601.3.1.3.3 [Section 140.6(c)2Gvii]; and
  - 7.2. The *videoconferencing studio* is a room with permanently installed videoconferencing cameras, audio *equipment*, and playback *equipment* for both audio-based and video-based two-way communication between local and remote sites; and
  - 7.3. *General lighting* is switched in accordance with the requirements of Section 601.2.2.2 [Section 130.1(b)]; and
  - 7.4. Wall wash *lighting* is separately switched from the *general lighting* system; and
  - 7.5. All of the *lighting* in the studio, including *general lighting* and additional videoconferencing lighting power allowed by Section 601.3.1.3.3

[Section 140.6(c)2Gvii] is controlled by a *multi-scene programmable control* system (also known as a scene preset control system).

8. **Floor Decorative/displays allowance**. ~~Floor displays shall not qualify for wall display allowances~~ The allowed decorative/display power in a space shall be the lesser of the installed decorative/display lighting in the space and square feet of the primary function area times the decorative/display allowance specified in Table 601.3-C [Table 140.6-C]. Luminaires allocated to the display decorative allowance based on floor area shall not also be allocated to wall decorative/display allowed wattage.
9. **Wall decorative/displays allowance**. Additional allowed power for wall decorative/display lighting in a space is ~~available only for lighting the~~ lesser of the installed decorative/display lighting that is within 10 feet of illuminates walls in the space and the length of walls multiplied by the wall decorative/display allowance in units of Watts per linear feet of wall specified in Table 601.3-C [Table 140.6-C]. ~~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 within two feet of the ceiling or are taller than ten feet and (II) are permanently anchored to the floor. Qualifying wall *lighting* shall:
  - 9.1. Be mounted within 10 feet of walls, the wall having the wall display. ~~When track lighting is used for wall display, and where~~ 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 decorative/display allowance; and
  - 9.2. 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* providing directional display *light*.)
10. **Mounting Ceiling Height**. ~~Mounting Ceiling height shall be the luminaire mounting height measured from the finished floor to the bottom of the luminaire. If luminaires are mounted at different mounting height within the same space, the average mounting height of the ceiling of the primary function area. the luminaires qualified for the additional lighting power allowances in Table 601.3-C [Table 140.6-C] can be used to establish the mounting height of the qualified luminaires for calculations of the additional lighting power allowances of the qualified luminaires.~~
11. **Very valuable display case lighting**. The allowed additional lighting power for very valuable display case lighting, is the lesser of the installed lighting power located within the very valuable display case and the product of the area of the top of the display case and the very valuable

display case interior lighting allowance specified in Table 601.3-C [Table 140.6-C].

**TABLE 601.3-C1 [TABLE 140.6-C1] AREA CATEGORY METHOD—LIGHTING POWER DENSITY VALUES (WATTS/FT<sup>2</sup>) FOR NONRESIDENTIAL BUILDINGS NOT INCLUDING GROUP R OCCUPANCIES AND COMMON USE OR PUBLIC USE AREAS**

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft <sup>2</sup> unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft <sup>2</sup> unless other units)
Aging Eye/Low-vision: <sup>1</sup> Corridor Area	0.60	Decorative/Display	0.30		
Aging Eye/Low-vision: <sup>1</sup> Dining	0.80	Decorative/Display	0.40	Tunable white or dim-to-warm <sup>2</sup>	0.10
Aging Eye/Low-vision: <sup>1</sup> Main Entry Lobby	0.80	Decorative/Display	1.10	Transition Lighting OFF at night <sup>3</sup>	0.80
Aging Eye/Low-vision: <sup>1</sup> Lounge/Waiting Area	0.80	Decorative/Display	0.40	Tunable white or dim-to-warm <sup>2</sup>	0.10
Aging Eye/Low-vision: <sup>1</sup> Multipurpose Room	0.80	Decorative/Display	0.40	Tunable white or dim-to-warm <sup>2</sup>	0.10
Aging Eye/Low-vision: <sup>1</sup> Religious Worship Area	0.80	Decorative/Display	0.50	Tunable white or dim-to-warm <sup>2</sup>	0.10
Aging Eye/Low-vision: <sup>1</sup> Restroom	0.90	Decorative/Display	0.30		
Aging Eye/Low-vision: <sup>1</sup> Stairwell	0.80	Decorative/Display	0.30		
Atria < 20 ft tall	0.30	Decorative/Display	0.20		
Atria 20 to < 40 ft	0.40	Decorative/Display	0.25		
Atria > 40 ft	0.50	Decorative/Display	0.30		
Audience Seating Area	0.30	Display/decorative	0.35		
Auditorium Area	0.50	Display/decorative	0.45		
Auto Repair / Maintenance Area	0.55	Detailed Task <sup>4</sup>	0.20		
Barber, Beauty Salon and Spa Area	0.65	Detailed Task <sup>4</sup>	0.30	Decorative/Display	0.20
Civic Meeting Room	0.70	Decorative/Display	0.30		
Concourse	0.45	Decorative/Display	0.25		
<a href="#">Convention Center: Ballroom</a>	<a href="#">0.45</a>	<a href="#">Decorative/Display</a>	<a href="#">0.40</a>		
<a href="#">Convention: Exhibit Space</a>	<a href="#">0.45</a>	<a href="#">Decorative/Display</a>	<a href="#">0.30</a>		
<a href="#">Convention: Meeting Room</a>	<a href="#">0.65</a>	<a href="#">Decorative/Display</a>	<a href="#">0.25</a>		
Control room	0.50	Decorative/Display	0.00		
Copy Room	0.45	Decorative/Display	0.00		
Corridor Area	0.35	Decorative/Display	0.30		
Data center: Computer room	0.45	Detailed Task <sup>4</sup>	0.25		
Dining Area: Bar/Lounge and Fine Dining	0.40	Decorative/Display	0.45	Task	0.30
Dining Area: Cafeteria/Fast Food	0.40	Decorative/Display	0.25		
Dining Area: Family and Leisure	0.35	Decorative/Display	0.25		
Education/Business: Classroom, Training,	0.55	Whiteboard or chalkboard <sup>7</sup>	0.00		

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft2 unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft2 unless other units)
<a href="#">Educational, civic: Multipurpose room (art, music etc.)</a>	<a href="#">0.60</a>	<a href="#">Decorative/Display</a>	<a href="#">0.30</a>		
Electrical, Mechanical, Telephone Rooms	0.40	Detailed Task <sup>4</sup>	0.20		
Exercise/Fitness Center and Gymnasium Area	0.55	N/A	0.00		
Financial Transaction Area	0.53	Decorative/Display	0.30		
Healthcare: Corridor	0.55	Decorative/Display	0.25		
Healthcare: Exam/Treatment Room	1.10	N/A	0.00		
Healthcare: Imaging Room	0.55	Decorative/Display	0.35	Tunable white or dim-to-warm <sup>2</sup>	0.10
Healthcare: Medical Supply Room	0.50	N/A	0.00		
Healthcare: Nursery	0.80			Tunable white or dim-to-warm <sup>2</sup>	0.10
Healthcare: Nurse's Station	0.75	Detailed Task <sup>4</sup>	0.20	Tunable white or dim-to-warm <sup>2</sup>	0.10
Healthcare: Operating Room	1.90	N/A	0.00		
<a href="#">Healthcare: Patient Room - Critical care</a>	0.90	Decorative/Display	0.35	Tunable white or dim-to-warm <sup>2</sup>	0.10
Healthcare: Patient Room – <a href="#">General</a>	0.70	Decorative/Display	0.35	Tunable white or dim-to-warm <sup>2</sup>	0.10
Healthcare: Physical Therapy Room	0.65	Decorative/Display	0.10		
Healthcare: Recovery Room	0.85	Decorative/Display	0.20	Tunable white or dim-to-warm <sup>2</sup>	0.10
Kitchen/Food Preparation Area	0.85	Decorative/Display	0.00		
Laboratory: Scientific and Teaching	0.80	Specialized Task <sup>5</sup>	0.35		
Laundry Area	0.43	N/A	0.00		
Library : Reading Area	0.70	Decorative/Display	0.25		
Library : Stacks Area	0.91	N/A	0.00		
Lobby: Main entry	0.60	Decorative/Display	0.40		
Lobby: Performing Arts	0.60	Decorative/Display	0.40		
Locker Room	0.40	N/A	0.00		
Lounge, Breakroom, or Waiting Area	0.45	Decorative/Display	0.35		
Manufacturing & Commercial Work Area: Low Bay	0.63	Detailed Task <sup>4</sup>	0.20		
Manufacturing & Commercial Work Area: High Bay	0.65	Detailed Task <sup>4</sup>	0.20		
Manufacturing & Commercial Work Area: Precision	0.80	Precision Specialized <sup>6</sup>	0.70		
Motion picture: Theater area	0.32	Decorative/Display	0.25		

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft2 unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft2 unless other units)
Museum: Exhibition/Display	0.60	Decorative/Display	0.50		
Museum Area: Restoration Room	0.65	Detailed task	0.35		
Office Area: ≤ 250 square feet	0.55	Decorative/Display and portable <sup>10</sup>	0.25		
Office Area: > 250 square feet	0.50	Decorative/Display and portable <sup>10</sup>	0.25		
<a href="#">Office: Conference Room</a>	0.60	Decorative/Display	0.25		
Parking Garage Area: Parking Zone and Ramps	0.08	N/A	0.00		
Parking Garage Area: Daylight Adaptation Zones <sup>8</sup>	0.08	<a href="#">Transition Lighting OFF at night<sup>8</sup></a>	<a href="#">0.70</a>		
Performance: Theater area	0.50	Decorative/Display	0.40		
<a href="#">Performance: Dressing room</a>	<a href="#">0.50</a>	<a href="#">External illuminated mirror<sup>9</sup></a>	<a href="#">40 W/ mirror</a>	<a href="#">Internal illuminated mirror<sup>9</sup></a>	<a href="#">120 W/ mirror</a>
Pharmacy Area	1.00	Specialized Task <sup>5</sup>	0.35		
Retail: Grocery Sales Ceiling Height ≤10'4"	0.80	Decorative/Display	0.45	Wall decorative/display	3 W/ft
Retail: Grocery Sales Ceiling Height -10'5"-14'	0.85	Decorative/Display	0.50	Wall decorative/display	5 W/ft
Retail: Grocery Sales Ceiling Height >14'	0.90	Decorative/Display	0.55	Wall decorative/display	6 W/ft
Retail: Merchandise Ceiling Height ≤10'4"	0.70	Decorative/Display	0.85	Wall decorative/display	6 W/ft
Retail: Merchandise Sales Ceiling Height - 10'5"-14'	0.75	Decorative/Display	0.90	Wall decorative/display	10 W/ft
Retail: Merchandise Sales Ceiling Height >14'	0.80	Decorative/Display	0.95	Wall decorative/display	12 W/ft
Retail: Merchandise Sales: very valuable display case lighting, W/sf of display case	N/A	Very valuable display case interior lighting	5 W/ sf		
Retail: Fitting Room	0.50	External illuminated mirror <sup>9</sup>	40 W/mirror	Internal illuminated mirror <sup>9</sup>	120 W/mirror
Religious Worship Area	0.75	Decorative/Display	0.25		
Restrooms	0.60	Decorative/Display	0.35		
Stairwell	0.57	Decorative/Display	0.35		
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	2.25	N/A	0.00		
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	1.45	N/A	0.00		
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	1.05	N/A	0.00		
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	0.71	N/A	0.00		

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft2 unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft2 unless other units)
Transportation: Baggage Area	0.30	N/A	0.10		
Transportation: Ticketing Area	0.40	Decorative/Display	0.20		
Transportation: Waiting area	0.45	Decorative/Display	0.20		
Unleased tenant area <sup>12</sup>	0.40				
Videoconferencing Studio <sup>13</sup>	0.70	Decorative/Display	1.00		
Warehouse: Storage	0.40	N/A	0.00		
Warehouse: Shipping and Handling	0.60	N/A	0.00		

**Footnotes to TABLE 140.6-C1:**

1. 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 or state authorities for either senior long-term care, adult day care, senior support, and/or people with special visual needs
2. Tunable white luminaires capable of color change greater than or equal to 2000K CCT, or dim-to-warm luminaires capable of color change greater than or equal to 500K CCT, connected to controls that allow color changing of the luminaires.
3. Transition lighting OFF at night. Lighting power controlled by astronomical time clock or other control to shut off lighting at night. For aging eye/low vision lobbies: additional allowance only applies to area within 30 feet of an exit and not applicable to lighting in daylight zones..
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 for small-scale, cognitive or fast performance visual tasks; lighting required for operating specialized equipment associated with pharmaceutical/laboratorial activities.
6. 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
7. White board or chalk board.—Directional lighting dedicated to a white board or chalk board.
8. Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage. For parking garages: additional allowance only applicable to Daylight Adaptation Zones with lighting power controlled by astronomical time clock or other control to shut off lighting at night.
9. Illuminated mirrors. Lighting shall be dedicated to the mirror.
10. Portable lighting in office areas includes under shelf or furniture-mounted supplemental task lighting qualifies when controlled by a time clock or an occupancy sensor.
11. Class I Facility is used for competition play for 5000 or more spectators.  
Class II Facility is used for competition play for up to 5000 spectators.  
Class III Facility is used for competition play for up to 2000 spectators.  
Class IV Facility is normally used for recreational play and there is limited or no provision for spectators."
12. Unleased tenant areas in which a tenant has not been identified. See section 601.3.1.3.2.1(2).
13. The additional videoconferencing lighting power shall be allowed provided the videoconferencing studio meets all the requirements of Section 601.3.1.3.3 [Section 140.6(c)2Gvii].

**Note:** Table 601.3-C2 [Table 140.6-C2] is unchanged from Table 140.6-C in the 2025 Title 24, part 6 energy code in keeping with the requirements of AB 130 that building codes for Group R Occupancies and Common Use or Public Use Areas remain unchanged until 2031. All the values are unchanged but for ease of compliance this table is reformatted to be aligned with the Area Category Method table format for Nonresidential buildings Table 601.3-C1 [Table 140.6-C1]

**TABLE 601.3-C2 [TABLE 140.6-C2] AREA CATEGORY METHOD—LIGHTING POWER DENSITY VALUES (WATTS/FT<sup>2</sup>) FOR GROUP R OCCUPANCIES AND COMMON USE OR PUBLIC USE AREAS**

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Aging Eye/Low-vision <sup>10</sup>	Corridor Area	0.70	Decorative/Display	0.30		
Aging Eye/Low-vision <sup>10</sup>	Dining	0.80	Decorative/Display	0.30	Tunable white or dim-to-warm <sup>9</sup>	0.10
Aging Eye/Low-vision <sup>10</sup>	Lobby, Main Entry	0.85	Decorative/Display	0.30	Transition Lighting OFF at night <sup>11</sup>	0.95
Aging Eye/Low-vision <sup>10</sup>	Lobby, Main Entry	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10		
Aging Eye/Low-vision <sup>10</sup>	Lounge/Waiting Area	0.80	Decorative/Display	0.30	Tunable white or dim-to-warm <sup>9</sup>	0.10
Aging Eye/Low-vision <sup>10</sup>	Multipurpose Room	0.85	Decorative/Display	0.30	Tunable white or dim-to-warm <sup>9</sup>	0.10
Aging Eye/Low-vision <sup>10</sup>	Religious Worship Area	1.00	Decorative/Display	0.30	Tunable white or dim-to-warm <sup>9</sup>	0.10
Aging Eye/Low-vision <sup>10</sup>	Restroom	1.00	Decorative/Display	0.20		
Aging Eye/Low-vision <sup>10</sup>	Stairwell	0.80	Decorative/Display	0.30		
Audience Seating Area	NA	0.50	Decorative/Display	0.25		
Auditorium Area	NA	0.70	Decorative/Display	0.45		
Auto Repair / Maintenance Area	NA	0.55	Detailed Task Work <sup>6</sup>	0.20		
Barber, Beauty Salon, Spa Area	NA	0.70	Detailed Task Work <sup>6</sup>	0.30	Decorative/Display	0.25
Civic Meeting Place Area	NA	0.90	Decorative/Display	0.25		

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance<sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance<sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
Classroom, Lecture, Training, Vocational Area	NA	0.60	White or Chalk Board <sup>1</sup>	7 W/ft		
Concourse and Atria Area	NA	0.60	Decorative/Display	0.25		
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Decorative	0.25	Wall Display MH <= 10'6"	2 W/ft
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Wall Display MH 10'7" - 14'	2.35 W/ft	Wall Display MH > 14'	2.66 W/ft
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Floor Display and Task MH <= 10'6"	0.30	Floor Display and Task MH 10'7" - 14'	0.35
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Floor Display and Task MH > 14'	0.40		
Copy Room	NA	0.50	NA	NA		
Corridor Area	NA	0.40	Decorative/Display	0.25		
Dining Area	Bar/Lounge and Fine Dining	0.45	Decorative	0.35	Wall Display MH <= 10'6"	1.25 W/ft
Dining Area	Bar/Lounge and Fine Dining	0.45	Wall Display MH 10'7" - 14'	1.5 W/ft	Wall Display MH > 14'	1.7 W/ft
Dining Area	Bar/Lounge and Fine Dining	0.45	Floor Display and Task MH <= 10'6"	0.45	Floor Display and Task MH 10'7" - 14'	0.52
Dining Area	Bar/Lounge and Fine Dining	0.45	Floor Display and Task MH > 14'	0.60	General Lighting in the enclosed space of ceiling height > 10'	0.25
Dining Area	Cafeteria/Fast Food	0.45	Decorative/Display	0.25		

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
Dining Area	Family and Leisure	0.40	Decorative/Display	0.25		
Electrical, Mechanical, Telephone Rooms	NA	0.40	Detailed Task Work <sup>6</sup>	0.20		
Exercise/Fitness Center and Gymnasium Area	NA	0.50	NA	NA		
Financial Transaction Area	NA	0.70	Decorative/Display	0.25		
Healthcare Facility and Hospitals	Exam/Treatment Room	1.15	NA	NA		
Healthcare Facility and Hospitals	Imaging Room	0.60	Decorative/Display	0.20	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Medical Supply Room	0.55	NA	NA		
Healthcare Facility and Hospitals	Nursery	0.80	Tunable white or dim-to-warm <sup>9</sup>	0.10		
Healthcare Facility and Hospitals	Nurse's Station	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10	Detailed Task Work <sup>6</sup>	0.20
Healthcare Facility and Hospitals	Operating Room	1.90	NA	NA		
Healthcare Facility and Hospitals	Patient Room	0.70	Decorative/Display	0.15	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Physical Therapy Room	0.75	Tunable white or dim-to-warm <sup>9</sup>	0.10		
Healthcare Facility and Hospitals	Recovery Room	0.90	Tunable white or dim-to-warm <sup>9</sup>	0.10		
Hotel Function Area	NA	0.85	Decorative/Display	0.25		
Kitchen/Food Preparation Area	NA	0.95	NA	NA		
Laboratory, Scientific	NA	0.90	Specialized Task Work <sup>8</sup>	0.35		
Laundry Area	NA	0.45	-	-		
Library	Reading Area	0.80	Decorative/Display	0.25		
Library	Stacks Area	1.00	NA	NA		

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
Lobby, Main Entry	NA	0.70	Decorative	0.25	Wall Display MH <= 10'6"	3 W/ft
Lobby, Main Entry	NA	0.70	Wall Display MH 10'7"- 14'	3.5 W/ft	Wall Display MH > 14'	4 W/ft
Locker Room	NA	0.45	NA	NA		
Lounge, Breakroom, or Waiting Area	NA	0.55	Decorative/Display	0.25		
Manufacturing, Commercial and Industrial Work Area	Low Bay	0.60	Detailed Task Work <sup>6</sup>	0.20		
Manufacturing, Commercial and Industrial Work Area	High Bay	0.65	Detailed Task Work <sup>6</sup>	0.20		
Manufacturing, Commercial and Industrial Work Area	Precision	0.85	Precision Specialized Work <sup>8</sup>	0.70		
Museum Area	Exhibition/Display	0.60	Decorative/Display	0.45		
Museum Area	Restoration Room	0.70	Detailed Task Work <sup>6</sup>	0.35		
Office Area	> 250 square feet	0.60	Decorative/Display and Portable lighting for office areas <sup>5</sup>	0.20		
Office Area	≤ 250 square feet	0.65	Decorative/Display and Portable lighting for office areas <sup>5</sup>	0.20		
Parking Garage Area	Parking Zone and Ramps	0.10	First ATM or Ticket Machine	100 W	Additional ATM or Ticket Machine	50 W/each
Parking Garage Area	Daylight Adaptation Zones <sup>2</sup>	1.00	NA	NA		
Pharmacy Area		1.00	Specialized Task Work <sup>8</sup>	0.35		

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance<sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance<sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
Retail Sales Area	Grocery Sales	1.00	Decorative	0.35	Wall Display MH <= 10'6"	6.6 W/ft
Retail Sales Area	Grocery Sales	1.00	Wall Display MH 10'7"- 14'	7.76 W/ft	Wall Display MH > 14'	8.8 W/ft
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH <= 10'6"	0.60	Floor Display and Task MH 10'7"- 14'	0.70
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH > 14'	0.80	General Lighting in the enclosed space of ceiling height > 10'	0.10
Retail Sales Area	Retail Merchandise Sales	0.95	Decorative	0.35	Wall Display MH <= 10'6"	9.5 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH 10'7"- 14'	11.2 W/ft	Wall Display MH > 14'	12.7 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH <= 10'6"	0.45	Floor Display and Task MH 10'7"- 14'	0.52
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH > 14'	0.60	Valuable Display Case	0.50
Retail Sales Area	Retail Merchandise Sales	0.95	General Lighting in the enclosed space of ceiling height > 10'	0.10		
Retail Sales Area	Fitting Room	0.60	External Illuminated Mirror <sup>4</sup>	40 W/ea	Internal Illuminated Mirror <sup>4</sup>	120 W/ea
Religious Worship Area		0.95	Decorative/Display	0.25		
Restrooms		0.65	Decorative/Display	0.35		
Stairwell		0.60	Decorative/Display	0.35		
Storage, Commercial/Industrial	Warehouse	0.40	NA	NA		
Storage, Commercial/Industrial	Shipping and Handling	0.60	NA	NA		
Sports Arena—Playing Area	Class I Facility <sup>12</sup>	2.25	NA	NA		

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Sports Arena—Playing Area	Class II Facility <sup>12</sup>	1.45	NA	NA		
Sports Arena—Playing Area	Class III Facility <sup>12</sup>	1.10	NA	NA		
Sports Arena—Playing Area	Class IV Facility <sup>12</sup>	0.75	NA	NA		
Theater Area	Motion picture	0.50	Decorative/Display	0.25		
Theater Area	Performance	0.80	Decorative/Display	0.25		
Transportation Function	Baggage Area	0.40	NA	NA		
Transportation Function	Ticketing Area	0.45	Decorative/Display	0.20		
Videoconferencing Studio	NA	0.90	Videoconferencing <sup>13</sup>	1.00		
All other	NA	0.40	NA	NA		

Footnotes for Table 601.3-C2 [Table 140.6-C2] are listed below.

1. White board or chalk board.—Directional *lighting* dedicated to a white board or chalk board.
2. *Daylight Adaptation Zones* shall be no longer than 66 feet from the entrance to the parking *garage*.
3. MH denotes the *luminaire* mounting height of the qualified *lighting* systems.
4. Illuminated mirrors. *Lighting* shall be dedicated to the mirror.
5. *Portable lighting* in *office areas* includes under shelf or furniture-mounted supplemental *task lighting* qualifies when controlled by a time clock or an *occupancy* sensor.
6. 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.
7. Specialized task work—*Lighting* provides for small-scale, cognitive or fast performance visual tasks; *lighting* required for operating specialized *equipment* associated with pharmaceutical/laboratorial activities.
8. *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.
9. *Tunable white luminaires* capable of color change greater than or equal to 2000K CCT, or *dim-to-warm luminaires* capable of color change greater than or equal to 500K CCT, connected to controls that allow color changing of the *luminaires*.

10. 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 or state authorities for either senior long-term care, adult day care, senior support, and/or people with special visual needs.
11. Transition *lighting* OFF at night. Lighting power controlled by astronomical time clock or other control to shut off *lighting* at night. Additional LPD only applies to area within 30 feet of an exit. Not applicable to *lighting* in *daylit* zones.
12. Class I Facility is used for competition play for 5000 or more spectators. Class II Facility is used for competition play for up to 5000 spectators. Class III Facility is used for competition play for up to 2000 spectators. Class IV Facility is normally used for recreational play and there is limited or no provision for spectators.
13. The additional videoconferencing lighting power shall be allowed provided the *videoconferencing studio* meets all the requirements of [Section 601.3.1.3.3](#) [Section 140.6(c)2Gvii].

### 7.3.4 Proposed Changes to Appendix 1-A Standards And Documents Referenced in the Energy Code

#### APPENDIX 1-A STANDARDS AND DOCUMENTS REFERENCED IN THE ENERGY CODE

The following documents are incorporated by reference to the extent they are referenced in the Energy Code.

#### UNDERWRITERS LABORATORIES / UL

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[UL 1993-24 \(Version 6\)](#)      [Self-Ballasted Lamps and Lamp Adapters](#)

Available from:

UL LLC  
333 Pfingsten Road  
Northbrook, IL 60062-2096  
(847) 272-8800

### 7.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

### 7.5 Compliance Manuals

The Statewide CASE Team will provide recommended revisions to compliance manuals after the 45-Day Language is published.

### 7.6 ACM Reference Manual

It is envisioned that the Alternative Calculation Method (ACM) software would be redesigned so that if a building type that is a Nonresidential Building is selected, excluding *Group R occupancies and common use or public use areas*, the 2028 NRACM ruleset, including the updated LPDs, would be used. If a building type is selected that includes *Group R occupancies and common use or public use areas*, the software would, one way or the other, guide the user to the 2025 version of the performance compliance software or incorporate the 2025 rulesets and LPDs for these building types.

The 2028 Nonresidential ACM Appendix 5.4A specific to Nonresidential Buildings excluding Group R Occupancies and Common Use or Public Use Areas would need to

be updated with the new LPD values for the Complete Building Method and Area Category Method. Specifically, Table BldgUseData in Appendix 5.4A references the LPDs for the Complete Building Method and Table SpaceFunctionData in Appendix 5.4A references the LPDs for the Area Category Method.

The LPDs and additional lighting wattage allowances associated with Group R Occupancies and Common Use or Public Use Areas would be unchanged from the 2025 Nonresidential ACM Appendix 5.4A.

## **7.7 Compliance Forms**

As discussed in Section 2.6.5, if adopted, the current LPD values in the NRCC/LMCC-LTI-E and NRCC-PRF-E forms would be updated to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

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# Appendix A: Assumptions for Cost-Effectiveness Analysis

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## A.1 Assumptions for Energy Savings Analysis

Section 2.4 describes the process of developing the allowed lighting power densities needed to meet the maintained illuminance recommendations of the Illuminating Engineering Society, accounting for good design practice and moderately difficult geometries. The main assumptions that underly the energy savings estimates are:

- Energy savings is based on a design that is minimally compliant with the 2025 Title 24 standard as compared to a similar space compliant with the proposed 2028 Title 24 lighting system.
- Hours of operation and lighting profile (partial operation) schedule are as given by Appendix 5.4 in the nonresidential ACM Reference Manual.
- Also, in keeping with the ACM, lighting schedules do not change with climate zones.
- The lighting LPD energy savings model is a spreadsheet only model. It calculates the primary energy savings from reduced energy consumption by lighting for the 70+ space types considered.
- Interaction effects with heating and cooling are ignored.
  - The reduction in light power reduces internal gains which reduces cooling energy consumption and increases heating energy consumption, but the effect is small. The cooling benefit is greater than the heating increase, but overall, the interaction effect is a net small savings benefit (around 10 percent).
  - From (Sezgen & Koomey 1998) on a nationwide basis across all buildings 1 kWh of lighting energy savings results in an additional 0.19 kWh cooling savings and an additional 0.10 kWh heating energy consumption.<sup>12</sup>
  - From (CPUC 2018) lighting has a 1.10 to 1.17 HVAC kWh interaction factors (increase savings) depending upon California electricity IOU and

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<sup>12</sup>Sezgen, Osman, and Jonathan G. Koomey. 1998. *Interactions Between Lighting and Space Conditioning Energy Use in U.S. Commercial Buildings*. Lawrence Berkeley National Laboratory <https://eta-publications.lbl.gov/sites/default/files/lbnl-39795.pdf>

a 12 percent to 2 percent gas take back factors (decrease savings) that varies by California gas IOU.<sup>13</sup>

## A.2 Energy Savings Methodology

Energy savings is not calculated per prototypical building. This would not be particularly useful as the key metric for this analysis is the feasibility and cost-effectiveness of each LPD allowance for each space type. The analysis is conducted per space type in the area category approach.

To calculate annual energy savings, the change in W/sf of each space category is divided by 1,000 to convert into kW and then multiplied by the lighting profile from the NRACM appendix 5.4A for each hour of the day for 365 days per year. This yields a string of annual hourly energy consumption values in units of kWh for each of the 8,760 hours per year. Since interaction effects are not calculated, life cycle energy cost savings, source energy savings, carbon emission reductions and nominal cost savings are directly calculated from the hourly kWh savings multiplied by the applicable hourly conversion factors posted at: <https://www.energy.ca.gov/files/2028-energy-code-energy-accounting-metrics>

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<sup>13</sup> CPUC (2018) *Resolution E-4952 updates to the Database for Energy-Efficient Resources (DEER) for program year (PY) 2020.*

<https://docs.cpuc.ca.gov/publisheddocs/published/g000/m232/k459/232459122.pdf>

# Appendix B: Purpose and Necessity of Proposed Code Changes

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## B.1 Introduction

The sections below provide the purpose and necessity of proposed changes to Title 24, Part 1; Title 24, Part 6; and the reference appendices. This section intends to provide the CEC with the information needed for the Initial Statement of Reasons.

See Section 7 of this report for marked-up code language.

## B.2 Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1

## B.3 Purpose and Necessity of Changes to Title 24, Part 6

**Section:** 601.2.1.1.1 [*Section 130.0(c)2*]

**Purpose:** The purpose of this change is to specify the code determined wattage of a luminaire with line voltage sockets containing removable lamps for calculating the installed wattage of the lighting system. The changes to this section define wattage of luminaires containing line voltage lamps as the total wattage of the specified and installed lamps or solid state lighting (SSL) light engines.

**Necessity:** The necessity for this change is to remove a barrier to reusing luminaires with line voltage sockets. In many cases the least expensive energy efficiency upgrade is to replace higher wattage legacy lamps with lower wattage but more efficacious new lamps. Currently luminaire wattage is based on a factory installed label. For code compliance this creates a motivation to throw out the existing luminaire and replace with a new luminaire. In the past, the labeling of luminaires was desirable so as to create a barrier to temporarily installing high efficacy lamps and after inspection replace with a less expensive, low efficacy but higher color quality and more focused beam spread of an incandescent lamp. These issues have diminished with modern LED lamps having the amenity issues resolved and cost differential have also been reduced. There is no longer an energy efficiency rationale to base the luminaire wattage on the luminaire label, the total of the lamp wattages is a more accurate way of allocating wattage to luminaires with line voltage sockets. This reduces the unnecessary disposal of suitable luminaires, which reduces the cost of lighting upgrades, reduces the greenhouse gas emissions associated with embodied energy in the luminaire materials, and reduces barriers to lighting retrofits.

**Section:** 601.2.1.2.4 [Section 130.0(c)3]

**Purpose:** The purpose of this change is to specify the code-defined wattage of an SSL luminaire with integral or remote driver and clarify what is the deemed wattage of a luminaire with multiple power settings. This also addresses technology changes such as programmable drivers that allow the maximum wattage to be changed after a luminaire leaves the factory. The luminaire wattage is defined as the maximum labelled wattage of the luminaire as labelled by the manufacturer or by the manufacturers authorized representative.

**Necessity:** The update is driven by the growing market share of multi-wattage luminaires. The energy code should provides a clear determination of what the deemed luminaire wattage is when multi-wattage luminaires are used, and how this wattage is displayed on the luminaire. Additionally advances in lighting technology such as programmable drivers reduce supply chain costs and increase product flexibility by setting maximum wattage at the lighting representative or distributor using near field communication (NFC). Prior to this change, the energy code is a barrier to this flexibility by requiring that luminaire wattage labels must be factory installed.

**Section:** 601.2.1.1.4 [new]

**Purpose:** Changes to this section are to clarify the defined wattage used when a legacy ballast for HID or fluorescent systems is left in an existing luminaire and remains energized after a solid state lighting (SSL) retrofit. When tubular LEDs are used, they are usually called “Type A” retrofits, as described in Section 2.3. In this situation, there are losses from both the reused ballast and the SSL driver before the electrical power is converted into light in the SSL device. The purpose is to clearly define the wattage of these hybrid devices.

**Necessity:** California’s AB 2208 has banned fluorescent lamps for environmental health reasons as they contain mercury, a potent neurotoxic element, while less hazardous SSL sources are available, which are less toxic and more efficacious. Because Type A lamps are designed to combine with a variety of fluorescent ballasts, a clearly defined wattage of the lighting system is hard to determine. Additionally, these retrofits are rarely dimmable.

**Section:** 601.2.1.1.7 [new]

**Purpose:** This section expands the scope of lighting systems that may use current limiters or supplementary overprotection protection to define the wattage of the defined lighting system. This used to be reserved for only modular lighting systems. The scope is increased to all lighting systems.

**Necessity:** Updates to lighting technologies have introduced a wider range of products that can vary both light output and input wattage. Expanding the circumstances under which deemed wattage may be based on the maximum power draw allowed by current limiters or overcurrent protection would provide greater design flexibility while preserving the intended wattage limit.

**Section:** 601.3.1 [Section 140.6]

**Purpose:** Streamlining the code language so there is consistent use of the comparison of Adjusted Lighting Power with Allowed Indoor Lighting Power. Updates include removing the incorrect statement that the two methods are “lighting power density for general lighting” these methods apply to all lighting not just general lighting. Removed all instances of the term “allotment” and replaced with “lighting power allowance” for the description of the lighting power density that is in turn multiplied by the square feet of the primary function area to calculate the “allowed lighting power.” Also removed the term allotment when referring to the Allowed Lighting Power. Also removed a repetition of the specific methodologies from the general methodology section.

**Necessity:** Removed confusing terms and streamline the requirements to be more clearly stated.

**Section:** Table 601.3-B [*Table 140.6-B*],

**Purpose:** Update allowed lighting power density (LPD) requirements for the Complete Building Method. Also added building types “Data Center building” and “Service Facility (including auto repair.”

**Necessity:** The complete building method is based on the area-weighted general lighting power densities associated with the Area Category Method applied to prototypes of each building type. This method reflects changes in lighting equipment performance and design practice from six years ago. Recent market patterns indicate that there is a significant expected growth in data centers and the addition allows the use of the more stringent by easier to use complete building method for this building class. Service facilities including care repair and other services (beauty salons, kennels etc.) are California Building Code B (business) occupancies and have different illuminance requirements than retail occupancies which are California Building Code M (Mercantile) occupancies.

**Section:** 601.3.1.3.2 and subsections [Section 140.6(c)2]

**Purpose:** Reorganized this section on the specific requirements for the area category method so that it had introductory language and then specific subsections for the calculation of the Allowed Baseline Lighting Power and the calculation of Allowed Additional Lighting Power.

**Necessity:** The rules are qualitatively different for these two sections, as the baseline allowance is a function only of the space type and its areas whereas the additional lighting power is the lesser of the installed power of a certain type of lighting and its allowance. This clarified how decorative/display allowances applied. The modifications here and in the table combine decorative and display allowances since the same luminaire can be providing both decorative and display illumination at the same time. This removes a differentiation that is hard to enforce. Similarly, this change also does not differentiate lighting upon the direction it is pointed (for display lighting) but where it is located on the plans. This simplifies the enforcement process.

The modifications to this section also describe the very valuable display allowance.

**Section:** Table 601.3-C1 [*Table 140.6-C1*]

**Purpose:** Update allowed lighting power density (LPD) requirements for the Area Category Method for Nonresidential Buildings not including Group R Occupancies and Common Use or Public Use Areas.

**Necessity:** Though equipment efficiencies have increased over time, there is significant variability in published product efficacy. If lighting target LPDs do not decrease as product efficacies increase over time, the standard does not limit inefficient design practices.

When the performance approach is used, and allowable LPDs are excessively high, the nominal savings from the code-allowed lighting wattage baseline result in the overall efficiency of the building design to be less efficient.

The proposed updates to LPD values is needed to reflect the updates in lighting equipment performance and design practices as opposed to what was standard six years ago when the current LPD values were developed.

**Section:** 601.5.2.2.4 item 3 (revised) and item 4 (editorial only). [*Section 141.0(b)2/141.0(b)2/ item iii*]

**Purpose:** For item 3 “one-for-one luminaire alterations” for Nonresidential Buildings not Including Group R Occupancies and Common Use or Public Use Areas, the criteria was changed from 5,000 square feet maximum to no greater than 3,000 watts. The content of item 4 “one-for-one luminaire alterations” for Group R Occupancies and Common

Use or Public Use Areas is unaltered in keeping with requirements associated with AB130 that for Group R Occupancies and Common Use or Public Use Areas building standards be unchanged until 2013. For both item 3 and item 4 the term “one-for-one luminaire alteration” is replaced with the defined term “*one-to-one alteration*.”

**Necessity:** By basing the criteria for one-to-one alterations on 3,000 watts of post-altered luminaires, these alterations are streamlined from the 5,000 square feet without changing the stringency of the requirement. In some cases, the jurisdictions require that a set of plans be drawn up to document that the 5,000 square foot criteria is not exceeded. This adds time and cost to the project without corresponding benefit. Editorially wherever “one-for-one luminaire alteration” appears in items 3 and 4, this is replaced with the defined term “*one-to-one alteration*.” This is fixing a typo as the intention is clear “one-for-one luminaire alteration” was meant to represent the defined term “*one-to-one alteration*.”

## **B.4 Purpose and Necessity of Changes to the Reference Appendices**

There are no proposed changes to reference appendices.

## **B.5 Purpose and Necessity of Changes to Nonresidential ACM**

**Section:** NRACM Appendix 5.4A. Filename: “Appendix\_5.4A\_SpaceUseData-T24N.xlsx”

**Purpose:** NRACM Appendix 5.4A Space by Spaces LPDs and Additional Allowances set the base case wattage allowances that the proposed design is compared against.

**Necessity:** This update to the NRACM is necessary to incorporate the prescriptive values into the baseline and thereby increase the stringency of the performance approach to match that of the prescriptive approach.

# Appendix C: Assumptions for Statewide Savings Estimates

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The Statewide CASE Team estimated statewide impacts for the first year by multiplying the kWh/y-sf estimates for each space type by the statewide construction forecasts provided by the CEC. The [2028 CASE Methodology Report](#) includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

## C.1 Statewide Technical Potential

To calculate the statewide new construction and retrofit areas for space type:

- Each space type application is mapped to multiple building types associated with the complete building method and weighted by fraction of space type area per building area. The space type fractions add up to 100 percent per building.
- The statewide new construction and retrofit square footages is derated by the fraction of market share impacted by the proposal and then allocated to the various complete building method building types to yield the total construction areas of the complete building methods building types.
- The areas of the complete building method areas are multiplied by the space type fractions to yield the annual new construction and alteration square footage per space type.

The current market share is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past Title 24 code cycles. The Statewide CASE Team estimated that the current market share rate for the proposed code change is 100 percent for the new construction market and seven percent (one divided by the 15-year expected useful life) for the retrofit market. One exception is retail lighting, where the expected useful life is not a function of equipment life, but rather lighting systems are upgraded regularly to enhance the store's appearance and attract customers. For retail and grocery stores, the expected useful life of the lighting systems is projected to be 10 years, and the retrofit rate is 10 percent per year of the building stock for these applications.

Controlled environment horticulture building type is not included, as all process lighting in these spaces is specifically exempt from the LPD requirements in Section 140.6 and is covered by the requirements in Section 120.6(h) *Mandatory requirements for Controlled Environment Horticulture (CEH) spaces*.

Table 23 presents the projected nonresidential new construction that the proposed code change would impact in 2026, the percentage estimated to be applicable, and the total applicable area impacted by the code change. Note that lighting in controlled environment horticulture process applications is not included (zero percent applicable) as the lighting systems for these areas are covered by Section 120.6(h) and are excluded from coverage by the LPDs in Section 140.6. Only 40 percent of enclosed parking garage area is included, as it is expected that 60 percent of the enclosed parking garages serve residential buildings (multifamily and hotel/motel), and the new LPDs would not be applicable due to the restrictions placed by AB 130 on residential code updates.

**Table 23: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2029, by Building Type (Million Square Feet)**

<b>Building Prototype</b>	<b>Nonresidential New Construction (Million sf/yr)</b>	<b>Percent Applicable</b>	<b>NRNC Applicable Area (Million sf/yr)</b>
Large Office	17.2	100%	17.2
Medium Office	13.8	100%	13.8
Small Office	3.0	100%	3.0
Large Retail	9.5	100%	9.5
Medium Retail	13.0	100%	13.0
Strip Mall	3.8	100%	3.8
Large School	6.5	100%	6.5
Small School	5.5	100%	5.5
K-8 School	6.4	100%	6.4
Non-refrigerated Warehouse	17.8	100%	17.8
Assembly	9.4	100%	9.4
Hospital	6.7	100%	6.7
Laboratory	5.8	100%	5.8
Restaurant	3.7	100%	3.7
Enclosed Parking Garage	9.0	40%	3.6
Open Parking Garage	16.8	100%	16.8
Grocery	0.9	100%	0.9
Refrigerated Warehouse	0.8	100%	0.8
Controlled-environment Horticulture	2.2	0%	0.0
Vehicle Service	3.6	100%	3.6
Data Center	1.3	100%	1.3
Manufacturing	1.6	100%	1.6
Miscellaneous	2.0	100%	2.0
<b>Totals (million sq ft)</b>	<b>160.4</b>		<b>152.8</b>

Table 24 contains a listing of the nonresidential existing statewide building stock that the proposed code change would affect, the percent applicable area projected to be altered per year, based on the expected useful life of lighting systems for each building type. The Statewide CASE Team developed these estimates using the methods described in this section. For most alterations seven percent (one divided by the 15-year expected useful life) of the building stock is expected to be altered per year. One exception is

retail lighting, where the expected useful life is not a function of equipment life, but rather lighting systems are upgraded regularly to enhance the store’s appearance and attract customers. For retail and grocery stores, the expected useful life of the lighting systems is projected to be 10 years, and the retrofit rate is 10 percent per year of the building stock for these applications.

**Table 24: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2029 (Alterations), by Climate Zone and Building Type (Million Square Feet)**

Building Prototype	Nonresidential Building Stock (Million sf)	Expected Useful Life (yr)	Percent Applicable Area per Year	Alterations (Million sf/yr)
Large Office	1,047	15	7%	69.8
Medium Office	628	15	7%	41.9
Small Office	224	15	7%	14.9
Large Retail	470	10	10%	47.0
Medium Retail	564	7	14%	80.6
Strip Mall	487	10	10%	48.7
Large School	296	15	7%	19.7
Small School	366	15	7%	24.4
K-8 School	368	15	7%	24.5
Non-refrigerated Warehouse	1,200	15	7%	80.0
Assembly	581	15	7%	38.7
Hospital	425	15	7%	28.3
Laboratory	191	15	7%	12.7
Restaurant	195	15	7%	13.0
Enclosed Parking Garage	283	15	3%	7.5
Open Parking Garage	517	15	7%	34.5
Grocery	40	7	14%	5.7
Refrigerated Warehouse	20	15	7%	1.3
Controlled-environment Horticulture	41	15	0%	0.0
Vehicle Service	320	15	7%	21.3
Data Center	9	16	6%	0.6
Manufacturing	655	15	7%	43.7
Miscellaneous	107	15	7%	7.1
<b>Totals (million sq ft)</b>	<b>9,091</b>	<b>-</b>	<b>-</b>	<b>666.1</b>

The matrix in Table 25 assigns a fraction of the complete building method areas (columns) to each of the CEC forecast building types (rows). All rows for new construction add up to 100 percent, as all the building construction type forecasts are completely allocated to the different complete building method buildings. There is one exception: Controlled-environment horticulture is not assigned to any complete building method building types as this application is exempt from the lighting power requirements but is instead regulated in terms of its Photosynthetic Photon Efficacy (see Title 24, part 6 Section 120.6(h)).

Table 26 contains the projected areas by complete building method building type of one year's new construction and additions activity and alterations activity. This estimate for new construction was accomplished by taking the last column in Table 23 (million square feet from the CEC forecast estimated to be within scope of revised LPDs for each forecasted building type) and multiplying this value by the fraction of building type that is mapped to the complete building method type in Table 25.

For alterations the same approach is taken, by taking the last column in Table 24 (millions of square feet from the portion of CEC building stock estimate projected to be within scope of revised LPDs for each forecasted building type) and multiplying this by the fraction of building type that is mapped to the complete building method type. This yields the total complete building method areas subject to alterations each year.

Note that the sum of the areas in Table 26 equals the sum of the impacted areas in Table 23 and Table 24; this illustrates that the total areas are the same, but building types are defined differently.

**Table 25: Assignment of Complete Building Method Areas (Columns) to CEC Forecast Areas (Rows)**

Complete Building Type (Columns) / CEC Forecast Buildings (Rows)	Assembly	Bank /Financial	Data Center	Grocery Store	Gymnasium	Healthcare Outpatient	Healthcare - Inpatient	Industrial / Manufacturing	Library	Motion Picture	Museum	Office	Parking Garage	Performing Arts Theater	Religious Facility	Restaurant	Retail Store	School	Sports Arena	Service Facility	Warehouse	
Large Office												100%										
Medium Office		6%										94%										
Small Office		10%				8%						82%										
Large Retail																	100%					
Medium Retail																	100%					
Strip Mall																	100%					
Large School					10%				2%					1%				87%				
Small School					10%				2%									88%				
K-8 School					10%				2%									88%				
Non-refrigerated Warehouse								20%														80%
Assembly	40%				10%					10%	5%			10%	20%					5%		
Hospital						40%	60%															
Laboratory								20%				80%										
Restaurant																100%						
Enclosed Parking Garage													100%									
Open Parking Garage													100%									
Grocery				100%																		
Refrigerated Warehouse								20%														80%
Controlled-environment Horticulture																						
Vehicle Service																					100%	
Data Center			100%																			
Manufacturing								100%														
Miscellaneous	15%							35%													25%	25%

**Table 26: First Year New Construction and Additions and Alterations Forecasts for each Building Type in the Complete Building Method Approach (Million sf/y)**

Complete Building Method Type of Building	Nonresidential New Construction + Additions (Million sf/yr)	Nonresidential Alterations (Million sf/yr)
Assembly	4.1	16.6
Bank /Financial	1.1	4.0
Data Center	1.3	0.6
Grocery Store	0.9	5.7
Gymnasium	2.8	10.7
Healthcare Outpatient	6.9	29.5
Industrial /Manuf	7.1	65.0
Library	0.4	1.4
Motion Picture Theater	0.9	3.9
Museum	0.5	1.9
Office	37.2	131.6
Parking Garage	20.4	42.0
Performing Arts Theater	1.0	4.1
Religious facility	1.9	7.7
Restaurant	3.7	13.0
Retail Store	26.4	176.2
School	16.1	60.2
Sports Arena	0.5	1.9
Service Facility	4.2	23.1
Warehouse	15.4	66.9
<b>Total</b>	<b>152.8</b>	<b>666.1</b>

## C.2 Statewide Market Probability Adjustment

The technical potential calculation treats the installed power as being minimally compliant with the allowed LPD, thus the change in LPD is multiplied by all the affected applications based on new construction and alteration construction rates. However, the installed lighting power of populations of buildings and applications is more accurately described as a probability distribution of LPDs.

There are two major categories of code compliance: prescriptive compliance and performance compliance.

Prescriptive compliance results from complying with the various mandatory and prescriptive requirements. For lighting power, the total installed lighting power is not allowed to exceed the allowed lighting power densities. For performance compliance, the efficiency of building components is allowed to vary as long as the whole building

energy consumption, as simulated according to the nonresidential ACM Reference Manual, is less than a similar building modelled as prescriptively minimally compliant.

For performance lighting compliance, the majority of projects have lower installed lighting power than the allowed lighting power, but this difference is used to reduce the efficiency of other building components, primarily the envelope. The market assumption applied here is that most of the reductions in allowed lighting power result in equivalent savings in the performance approach because this resets the stringency of the baseline. As a result, installed lighting savings mostly result in additional energy consumption in other building components. In reviewing a compliance database maintained by the Statewide Codes and Standards Compliance Improvement Team, approximately **31 percent** of nonresidential new construction building area complies with the lighting requirements using the performance approach. Similarly, approximately **7 percent** of the floor area of nonresidential lighting alterations complies with the performance approach.

To quantify the impact of the changed LPDs on the distribution of installing lighting power, a skewed normal probability distribution is used. This formulation is used for several reasons. Using a normal distribution, the probability function is well understood and matches probability distributions found in nature and human factors research, namely a central tendency with smoothly declining probabilities from the central value. A skewed distribution is used to represent that the maximum allowed LPD limit places some constraint on the range of LPDs and as a result, the distribution is single-sided with a long tail to the right (left skewed). Conversely, if the LPD was specified to be so high that the installed LPDs were unconstrained, one would expect a symmetric distribution.

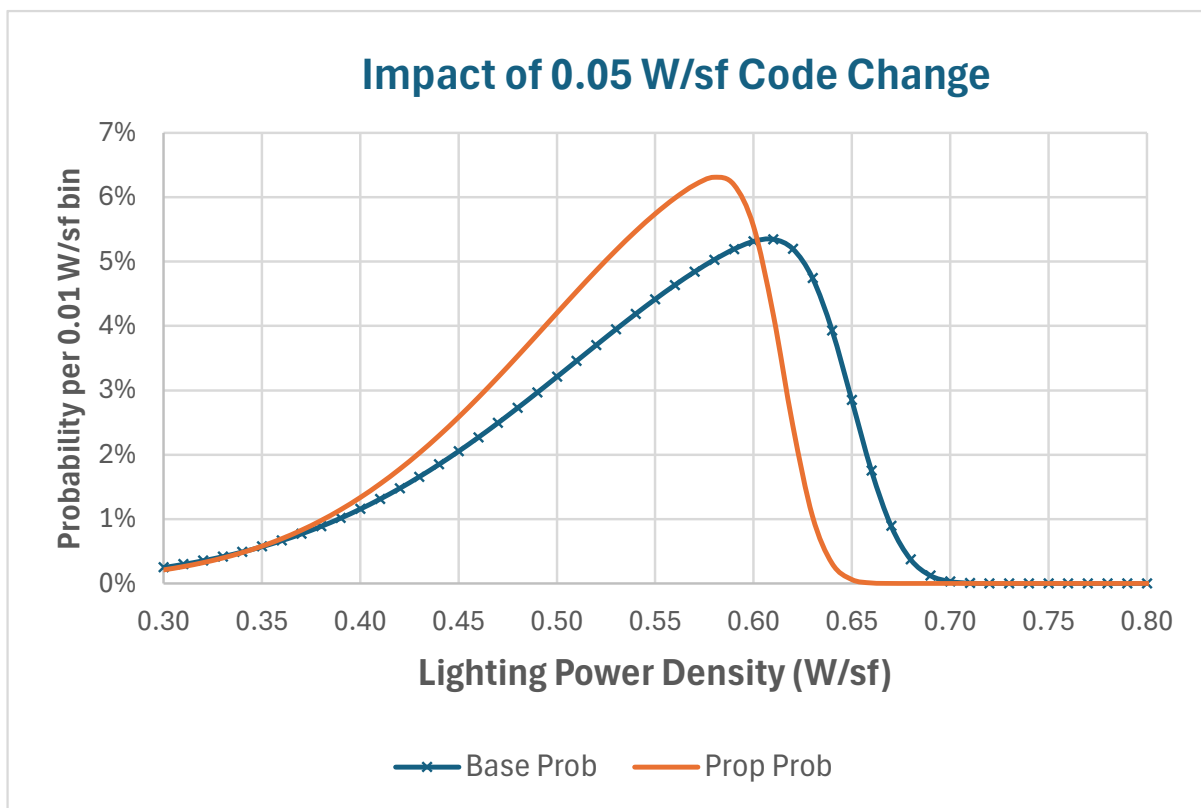
The skewed normal probability distribution function, SNPDF (LPD), with respect to LPD is given by the following:

$$\text{SNPDF}(\text{LPD}) = \left\{ \frac{2}{SD} \times \text{NORM.PDF} \left( \frac{\text{LPD} - \mu}{SD} \right) \times \text{NORM.CDF} \left( \alpha \times \frac{\text{LPD} - \mu}{SD} \right) \right\} \times (\delta\text{LPD})$$

Where,

- SD = Standard deviation, W/sf
- NORM.PDF = Standard normal probability distribution function
- $\mu$  = mean of LPDs, W/sf
- NORM.CDF = Standard normal cumulative distribution function
- $\alpha$  = skewness parameter
- dLPD = bin width for LPD increments, W/sf

The following hypothetical distribution provides an analysis of the expected change in distribution of installed LPDs from a change in the allowed LPD. This example makes use of a base case condition of a 0.70 W per square foot LPD allowance, with a corresponding installed LPD distribution having a mean offset of 0.65 W per square foot, a standard deviation of 0.14 W per square foot and skewness factor of -7 (left skewed). The proposed case with a LPD allowance of 0.65 W per square foot, is expected to squeeze the distribution against the new limit thus it has a mean offset of 0.615 that is less than the offset in the new LPD allowance, has a smaller standard deviation of 0.12 W per square foot to represent a tighter clustering of the installed LPDs and a skewness of -8, to represent more LPDs skewed toward the new LPD limit. These distributions are illustrated in Figure 3.



**Figure 3: Skewed Normal Distribution of Base Case and Proposed Case probabilities of installed LPDs.**

The resulting probability weighted LPDs are 0.539 W per square foot for the base case and 0.520 W per square foot for the proposed case that has a 0.050 W per square foot lower allowed wattage. The weighted average difference in LPDs is 0.019 W per square foot or a 39 percent net installed wattage reduction relative to the allowed LPD reduction.

Thus, when applying the full technical potential of LPD savings that affects the performance approach (31 percent of new construction and 7 percent of alterations) and

the 39 percent fraction of savings that applies to prescriptive compliance (69 percent of new construction and 93 percent in alterations), the corresponding fractions of the statewide wide technical potential are as follows:

New construction market savings:

- New construction market savings (GWh/yr) = NC statewide technical potential (GWh/yr) x (31% + 69% x 39%)
- Simplifying the formula:
  - New construction market savings (GWh/yr) = NC statewide technical potential (GWh/yr) x (58%)

Alterations market savings:

- Alteration market savings (GWh/yr) = Alteration statewide technical potential (GWh/yr) x (7% + 93% x 39%)
- Simplifying the formula:
  - Alteration market savings (GWh/yr) = Alteration statewide technical potential (GWh/yr) x (43%)

# Appendix D: Environmental Analysis

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## D.1 Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including, but not limited to an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal would not result in a significant effect on the environment.

## D.2 Direct Environmental Impacts

### Direct Environmental Benefits

The proposed measure reduces LPDs, which lowers energy use and yields reduced GHG emissions. Some applications may also require fewer luminaires as a result of the lower LPDs, which would result in reduced material usage and associated emissions such as manufacturing, transportation, and end-of-life impacts. The proposed measure also reduces material usage and associated lifecycle emissions by updating requirements for existing luminaires. Specifically, the proposed measure allows certain luminaires to claim updated wattages when new lamps are retrofitted in these scenarios. This means some projects are more likely to simply replace lamps in existing luminaires instead of replacing the whole luminaires and installing new ones. Materials and associated lifecycle emissions are significantly reduced as a result, especially in scenarios where significant deconstruction and installation activities would have been required. An example scenario is where luminaires are installed in a concrete ceiling. Previously, the only way to claim lower wattage would have been to demolish the concrete to allow the entire luminaire to be replaced with a lower wattage luminaire. The proposed measure allows a new lower wattage lamp to simply be installed into the existing luminaire which yields significant material savings.

### Direct Adverse Environmental Impacts

The proposed code change would not result in any direct adverse environmental impacts.

## D.3 Indirect Environmental Impacts

### Indirect Environmental Benefits

The proposed code change would not result in any indirect environmental benefits.

## **Indirect Adverse Environmental Impacts**

The proposed code change would not result in any indirect adverse environmental impacts.

### **D.4 Mitigation Measures**

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of “specific economic, environmental, legal, social, and technological factors” (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore, did not develop any mitigation measures.

### **D.5 Reasonable Alternatives to Proposal**

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

### **D.6 Water Use and Water Quality Impacts Methodology**

This proposal has no impacts on water.

## Appendix E: Energy Cost Savings in Nominal Dollars

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The CEC requested energy cost savings over the 30-year period of analysis in both 2029 present value dollars (2029 PV\$) and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2029 PV\$. Costs and cost effectiveness in 2029 PV\$ are presented in Section 6 of this report. This appendix presents energy cost savings in nominal dollars.

Table 27: First Year Statewide Nominal Energy Cost Savings Impacts for New Construction and Additions and Alterations.

Primary Function Area	Statewide New Construction and Additions (Million sf/yr)	New Construction Nominal Energy Cost Savings (Million 30-year Nominal \$)	First-Year Statewide Alterations (Million sf/yr)	Alteration Nom Energy Cost Savings (Million 30-year Nominal \$)
Aging Eye/Low-vision:1 Corridor Area	0.04	\$0.00	0.14	\$0.00
Aging Eye/Low-vision:1 Dining	0.04	\$0.00	0.14	\$0.00
Aging Eye/Low-vision:1 Main Entry Lobby	0.04	\$0.47	0.14	\$1.76
Aging Eye/Low-vision:1 Lounge/Waiting Area	0.04	\$0.00	0.14	\$0.00
Aging Eye/Low-vision:1 Multipurpose Room	0.04	\$0.08	0.14	\$0.29
Aging Eye/Low-vision:1 Religious Worship Area	0.04	\$0.16	0.14	\$0.59
Aging Eye/Low-vision:1 Restroom	0.04	\$0.00	0.14	\$0.00
Aging Eye/Low-vision:1 Stairwell	0.04	\$0.00	0.14	\$0.00
Atria < 20 ft tall	0.35	\$4.88	1.31	\$18.38
Atria 20 to < 40 ft	0.17	\$1.39	0.69	\$5.55
Atria > 40 ft	0.02	\$0.05	0.09	\$0.19
Audience Seating Area	1.63	\$6.98	6.59	\$28.16
Auditorium Area	1.04	\$8.92	4.16	\$35.55
Auto Repair / Maintenance Area	2.36	\$0.00	14.14	\$0.00
Barber, Beauty Salon and Spa Area	0.25	\$1.00	1.39	\$5.54
Civic Meeting Room	0.08	\$0.54	0.67	\$4.28
Concourse	2.11	\$13.51	13.40	\$85.96
Convention Center: Ballroom	0.03	\$0.19	0.12	\$0.79
Convention: Exhibit Space	0.16	\$1.73	0.66	\$7.08
Convention: Meeting Room	0.16	\$0.69	0.66	\$2.83
Control room	0.15	\$0.46	0.37	\$1.17
Copy Room	1.20	\$1.60	4.27	\$5.71
Corridor Area	6.07	\$0.00	25.11	\$0.00

Primary Function Area	Statewide New Construction and Additions (Million sf/yr)	New Construction Nominal Energy Cost Savings (Million 30-year Nominal \$)	First-Year Statewide Alterations (Million sf/yr)	Alteration Nominal Energy Cost Savings (Million 30-year Nominal \$)
Data center: Computer room	2.80	\$8.90	9.62	\$30.51
Dining Area: Bar/Lounge and Fine Dining	0.28	\$1.76	1.01	\$6.30
Dining Area: Cafeteria/Fast Food	2.06	\$6.42	8.58	\$26.69
Dining Area: Family and Leisure	0.65	\$2.01	2.26	\$7.01
Education/Business: Classroom, Training,	7.01	\$8.81	27.38	\$34.42
Educational, civic: Multipurpose room (art, music etc.)	1.01	\$2.53	3.83	\$9.63
Electrical, Mechanical, Telephone Rooms	3.28	\$0.00	13.52	\$0.00
Exercise/Fitness Center and Gymnasium Area	2.69	-\$5.39	10.25	-\$20.52
Financial Transaction Area	1.46	\$4.67	5.04	\$16.19
Healthcare: Corridor	0.40	-\$2.05	1.70	-\$8.66
Healthcare: Exam/Treatment Room	1.93	\$3.28	8.24	\$14.00
Healthcare: Imaging Room	0.10	\$0.00	0.42	\$0.00
Healthcare: Medical Supply Room	0.07	\$0.12	0.30	\$0.50
Healthcare: Nursery	0.08	\$0.00	0.34	\$0.00
Healthcare: Nurse's Station	0.13	\$0.44	0.55	\$1.87
Healthcare: Operating Room	0.20	\$0.00	0.85	\$0.00
Healthcare: Patient Room - Critical care	0.11	-\$0.75	0.47	-\$3.18
Healthcare: Patient Room - General	0.28	\$0.00	1.19	\$0.00
Healthcare: Physical Therapy Room	0.16	\$0.54	0.67	\$2.31
Healthcare: Recovery Room	0.08	-\$0.41	0.34	-\$1.73
Kitchen/Food Preparation Area	2.24	\$13.92	9.30	\$57.83
Laboratory: Scientific and Teaching	0.52	\$2.38	2.48	\$11.33
Laundry Area	0.39	\$0.31	2.31	\$1.85
Library : Reading Area	0.29	\$0.75	1.08	\$2.81

Primary Function Area	Statewide New Construction and Additions (Million sf/yr)	New Construction Nominal Energy Cost Savings (Million 30-year Nominal \$)	First-Year Statewide Alterations (Million sf/yr)	Alteration Nominal Energy Cost Savings (Million 30-year Nominal \$)
Library : Stacks Area	0.24	\$0.60	0.90	\$2.25
Lobby: Main entry	4.44	\$37.96	18.11	\$154.92
Lobby: Performing Arts	0.28	\$2.42	1.15	\$9.86
Locker Room	0.99	\$1.98	4.48	\$8.97
Lounge, Breakroom, or Waiting Area	2.85	\$12.19	13.75	\$58.83
Manufacturing & Commercial Work Area: Low Bay	3.81	\$0.00	27.30	\$0.00
Manufacturing & Commercial Work Area: High Bay	1.43	\$0.00	13.00	\$0.00
Manufacturing & Commercial Work Area: Precision	0.29	\$0.45	2.60	\$4.12
Motion picture: Theater area	0.50	\$0.00	2.05	\$0.00
Museum: Exhibition/Display	0.22	\$1.85	0.89	\$7.64
Museum Area: Restoration Room	0.04	\$0.08	0.15	\$0.33
Office Area: ≤ 250 square feet	11.93	\$15.96	47.56	\$63.60
Office Area: > 250 square feet	13.32	\$17.81	47.58	\$63.64
Office: Conference Room	1.50	\$6.01	5.27	\$21.16
Parking Garage Area: Parking Zone and Ramps	18.49	\$33.42	38.02	\$68.73
Parking Garage Area: Daylight Adaptation Zones8	0.82	\$16.25	1.68	\$33.42
Performance: Theater area	0.50	\$3.22	2.04	\$13.06
Performance: Dressing room	0.03	\$0.06	0.12	\$0.26
Pharmacy Area	0.26	\$0.00	1.43	\$0.00
Retail: Grocery Sales	0.56	\$13.38	3.42	\$82.09
Retail: Merchandise Sales	16.63	\$99.88	110.66	\$664.47
Retail: Fitting Room	0.41	\$1.66	2.72	\$10.89
Religious Worship Area	0.99	\$8.52	4.11	\$35.17
Restrooms	4.26	\$0.00	18.63	\$0.00

Primary Function Area	Statewide New Construction and Additions (Million sf/yr)	New Construction Nominal Energy Cost Savings (Million 30-year Nominal \$)	First-Year Statewide Alterations (Million sf/yr)	Alteration Nominal Energy Cost Savings (Million 30-year Nominal \$)
Stairwell	1.86	\$0.00	7.66	\$0.00
Sports Arena – Playing Area: Class I Facility <sup>11</sup>	0.07	\$0.00	0.29	\$0.00
Sports Arena – Playing Area: Class II Facility <sup>11</sup>	0.00	\$0.00	0.00	\$0.00
Sports Arena – Playing Area: Class III Facility <sup>11</sup>	0.00	\$0.00	0.00	\$0.00
Sports Arena – Playing Area: Class IV Facility <sup>11</sup>	0.00	\$0.00	0.00	\$0.00
Transportation: Baggage Area	0.02	\$0.00	0.08	\$0.00
Transportation: Ticketing Area	0.04	\$0.09	0.17	\$0.35
Transportation: Waiting area	0.08	\$0.69	0.33	\$2.83
Videoconferencing Studio <sup>12</sup>	0.35	\$1.86	1.26	\$6.74
Warehouse: Storage	17.35	\$0.00	83.02	\$0.00
Warehouse: Shipping and Handling	4.00	\$0.00	19.15	\$0.00
<b>Totals</b>	<b>152.84</b>	<b>\$367.23</b>	<b>666.07</b>	<b>\$1,706.33</b>

# Appendix F: Summary of Stakeholder Engagement

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## F.1 Introduction to Stakeholder Engagement

Collaborating with stakeholders who may be affected by proposed code changes is a core component of the Statewide CASE Team process. The Statewide CASE Team engages interested parties to identify and address issues related to the proposals, with the goal of submitting recommendations to the CEC. The recommendations in this CASE Report reflect broad technical input and stakeholder engagement. Public stakeholders provide valuable feedback on draft analyses and help identify and address adoption challenges, including cost effectiveness, market and technical barriers, compliance and enforcement considerations, and potential impacts on human health or the environment. Some stakeholders also provide project experience, design practice insights, and technical data that the Statewide CASE Team uses to refine assumptions and support analyses.

This appendix summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations, including participation in utility-sponsored stakeholder meetings, live polling activities, and written comments submitted during webinars.

## F.2 Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity for stakeholders to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals being evaluated for the 2028 Title 24 code cycle. The goal of these meetings is to solicit input on proposals early enough in the process to ensure the proposals and supporting analyses are well vetted and have as few outstanding issues as possible prior to submission of the Draft CASE Report.

To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results of energy and cost-effectiveness analyses
- Data to support modeling assumptions
- Compliance and enforcement considerations
- Technical feasibility and market readiness

To date, the Statewide CASE Team has hosted one utility-sponsored stakeholder meeting focused on LPD and Luminaire Classification and Power measures via webinar, as described in Table 28. Please see below for dates and links to event pages

on [Title24Stakeholders.com](https://Title24Stakeholders.com). Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

**Table 28: Utility-Sponsored Stakeholder Meetings**

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of LPD and Luminaire Classification Utility-Sponsored Stakeholder Meeting	September 24, 2025	Update 1) the prescriptive requirements for allowed lighting power density for nonresidential indoor spaces, and 2) the luminaire classification and adjusted indoor lighting power determination.
Second Round of LPD and Luminaire Classification Utility-Sponsored Stakeholder Meeting	March 19, 2026	Presentation of refined code proposals, preliminary analysis results, and updated draft code language.

### First Round Stakeholder Meeting Summary

The first round of utility-sponsored stakeholder meetings began in September 2025 and served as an early forum to promote transparency and gather stakeholder feedback on measures under consideration by the Statewide CASE Team. The objectives of the first round of stakeholder meetings were to:

- Solicit input on the scope of the proposed code changes for the 2028 code cycle
- Request data and feedback on approaches, assumptions, and methodologies used in energy impacts and cost-effectiveness analyses
- Identify potential technical, market, and compliance barriers.
- Present and collect feedback on preliminary draft code language

#### *Lighting Power Density*

During the first-round stakeholder meeting, stakeholders participated in several live polling questions designed to better understand current lighting design practices and assumptions used in lighting calculations. Poll questions focused on topics such as lamp lumen depreciation (LLD) factors, total light loss factors (LLF), compliance pathways for lighting power allowances, and the use of additional power allowances and power adjustment factors.

Results from these polls indicated a wide range of stakeholder familiarity with lighting design assumptions. For example, when asked about the LLD factor typically applied in indoor lighting applications, approximately 19 percent of respondents indicated values

of 0.90 or greater, while 20 percent selected values between 0.8 and 0.85. A majority of respondents indicated that the question was not applicable to their role with 62 percent, suggesting that many meeting participants were not directly involved in lighting calculations.

Similarly, when asked about the LLF used in typical clean indoor environments such as offices, responses varied, with approximately 19 percent indicating an LLF around 0.8, while most respondents (69 percent) indicated the question was not applicable to their work.

Additional polls explored how frequently lighting projects require compliance trade-offs using performance modeling software. Responses suggested that performance trade-offs are used occasionally but are not the dominant compliance pathway for most projects worked on by stakeholders at the first stakeholder meeting.

Participants were also asked how frequently additional lighting power allowances (such as decorative or tunable white lighting allowances) and power adjustment factors are used to comply with lighting budgets. The majority of respondents indicated that these tools were either used only occasionally or were not applicable to their projects, suggesting that most lighting designs generally comply within standard prescriptive lighting power limits.

Another poll asked stakeholders about the ratio of installed lighting power to allowed lighting power in a typical project. Responses suggested that many projects operate near the allowable lighting power limit, with 25 percent of respondents reporting installed power levels between 90 and 100 percent of the allowed power.

Stakeholders also provided qualitative feedback through open-ended responses. One respondent noted that projects involving high-quality lighting designs with RGB color capability or tunable correlated color temperature (CCT) may experience more difficulty complying with standard lighting power allowances due to the additional power requirements associated with these features.

### ***Luminaire Classification and Power***

The meeting also included polling and discussion regarding proposed changes to luminaire wattage determination for retrofit situations. Stakeholders were asked about preferred approaches for verifying luminaire wattage labeling when retrofits occur.

The majority of respondents (58 percent) preferred a flexible approach allowing either lamp labeling or luminaire manufacturer labeling, while 17 percent supported using only lamp labels, and 25 percent supported using only manufacturer-supplied luminaire labels.

Stakeholders were also asked when and how compliance with new wattage labeling requirements should be verified. Responses were distributed across several verification approaches:

1. 38 percent preferred verification during both plan review and inspection.
2. 31 percent preferred verification during field inspection only.
3. 23 percent preferred documentation verification during plan review only.
4. 8 percent preferred other.

In addition to polling, stakeholders submitted questions and comments through the webinar chat and Q&A functions. These discussions provided additional insights into technical considerations related to lighting equipment performance, retrofit practices, and compliance approaches.

Several stakeholders commented on LED driver reliability and actual equipment lifetime, noting that some field installations may not achieve the commonly assumed 50,000-hour lifetime used in lighting calculations. These comments highlighted the importance of considering real-world equipment performance when establishing lighting system assumptions.

Other stakeholders raised questions about the environmental and cost implications of different retrofit approaches, including Type A LED retrofit lamps. Participants noted that while Type A retrofits may not provide the highest energy savings, they can be a practical and cost-effective upgrade for facilities with limited budgets.

Stakeholders also discussed compliance challenges related to selectable-wattage luminaires and the need for clear guidance on how adjustable-output luminaires should be treated in lighting power calculations. Participants suggested that if wattage selection mechanisms cannot be permanently locked, the maximum selectable wattage should be used for compliance purposes.

These polls and discussions provided valuable insights into potential compliance challenges and areas where additional guidance in the compliance manuals or supporting documents may be beneficial.

Table 29 summarizes this feedback from the Utility-Sponsored Stakeholder Meeting on September 24, 2025. Stakeholders provided input on the potential benefits of allowing reuse of existing luminaires with replaceable lamps, as well as questions and concerns related to compliance, Type A retrofit lamps, and wattage calculations for selectable-output solid-state lighting (SSL) products.

**Table 29: Summary of Manufacturers and Facility Teams Feedback during First Stakeholder Meeting**

Category	Stakeholder Feedback	Notes
Support / Benefits	General support for reusing existing luminaires with replaceable lamps	“Glad to see that luminaires with removable lamps will be allowed. We have experienced a lot of early failure of LEDs so replacing lamps only is our preferred option for reducing cost and avoiding waste.”
Concerns / Questions	Compliance with retrofit using SSL and existing luminaires	If retrofit lamps use existing ballasts (e.g., Type A), actual energy savings may not reflect intended reductions because input ballast power, not new LED lamp power, determines wattage.
	Clarity regarding Type A retrofit lamps	Draft language does not explicitly mention Type A; recommended to clearly state in standard or compliance manual whether Type A is allowed or disallowed.
	Wattage calculation for selectable-output SSL luminaires	For adjustable-output luminaires, if output can be locked, selected wattage may be used; otherwise, maximum selectable wattage governs compliance.

## Second Round Stakeholder Meeting Planning

The second round of utility-sponsored stakeholder meetings took place March 19, 2026, where updated details on proposed code changes were provided. These meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

### Lighting Power Density

During the second-round stakeholder meeting, stakeholders participated in several live polling questions designed to better understand costs. Poll questions covered costs related to luminaires. Poll results indicated that sometimes higher efficacy luminaires have lower costs, but that mostly, participants did not evaluate bid pricing and therefore didn't have input.

Stakeholders provided feedback on two areas during the question and answer section of the meeting. The first item was that lighting equipment is replaced sooner than 30 years. The other item was surrounding costs. The Statewide CASE Team clarified that they are looking specifically at incremental costs and that labor and other costs would not be impacted because the same activities are needed to adhere to the proposed wattage allowances compared to the current 2025 wattage allowances. In other words, the only differences in costs would be equipment costs. One stakeholder suggested that there might be a difference in costs associated with and without pulling a permit.

## ***Luminaire Classification and Power***

Stakeholders commented on two areas related to luminaire classification and power during the discussion portion of the second-round stakeholder meeting. First, a stakeholder noted that for Type A linear LED lamps, the wattage should be based on the lamp and not the ballast.

The second comment was surrounding the move from an area threshold to a wattage threshold for the one-to-one luminaire alteration pathway. The stakeholder questioned whether the wattage threshold should be 2,000 watts instead of 3,000 watts. The Statewide CASE Team explained that the current pathway is allowable only for spaces that are 5,000 square feet or less. The proposed change to a 3,000 watt threshold is based on an analysis of typical legacy lighting conditions. Specifically, a legacy lighting power density of one watt per square foot would yield 5,000 watts of installed lighting in a 5,000 square foot space. The one-to-one replacement requires a 40 percent reduction in wattage, which is equal to 3,000 watts. Therefore, a wattage threshold of 2,000 watts would be a 60 percent reduction, which is more stringent than the existing square footage threshold. Another commenter noted that they thought the threshold should be based on real world testing of savings achieved through this pathway on average.

## **Stakeholder Outreach and Participation**

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from [info@title24stakeholders.com](mailto:info@title24stakeholders.com). One email was sent to the full Title 24 Stakeholders listserv, which includes more than 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from a diverse industries and trades, such as manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was announced on the Title 24 Stakeholders LinkedIn page and cross-promoted on the CEC LinkedIn page approximately two weeks in advance to engage individuals, organizations, and broader channels outside beyond the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers, individual comments, and results from live attendee polls to help evaluate stakeholder participation and support.

## **F.3 Targeted Statewide CASE Team Communications**

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report.

## Manufacturer and Facility Team Outreach

Specific to manufacturers and facility teams, the Statewide CASE Team communicated with six organizations. One organization represented four individuals, for a total of nine individual responses. A summary of the stakeholder feedback is provided below as well as the survey tool used to guide the discussions.

### *Survey Questions for Manufacturer and Facility Teams*

#### Questions About the Accuracy of Luminaire Specification Documentation

- **1a.** Is the data provided on cut sheets for luminaires introduced three to five years ago representative of the current efficacy of those luminaires?
- **1b.** Have IES photometry files been updated for luminaires originally introduced three to five years ago?
- **1c.** For older luminaires that are still in production, are the original LED chip sets still being used, or have the luminaires been upgraded with newer, more efficient LED chips?
- **1d.** Is the efficacy data provided on cut sheets representative of luminaires that were introduced within a two-year window?

#### Questions About Lumen Depreciation and 80 CRI Versus 90 CRI Efficacy

- **2a.** What luminaire lumen depreciation factor do you provide on luminaire specification sheets and other documentation?
- **2b.** If you do not provide official lumen depreciation values in your documentation, what do you consider to be a valid depreciation factor for LED luminaires at 50,000 hours?
- **2c.** Are the efficacies of 90+ CRI LEDs increasing more rapidly than the efficacies of 80 CRI LEDs? What is the ratio of efficacy for 90+ CRI luminaires compared to their 80 CRI counterparts?
- **2d.** Does your company offer downlight and accent light luminaires targeted for retail, high-end restaurants, and hospitality with 90+ CRI luminaires as the baseline?
- **2e.** If you offer luminaires with 90+ CRI as the baseline, what is the efficacy, in lumens per watt, of those luminaires?

#### Questions About Multi-Wattage Luminaires

- **3a.** Do you offer multi-wattage luminaires in your current product line?

- **3b.** The proliferation of multi-wattage luminaires has resulted in the Statewide CASE Team investigating how these luminaires should be addressed for California Title 24 code compliance. Options under consideration include:
  1. Require manufacturers to provide switches mounted on the underside of the luminaire. Some luminaires already use this approach; however, this option may only apply to recessed or surface-mounted luminaires.
  2. Require manufacturers to provide multi-wattage luminaires with break-off handles or tabs on selector switches, such as DIP switches, as a California-certified product.
  3. Require multi-wattage luminaires with various lumen or color outputs to be connected to a current limiter subpanel when specified on code compliance projects. This is similar to the current limiter concept applied to track lighting.
  4. Require multi-wattage luminaires to be rated at the highest wattage option. This option may result in some applications being unable to comply.

Which option do you prefer to address code compliance for multi-wattage luminaires?

- **3c.** Do you have any other thoughts or recommendations for how the Energy Code should address the use of multi-wattage luminaires?

## Questions About LED Retrofit Lamps

### Type A, Type B, Type C, and Selectable CCT / Lumen Output

- **4a.** Do you offer LED retrofit lamps as replacements for fluorescent and/or HID lamps? If yes, which type of LED retrofit lamps do you offer?
  - Type A
  - Type B
  - Type C
- **4b.** Type B and Type C LED retrofit lamps can be as efficient as LED luminaires. However, Type A LED retrofit lamps are less efficient because the ballast remains in the system. Code compliance options being considered for Type A lamps include:
  1. Allow Type A retrofit lamps in existing fluorescent or HID luminaires but require ballast input watts to be based on the rated wattage of the ballast with the legacy light source, with no credit for TLED lamp wattage.

2. Do not allow Type A LED retrofit lamps on nonrepair projects, such as remodels.

Which option do you prefer?

- **4c.** Do you have other thoughts or comments regarding the use of LED retrofit lamps on projects where code compliance is required?

### **Questions About Multi-Wattage LED Retrofit Lamps**

- **5a.** Do you offer multi-wattage LED retrofit lamps with multiple CCT options or multiple brightness levels?
- **5b.** The proliferation of multi-wattage LED retrofit lamps has resulted in the Statewide CASE Team investigating how these lamps should be addressed for code compliance. Options under consideration include:
  - Require manufacturers to provide multi-wattage lamps or drivers with break-off tabs as a California-certified product.
  - Require multi-wattage lamps to be rated at the highest wattage option. This option may result in some applications being unable to comply.
- **5c.** Do you have other thoughts or comments regarding the use of multi-wattage LED retrofit lamps on projects requiring code compliance?

### ***Summary of Stakeholder Feedback from Manufacturers and Facility Teams***

Stakeholder engagement revealed broad support for maintaining clear and enforceable wattage determination rules for multi-wattage luminaires, with most designers already complying at the maximum selectable wattage and manufacturers favoring this approach for simplicity. However, stakeholders expressed strong opposition to break-off tabs and current limiter requirements, citing inspection challenges, cost, and reduced flexibility. Some designers advocated for limited flexibility pathways, such as allowing commissioned set wattage if verifiable.

With respect to LED retrofit lamps, Type A products remain widely used due to cost and funding flexibility, particularly in institutional settings. Manufacturers generally support their continued allowance, though designers are divided on whether ballast-input wattage should be required or if use should be restricted in nonrepair projects.

Concerns were raised that overly restrictive treatment of retrofit lamps could increase costs and slow fluorescent-to-LED transitions. Type B lamps are commonly used but raise safety concerns in some settings, while Type C lamps are viewed by many as safer and more reliable, despite occasional early driver issues. Across stakeholders, there was consistent emphasis on avoiding adoption barriers and preserving practical compliance pathways.

Detailed individual responses are provided in Table 30.

**Table 30: Engaged Stakeholders—Manufacturers and Facility Teams**

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
<b>Manufacturer Representative 1</b>	Manufacturer Representative	Connected the Statewide CASE Team with Manufacturer 2 below.
<b>Manufacturer Representative 2</b>	Manufacturer Representative	No response
<b>Manufacturer Representative 3</b>	Manufacturer Representative	No response
<b>Manufacturer Association 1</b>	Manufacturer Association	Response received from four anonymous members regarding luminaire classification and power. Most respondents offer multi-wattage luminaires and retrofit lamps (Types A/B/A+B, some C) and generally support rating products at the highest selectable wattage for code compliance to preserve flexibility and reduce waste; Type A lamps should remain allowed (not limited to repairs), though opinions differ on using ballast-rated wattage due to accuracy concerns; break-off tabs are largely discouraged. Programming is reported to occur primarily at the factory or supplier level, with limited field or distributor involvement and typically under manufacturer-controlled processes. While field-selectable output is common, practical use of programming tools outside controlled settings is limited. Labeling approaches vary (lamp, field, or flexible), with a mix of durable factory-applied labels and supplemental, less permanent labels; concerns persist that field-applied labels may be overlooked. Safeguards for downstream labeling are limited, with some reliance on AHJ review or project documentation. UL listings are generally tied to factory configurations, with any changes expected to remain within evaluated limits. At least one respondent recommends verification at both plan check and inspection, emphasizing installer responsibility when manufacturers provide required documentation.
<b>University 1</b>	Higher Education Campus	A university facilities team reported that Type A LED retrofits are widely used due to cost and funding flexibility, while Type B (ballast bypass) is prohibited for safety reasons; labor costs depend on project scale and timing (with higher costs for contractor, night, or weekend work); Type A systems face maintenance issues including 3–5 year driver failures and discontinued lamp/ballast tracking; Type C is preferred for longevity but has seen early driver failures in some applications; overall, policy should

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
		enable practical, cost-effective fluorescent-to-LED transitions without creating adoption barriers.
<b>Manufacturer 1</b>	Luminaire Manufacturer	The manufacturer indicated that higher-efficacy (HE) luminaires achieve the same lumen output at lower wattage primarily by using more LEDs operated at lower drive currents, sometimes with additional boards depending on the product, resulting in modest (6—10 lm/W) efficacy gains and slight thermal benefits; HE products use the same core components with no performance trade-offs beyond a small, market-dependent cost premium, face no lead-time constraints, and represent a small share of overall sales, with limited growth expected as baseline LED efficacy continues to improve and rebate influence declines.
<b>Manufacturer 2</b>	Luminaire Manufacturer	The manufacturer reported that programming of luminaires with programmable drivers is conducted at the factory, with field adjustments limited to controlled, manufacturer-supported processes using factory-issued tools and not typically performed by representatives or distributors. Labeling depends on when final settings are established; labels may be provided in advance or applied post-installation by installers, resulting in some labeling occurring outside the factory with limited formal verification beyond manufacturer–installer communication. UL certification labels remain unchanged regardless of downstream programming, provided configurations stay within rated limits.

**Lighting Designer Outreach**

Specific to lighting designers, the Statewide CASE Team invited 14 individuals to participate in the survey. At the time of this report, six responses had provided responses. A summary of the stakeholder feedback is provided below as well as the survey tool used to guide the discussions.

**Survey Questions for Lighting Designers**

**Questions About the Accuracy of Luminaire Manufacturer Specification Documentation**

- **1a.** Is the data provided on cut sheets representative of the current efficacy of luminaires that manufacturers introduced 3 to 5 years ago?
- **1b.** Is the data provided on cut sheets representative of the efficacy of luminaires that manufacturers recently introduced, within a 2-year window?

- **1c.** Have IES photometry files been updated for luminaires originally introduced 3 to 5 years ago?
- **1d.** Do you find luminaire performance better, worse, or the same when modeling luminaires using available IES photometry files?

### Questions About Lumen Depreciation and 80 CRI Versus 90 CRI Efficacy

- **2a.** What luminaire lumen depreciation factor do you find in manufacturer documentation?
- **2b.** What luminaire lumen depreciation factor do you use in your lighting design applications?
- **2c.** For the luminaires you specify, what percentage efficacy difference do you find between 80 CRI and 90 CRI products?
- **2d.** Do you find that luminaires targeted for retail, high-end restaurants, and hospitality now offer 90+ CRI luminaires as the baseline?

### Questions About the Difficulty of Title 24 Code Compliance

- **3a.** What Lamp Lumen Depreciation (LLD) factor do you typically apply to indoor lighting applications? LLD is the reduction in light output over the life of the luminaire, typically around 50,000 hours. Select the closest option:
  - 0.90 or greater
  - 0.85
  - 0.80
  - 0.75 or less
  - Not applicable to me
- **3b.** What Total Light Loss Factor (LLF) do you typically apply for clean indoor lighting applications, such as offices? Initial illuminance multiplied by LLF is the maintained illuminance. Typically, LLF is the product of lamp lumen depreciation, luminaire dirt depreciation, and room surface dirt depreciation. Select the closest option:
  - 0.90 or greater
  - 0.80
  - 0.70
  - 0.60 or less
  - Not applicable to me
- **3c.** How frequently are your projects unable to comply using the lighting allowances, requiring trade-offs with other building components through the performance software approach?
  - Never

- Rarely
- Sometimes
- Usually
- Not applicable to me
- **3d.** How frequently must you use additional power allowances, such as decorative/display lighting or tunable white lighting, to comply with lighting budgets?
  - Never
  - Rarely
  - Sometimes
  - Usually
  - Not applicable to me
- **3e.** How frequently must you use power adjustment factors to comply with lighting budgets?
  - Never
  - Rarely
  - Sometimes
  - Usually
  - Not applicable to me
- **3f.** For a typical or average lighting project, what is the ratio of installed power to allowed power?
  - Greater than 100 percent, meaning PAFs or performance trade-offs are needed
  - 90 percent to 100 percent
  - 80 percent to 89 percent
  - 70 percent to 79 percent
  - Lower than 70 percent
  - Not applicable to me
- **3g.** Which types of designs or design features have difficulty complying with lighting power allowances? Open-ended response.
- **3h.** What fraction of the time do you fill out Title 24 lighting compliance documentation?
  - Greater than 90 percent of the time
  - 75 percent to 90 percent
  - 50 percent to 75 percent
  - 25 percent to 50 percent
  - Under 25 percent of the time
  - Never
- **3i.** When you do not fill out the Title 24 lighting documentation, who does? Select all that apply:

- California Energy Analyst (CEA)
- Electrical Engineer
- Mechanical Engineer
- Architect
- Owner's representative
- Other, please describe role

### Questions About Color- and Light Output-Selectable Luminaires

- **4a.** Do you use multi-wattage luminaires in your current design applications?
- **4b.** Have you used multi-wattage luminaires on projects requiring code compliance? If yes, how did you demonstrate compliance?
- **4c.** The proliferation of output-selectable luminaires has resulted in the Statewide CASE Team developing proposals to address these products for code compliance. Options under consideration include:
  1. Require a multi-wattage luminaire to be rated at the highest wattage option. This option may result in some applications being unable to comply.
  2. Require manufacturers to provide multi-wattage luminaires with break-off tabs as a California-certified product.
  3. Require manufacturers to provide lumen selection switches on the underside of recessed or surface-mounted luminaires. Some luminaires already include switches in this location.
  4. Require output-selectable luminaires with various lumen or wattage outputs to be connected to a current limiter sub-panel. This is similar to the current limiter concept applied to track lighting.

Which option do you prefer to address code compliance for multi-wattage luminaires?

- **4d.** Do you have any other recommendations for how the Energy Code should address user-selectable CCT and/or light output luminaires?

### Questions About LED Retrofit Lamps

#### Type A, Type B, Type C, and User-Selectable CCT / Lumen Output

- 1) **5a.** Do you use LED retrofit lamps as replacements for fluorescent and/or HID lamps? If yes, which type of LED retrofit lamps do you use? Select all that apply:
  - a. Type A—Power to the LED is provided by the existing fluorescent ballast.
  - b. Type B—The ballast is bypassed or removed, and line voltage is rewired to the LED source.
  - c. Type C—The ballast is replaced with a dedicated driver that delivers power to the LED.

2) **5b.** Type B and Type C LED retrofit lamps can be as efficient as LED luminaires. However, Type A LED retrofit lamps are less efficient because the ballast remains in the system. Code compliance options being considered for Type A lamps include:

1. Allow Type A retrofit lamps in existing fluorescent or HID luminaires, but require ballast input watts as the rated wattage of the ballast with legacy sources, rather than using the lamp wattage. For example, a 2-lamp ballast with a ballast factor of 1.0 originally intended for use with T8 fluorescent lamps would need to report its rated wattage of  $64\text{ W} + 4\text{ W} = 68\text{ W}$ .
2. Do not allow Type A LED retrofit lamps on projects requiring code compliance.
3. Other, please describe.

Which option do you prefer?

3) **5c.** Do you have other thoughts or comments regarding the use of LED retrofit lamps on projects where code compliance is required?

### **Questions About Multi-Wattage LED Retrofit Lamps**

- **6a.** Do you specify multi-wattage LED retrofit lamps? If yes, have you used these lamps on projects requiring code compliance? If yes, how did you demonstrate compliance?
- **6b.** The proliferation of multi-wattage LED retrofit lamps has resulted in the Statewide CASE Team developing proposals to address these products for code compliance. Options under consideration include:
  - Require manufacturers to provide multi-wattage LED retrofit lamps with break-off tabs as a California-certified product.
  - Require multi-wattage LED retrofit lamps to be rated at the highest wattage option. This option may result in some applications being unable to comply.
- **6c.** Do you have other thoughts or comments regarding the use of multi-wattage LED retrofit lamps on projects requiring code compliance?

### ***Summary of Stakeholder Feedback from Lighting Designers***

Preliminary data collected from the lighting designer focus group surveyed is as follows:

**Accuracy of Manufacturers data on specification cut sheets.** While the general trend is that data is accurate, most designers felt the manufacturer's performance data was often conservative. Manufacturers understate performance to avoid potential liabilities.

**Luminaire lumen depreciation factor used for your design applications.** Most of the designers use 0.9 LLD, a few use 0.85 LLD. When asked the total Light Loss Factor (LLF) the consensus was 0.85 to 0.80 LLF.

**Use of additional power allowances and adjustment factors.** Most of the designers surveyed to date said they usually must use these allowances and factors to meet code compliance.

**Multi-Wattage Luminaires with User Selectable CCT and Lumen Outputs.** Several designers stated that they specify this type of luminaire with the primary application being when project budgets are an issue. Of those designers using these luminaires most said they complied with code at the highest rated full power output. One designer said they would like to have the code allow use of average power output for compliance. None of them liked the idea of break off taps to set allowed watts for compliance. In instances when maximum power output cause compliance issues designers suggested that current limiter panels or dimming controls be used to meet code compliance.

**Questions about LED Retrofit Lamps.** Most designers, when using retrofit LED lamps, prefer the type B product. A few designers were also okay with type A LED retrofit lamps when project budgets were an issue or on small, limited area retrofit projects. One designer expressed the concern that the use of type B lamps is a safety issue, especially if the installation is in 277V input system. This designer only uses the type C LED retrofit lamps as type A retrofit lamp installations are sometimes unreliable and older legacy fluorescent luminaires are subject to ongoing maintenance issues.

**Questions About Multi-Wattage LED Retrofit Lamps.** As with luminaires with user selectable CCT and lumen outputs, designers that specify this type of LED retrofit lamps of those designers using these luminaires said they complied with code at the highest rated full power output. One designer, however, said they would like to have the code allow use of average power output for compliance. None of them liked the idea of breaking off taps to set allowed watts for compliance. When requiring maximum power output caused compliance issues, they suggested adjusting power output to meet compliance by using current limiter panels or dimming controls to meet code compliance.

Detailed individual responses are provided in Table 31.

**Table 31: Engaged Stakeholders—Lighting Designers**

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
Lighting Designer 1	Lighting Designer	Response pending.
Lighting Designer 2	Lighting Designer	Response pending.

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
<b>Lighting Designer 3</b>	Lighting Designer	Response pending.
<b>Lighting Designer 4</b>	Lighting Designer	<p>The stakeholder indicated that manufacturer cut sheet efficacy data is generally representative of both older and recently introduced luminaires, though IES files are not always updated; modeled performance aligns with expectations. They typically apply a 0.90+ LLD and ~0.81 LLF, rarely require trade-offs or additional allowances to meet Title 24, and report installed lighting power typically at 90–100% of allowed levels.</p> <p>Compliance challenges arise primarily with indirect lighting designs. The respondent specifies 90+ CRI products as standard and uses selectable-output luminaires, demonstrating compliance at full output. For multi-wattage luminaires, they prefer rating at the highest wattage option and suggest lower wattage allowances when connected to dimming controls.</p> <p>They strongly favor Type C LED retrofit lamps (for safety and performance), recommend disallowing Type A and B for code-compliant projects, and do not specify multi-wattage retrofit lamps, instead recommending controls that limit maximum installed wattage.</p>
<b>Lighting Designer 5</b>	Lighting Designer	<p>The stakeholder generally finds manufacturer cut-sheet efficacy data representative, but notes that rapid LED improvements make it challenging for specifications to stay current; they verify photometric file dates and adjust factors when discrepancies arise. They report an approximate ±15% efficacy difference between 80 and 90 CRI products and observe that 90+ CRI is quickly becoming the standard in hospitality and retail applications. They typically apply ~0.9 LLD and 0.8 LLF values.</p> <p>From a compliance standpoint, they indicate projects rarely require trade-offs, but hospitality projects with significant decorative lighting components can present challenges. They prefer early coordination with engineers to establish compliance strategies. Installed power ratios and use of adjustment factors were generally marked as limited or not applicable.</p> <p>The respondent does not currently use selectable-output luminaires but recognizes their potential value; when used on code projects, compliance has been demonstrated via annotated spec sheets. For LED retrofit lamps, they typically use Type B and prefer</p>

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
		allowing Type A under the option that counts ballast input wattage. They do not currently specify multi-wattage retrofit lamps and offered no additional recommendations regarding multi-tap luminaires or retrofit controls.
<b>Lighting Designer 6</b>	Lighting Designer	Response pending.
<b>Lighting Designer 7</b>	Lighting Designer	Response pending.
<b>Lighting Designer 8</b>	Lighting Designer	<p>The stakeholder generally believes manufacturers update cut sheets to reflect current information, particularly for recently introduced products, though IES files are only sometimes updated. They rely on current photometric files and expect modeled performance to align with those files. Rather than focusing on manufacturer-stated lumen depreciation, they apply a total LLF in design practice.</p> <p>They report continued use of 80 CRI products due to cost and energy considerations, while acknowledging that 90+ CRI luminaires are common in retail and hospitality. They do not apply LLD separately and typically use an LLF around 0.85. Projects sometimes require trade-offs, though this respondent noted they are not responsible for completing Title 24 documentation.</p> <p>From a compliance perspective, they indicated more frequent use of additional power allowances and adjustment factors, with installed power typically in the 90–100% range of allowed power. Designs that must also meet health codes (e.g., commercial kitchens and public restrooms) present the most compliance challenges.</p> <p>They use selectable-output luminaires in commercial kitchens and retail projects and demonstrate compliance by using the highest wattage setting. Among proposed code approaches for multi-wattage luminaires, they consider rating at the highest wattage the most reasonable and have not had compliance issues using that method; they view visible switches as undesirable and current limiters as adding unnecessary cost.</p> <p>The respondent does not use LED retrofit lamps but notes that retail projects frequently use Type A, B, and hybrid lamps. They oppose restrictions that would penalize owners for retrofitting to lower-wattage LED</p>

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
		<p>sources and question the need for strict limitations when energy use is reduced. They have not used multi-wattage retrofit lamps but believe replacing higher-wattage legacy sources with lower-wattage LEDs inherently provides an energy benefit.</p>
<p><b>Lighting Designer 9</b></p>	<p>Lighting Designer</p>	<p>The stakeholder believes luminaire efficacy has improved significantly in recent years, though it is not always clear whether improvements are reflected consistently on cut sheets. They note that IES file updates can be difficult to verify and feel photometric files may sometimes underperform relative to installed results, potentially due to LLF assumptions or conservative manufacturer reporting. Manufacturer documentation often includes factors for finish, CRI, and CCT, and the respondent typically applies ~0.9 LLF for interiors and ~0.85 for exteriors.</p> <p>They report that efficacy differences between 80 and 90 CRI products can vary, sometimes up to ~17%, and agree that 90+ CRI appears to be becoming the baseline in hospitality and retail applications.</p> <p>From a compliance standpoint, they typically apply 0.90+ LLD and around 0.90 total LLF for interiors. Projects sometimes require trade-offs, particularly in hospitality work. Restrooms, hotel/dwelling corridors, and tape light applications are described as especially difficult to bring into compliance due to decorative layering and driver/linear footage calculation challenges. Additional power allowances and adjustment factors are used frequently, and installed power can exceed allowances, relying on extra allowances to achieve layered lighting designs (often dimmed in practice).</p> <p>They use selectable-output luminaires frequently, particularly cost-conscious downlights, and typically count them at maximum wattage for compliance. While they see merit in multiple compliance approaches for multi-wattage luminaires, they question practicality and cost impacts of certain options (e.g., underside switches, current limiters). They suggest the possibility of using average wattage for compliance or actual commissioned set wattage if verifiable and emphasize flexibility for low-budget projects.</p> <p>For LED retrofit lamps, they sometimes use them (Type B noted as most common). They favor allowing Type A retrofits under the ballast-input-wattage</p>

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
		<p>method but advocate exemptions or flexibility for small retrofit budgets so as not to discourage energy-saving upgrades. They believe code should be more lenient for modest retrofit projects, as overly stringent requirements can delay improvements and negatively impact lighting quality.</p> <p>They have not yet specified multi-wattage retrofit lamps but see potential user benefits (stocking one lamp for multiple applications). They caution against penalizing users for selecting adjustable lamps in fixtures originally rated for higher wattages and recommend practical compliance pathways (e.g., using maximum wattage if required but recognizing retrofit energy reductions). Overall, they emphasize keeping compliance achievable to avoid discouraging energy-efficient upgrades.</p>
<b>Lighting Designer 10</b>	Lighting Designer	<p>The stakeholder generally finds manufacturer data accurate, though IES updates vary by product. Modeled performance typically matches expectations. Applied LLF values depend on space type, commonly around 0.95–0.90 for generic spaces.</p> <p>They note that 90+ CRI is typical for higher-end retail and hospitality, but lower-budget projects often use 80 CRI due to cost. Compliance challenges are most common in small retail, restaurants, and boutique offices with layered lighting designs. They report always using additional allowances and adjustment factors when multiple lighting systems are present, with installed power often near the allowed limit.</p> <p>They frequently use selectable-output luminaires for flexibility and cost reasons and document required wattage/CCT clearly in specifications. They oppose rating multi-wattage luminaires at the highest setting and believe this reduces design flexibility. They support clear labeling and accountability in specifications instead of added hardware or restrictions.</p> <p>LED retrofit lamps are used infrequently in their projects. They believe retrofit solutions should be encouraged to reduce outdated technology and waste. They prefer dedicated-wattage lamps and caution that overly rigid code rules could limit flexibility, reduce design quality, and increase environmental waste.</p>
<b>Lighting Designer 11</b>	Lighting Designer	Response pending.

Organization/ Individual Name	Market Role	Mentioned in CASE Report Sections
<b>Lighting Designer 12</b>	Lighting Designer	<p>The stakeholder is uncertain about the accuracy of manufacturer efficacy data and does not typically perform lighting calculations themselves. They prefer specifying higher CRI and note that CRI is often driven by price rather than end-user priorities.</p> <p>They report that projects sometimes require trade-offs to comply. Additional power allowances are usually used. Decorative fixtures with replaceable A19 LED retrofit lamps create confusion around allowable wattage, and they describe the current system as unclear.</p> <p>They use selectable CCT luminaires but dislike break-off tabs (difficult to inspect and irreversible) and are skeptical of current limiters. They believe that if exact wattage is shown on plans, installers should follow the specification rather than adding additional hardware or restrictions. They question why designers should be penalized by requiring multi-wattage fixtures to be rated at the highest wattage.</p> <p>LED retrofit restrictions are viewed negatively. They believe prohibiting ballast-compatible retrofit lamps (UL Type A) increases costs and may discourage compliance, particularly for small businesses. They suggest manufacturers provide clearer compatibility and power data instead of restricting retrofit use.</p>
<b>Lighting Designer 13</b>	Lighting Designer	Response pending.
<b>Lighting Designer 14</b>	Lighting Designer	Response pending.

## Appendix G: Simplification and Updates of LPDs

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This proposal has addressed the complexity of the current Area Category formatting in four ways:

1. Compact the naming of building type/primary function area and adding a second set of additional lighting power density qualifications with their LPDs. If there are two additional lighting power allowances, this organization now results in many more primary function area allowances fitting on a single row.
2. Divide up broadly written primary function areas into more focused descriptions—this results in fewer additional lighting power allowances to account for multiple uses contained with a primary function area.
3. Simplify the allowances by removing vestiges of the tailored lighting method for space types that rarely used the tailored method when it was available.
4. Combine the allowances for retail and grocery decorative/display lighting that are multiplied by floor area.

### **Streamlined Format of Area Category Method Table**

The only updates to the Area Category LPDs during the 2025 Title 24, part 6 updates were to remove the Tailored Method lighting and insert the requirements into the Area Category Method. Additionally, due to the formatting requirements of the Americans with Disabilities Act, merged cells of more than one additional lighting power allowances were removed and replaced with multiple rows of allowances for the same space type. These 2025 Area Category Method updates resulted in Table 140.6-C being harder to decode. The revised table had multiple rows of lighting power allowances for the same primary function area with some allowances able to be layered on each other and other allowances intended only to be used once. This format is logical, but can be difficult to decode.

Many of the Area Category LPDs have a baseline LPD and two additional lighting power allowances. As an example, the second primary function area in the category method table, “Aging Eye/Low-vision: Dining” has additional lighting power allowances for Decorative/Display lighting and tunable white or dim to warm lighting. In the 2025 Title 24, part 6 energy code, the format of Table 140.6-C Area Category Method LPD table has a column for general lighting, a column describing qualifications for additional lighting power and the additional lighting power allowance. When there is more than one additional lighting power allowance, and added row is entered the general lighting power is duplicated and the additional lighting power allowance is described. With two additional lighting power allowances per row, one sees all the allowances in a single row for all applications except grocery and retail sales.

**Table 32: Sample First Three Function Areas of Proposed Format for Table 601.3-C1 [Table 140.6-C1] Area Category Method**

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System <sup>1</sup>	Additional Allowance <sup>1</sup> (W/ft <sup>2</sup> unless other units)	Additional Qualified Lighting System <sup>2</sup>	Additional Allowance <sup>2</sup> (W/ft <sup>2</sup> unless other units)
Aging Eye/Low-vision: <sup>1</sup> Corridor Area	0.60	Decorative/Display	0.30		
Aging Eye/Low-vision: <sup>1</sup> Dining	0.80	Decorative/Display	0.40	Tunable white or dim-to-warm <sup>2</sup>	0.10
Aging Eye/Low-vision: <sup>1</sup> Main Entry Lobby	0.80	Decorative/Display	1.10	Transition Lighting OFF at night <sup>3</sup>	0.80

When one gets to the retail lighting power allowances, where there are multiple ceiling heights to consider and multiple allowances, this proposal recommends replacing the current 9 rows of allowances for retail with 3 rows (one for each ceiling height) and an additional row for a display case allowance. Appendix H for more details on the revised metrics and how retail lighting allowances are displayed. The revised format is substantially less imposing and easier to decode.

With two additional columns and depending upon required font sizes for accessibility compliance, the proposed format may necessitate placing the table in landscape mode.

**Table 33: Sample First Three Function Areas of Table 601.3-C [Table 140.6-] Area Category Method LPDs Displayed in the 2025 Title 24, Part 6 Table Format.**

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Aging Eye/Low-vision <sup>10</sup>	Corridor Area	0.70	Decorative/Display	0.30
Aging Eye/Low-vision <sup>10</sup>	Dining	0.80	Decorative/Display	0.30
Aging Eye/Low-vision <sup>10</sup>	NA	0.80	Tunable white or dim-to-warm <sup>9</sup>	0.10
Aging Eye/Low-vision <sup>10</sup>	Lobby, Main Entry	0.85	Decorative/Display	0.30
Aging Eye/Low-vision <sup>10</sup>	Lobby, Main Entry	0.85	Transition Lighting OFF at night <sup>11</sup>	0.95
Aging Eye/Low-vision <sup>10</sup>	Lobby, Main Entry	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10

One of the considerations is that for compliance with AB 130 an area category table that has the 2025 LPDs must be maintained for *Group R Occupancies and Common Use or Public Use Areas*. This proposal retains the LPD values for the Group R table in the but

has reformatted used for the 2028 nonresidential LPDs for ease of use and consistent format. A comment arose about the desirability of having two formats for the tables.

## G.1 More Primary Function Areas

In the current standard, the Concourse and Atria Area covers a broad range of space configurations. Concourses tend to be large and tall, but because their size is so large they have a relatively low room cavity ratio (RCR). However atria can be relatively moderate sized and tall with a high RCR. For this application the proposal would harmonized with ASHRAE 90.1 in that the **Concourse and Atria** primary function area was split into 4 applications:

- Atria < 20 ft tall
- Atria 20 to < 40 ft
- Atria > 40 ft
- Concourse

Unlike ASHRAE 90.1, which has separate space types for transportation concourses and retail concourse, the proposed 2028 Title 24 concourse primary function area is not limited to a given space type as concourses also exist in convention centers, sports areas and yet their task illuminance is relatively similar as are their geometries.

In the 2025 T-24 standard **Convention, Conference, Multipurpose, and Meeting Area** apply to “are rooms or areas that are designed or used for meetings, conventions, or events, and that have neither fixed seating nor fixed staging.” This definition is very broad and applies to many room shapes and sizes varying illuminance needs. Given such a broad range of applications it was not surprising that this also had a complex allowed LPD based on luminaire mounting height, areas, walt length etc. This could be simplified by having more primary function areas that could be more closely suited to the task and the type of space. This proposal recommends breaking the Convention, Conference, Multipurpose, and Meeting Area primary function area into the following areas:

- Convention Center: Ballroom
- Convention: Concourse
- Convention: Exhibit Space
- Convention: Meeting Room
- Educational, civic: Multipurpose room (art, music etc.)
- Office: Conference Room

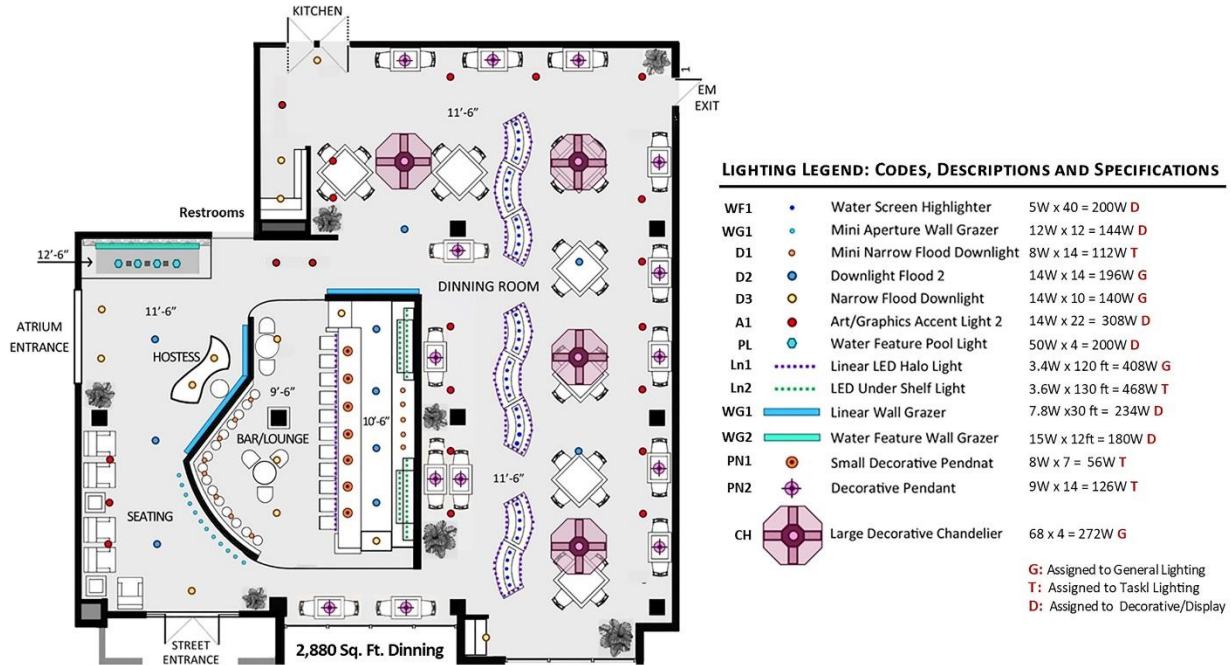
Besides these space types that more accurately reflect applications that that were encompassed in a broader primary function types, this proposal includes the following new space types

- Data center: computer room. Given the amount of projected construction for this application, it made sense to have a clearly defined primary function area.
- Healthcare: Patient Room - Critical care. The illuminance requirements are substantially different from a general patient room
- Performance: Dressing room. The needs are different than the closest other primary functional area, locker room.
- Transportation: waiting area. This has different needs than either lobbies or office waiting areas in terms of the amount of additional decorative allowances that are needed.

## G.2 Fine Dining Model

The fine dining model was developed to demonstrate lighting design with a considerable number of decorative elements that use efficient luminaires that place light where it is needed on the dining table, on artwork, and on decorative features.

The space depicted in Figure 4 has four water features. The water wall by the atrium entrance provides visual focus when first entering the space. The water wall is illuminated by four pool lights. Three water screens divide up the dining space and provide visual and auditory privacy. The water screens are illuminated by highlighters and linear halo light on each side of the screens.



**Figure 4: Example Fine Dining plan with luminaire schedule.**

Decorative wall grazers highlight the water wall by the atrium entrance and on walls separating the bar from the rest of the space.

Large decorative luminaires do triple duty by providing decorative focal interest while providing task lighting over tables and general circulation lighting.

Decorative pendants provide task lighting over dining tables and over the bar. Narrow beam flood lights provide task lighting over the receptionist desk and in the bar and lounge area. Shown on the plan are table lamps (plug load) on the tables between the chairs in the lounge.

The narrow beam luminaires also provide general circulation lighting by the entrances, as do downlight floods.

Mini-narrow flood downlights provide task lighting at the mini-standup tables and back bar. Undershelf lighting provides both task lighting and illumination of the bottles behind the bar, facilitating bartending and serving as a visual feature.

The lighting schedule in Table 34 demonstrates how compliance with the code can be achieved by assigning the luminaires into the available maximum allowed categories by lighting function (baseline/general, task, or decorative /display). About half of the luminaires serve multiple functions and can therefore be assigned to more than one lighting function. To prevent double counting, a luminaire can only be assigned to one of the three lighting functions (baseline/general, task, or decorative/display, not more than one category simultaneously).

General lighting installed wattage must be compared against the sum of the baseline lighting allowances for the entire building. The baseline allowance must include all general lighting and, if needed, task or decorative display lighting needed to provide circulation illuminance levels within the space with all other lighting systems turned off. Additional lighting can be allocated to baseline lighting allowance, but general lighting cannot be allocated to the additional lighting allowances for decorative/display and task lighting. The baseline lighting allowance can be shared among all spaces in the building, whereas the additional lighting allowances including decorative/display and task lighting are use-it-or-lose-it, and the allowances are not available to be traded among spaces in the building.

For the Fine Dining model (refer to Figure 4 and Table 34), luminaires were assigned to the various lighting functions—baseline/general, task, or decorative /display—with the following rationale.

- 1) Luminaire WF1 water screen highlighter and WG1 mini wall grazer can only be defined as a decorative/display luminaire and therefore must be listed under that category.
- 2) Luminaires D1 mini narrow flood and D3 narrow flood 25-degree optics allow them to be classified as task lighting as they provide a higher level of illumination needed for tasks. However, they can also be considered baseline lighting if needed to provide circulation illuminance levels within the space.
- 3) Luminaire D2, the wide flood, was assigned to baseline lighting as that is the only category allowed for this type of luminaire.
- 4) Luminaire A1 art/graphics adjustable accent light can only be defined as a decorative/display luminaire and therefore must be listed under that category.
- 5) Luminaire PL water feature pool light can only be defined as a decorative/display luminaire and therefore must be listed under that category.
- 6) Luminaire LN1 linear halo light can be classified as task lighting as it provides a higher level of illumination to provide a wayfinding task. However, it can also be considered baseline general lighting if needed to provide circulation illuminance levels within the space.
- 7) Luminaire LN2 under shelf linear light can be classified as task lighting as it provides illumination on the bottles for use in pouring drinks but also serves as a visual feature which would define it as a decorative/display luminaire.
- 8) Luminaire WG1 and WG2 are both wall grazers whose function is to highlight wall features and unique surfaces; therefore they must be classified as decorative/display and must be listed under that category.
- 9) Luminaire PN1 and PN2 decorative pendants provide a decorative element but also task illumination at the bar and tables. Therefore, it can be classified as either task or decorative/display lighting. The decision to apply them to task lighting is to maximize the use of that category.

- 10) Luminaire CH decorative chandelier provides a decorative element as well as task and baseline lighting functions. The decision to apply CH luminaires to baseline lighting was not to exceed the maximum allowed watts for task and decorative/display categories on the project.

In this example of the Fine Dining model there is only minimal base general lighting remaining to trade off with other areas. However, following the rationale for assigning qualifying luminaires into the task and decorative/display “use-it-lose it” categories will result in the most unused watts within baseline lighting for tradeoff with other areas of the project.

The analysis of this model helped inform the development of allowances for fine dining with a baseline allowance of 0.40 W per square foot, a decorative/display allowance of 0.45 W per square foot and a task lighting allowance of 0.30 W per square foot. This results in a lower general lighting power density that is 0.05 W per square foot lower than that in 2025 standard, a decorative/display lighting allowance that is 0.10 W per square foot higher and an additional task lighting allowance of 0.30 W per square foot that offsets three sets of wall display allowances and floor and task allowances that vary by luminaire mounting heights. This proposed Title 24, Part 6 simplified approach for the Area Category Method allows up to 1.15 W per square foot of lighting allowances.

This is much less than the theoretical amount of lighting power that could be installed under the 2025 standard that also includes, with the medium luminaire height, of wall allowances of 1.5 W per linear foot of wall areas and additional wall and task display allowed wattage of 0.52 W per square foot. Thus, this is substantially less than the theoretical maximum of the 2025 Area Category method allowances for Bar/Leisure and Fine Dining while providing the capability to install significant amounts of efficient decorative, display and task lighting elements into the fine dining space and still comply with the energy code.

**Table 34: Fine Dining Fixture Schedule and Allocation to Lighting Function**

Code	Luminaire Type/Specifications	Watts	Quantity	Baseline/General	Task	Deco/Display
WF1	Water screen highlighter [Wet location mini downlight] ( <i>only decorative/display</i> )	5	40			200
WG1	Mini wall grazer [2-inch aperture grazer downlight] ( <i>only decorative/display</i> )	12	12			144
D1	Mini narrow flood [2-inch aperture 25-degree downlight] ( <i>task or baseline/general</i> )	8	14		112	
D2	Downlight flood [4-inch aperture 60-degree wide flood downlight] ( <i>only baseline/general</i> )	14	14	196		
D3	Downlight flood [4-inch aperture 25-degree narrow flood downlight] ( <i>baseline or task</i> )	14	10	140	140	
A1	Art/graphics light [4-inch aperture 25-degree narrow flood adjustable accent light]	14	22			308
PL	Water feature pool light [Wet submerged rated medium flood NEMA 3 x 3 distribution]	50	4			200
LN1	Linear halo light ( <i>task or baseline/general</i> )	3.4/ft	120 ft	408		
LN2	Under shelf light ( <i>task, ornamental</i> )	3.6/ft	130 ft		468	
WG1	Linear Wall-Grazer [4-inch slot Luminaire wall-grazing optics] ( <i>only decorative/display</i> )	15/ft	12 ft			180
WG2	Water feature Grazer with protective moisture screen [4-inch slot Luminaire grazer]	7.8/ft	30 ft			234
PN1	Small Decorative Pendant ( <i>task or decorative/display</i> )	8	7		56	
PN2	Decorative Pendant ( <i>task or decorative/display</i> )	9	14		126	
CH	Large Chandelier ( <i>task, decorative/display or general</i> )	68	4	272		
-	SUB TOTAL INSTALLED WATTS BY ASSIGNED FUNCTION	-	-	<b>1016</b>	<b>762</b>	<b>1266</b>
-	T-24 MAXIMUM ALLOWED WATTS BY DESIGN FUNCTION	-	-	1152	864	1296

Code	Luminaire Type/Specifications	Watts	Quantity	Baseline/General	Task	Deco/ Display
-	DESIGN WATTS BY FUNCTION VERSUS TITLE 24 MAX ALLOWED WATTS			<b>136</b>	<b>102</b>	<b>30</b>
-	GRAND TOTAL ALL DESIGN WATTS [Actual]	<b>3044</b>	-	-	-	-
-	MAXIMUM TITLE-24 ALLOWED PROJECT WATTS	<b>3212</b>	-	-	-	-
-	IF INSTALLED WATTAGE LESS THAN ALLOWED WATTAGE - PASS	<b>(PASS)</b>	-	-	-	-

In comparison for this space type ASHRAE 90.1-2025 allows a general lighting allowance of 0.68 W per square foot and a decorative allowance of 0.5 W per square foot for a total allowed wattage of 1.18. Thus, the 1.15 W per square foot total wattage allowance of the proposal is a comparable 97 percent of the ASHRAE 90.1-2025 value.

**Table 35: Dining Lighting Power Density Allowances in the Area Category Method**

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft <sup>2</sup> unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft <sup>2</sup> unless other units)
Dining Area: Bar/Lounge & Fine Dining	0.40	Decorative/Display	0.45	Task	0.30
Dining Area: Cafeteria/Fast Food	0.40	Decorative/Display	0.25		
Dining Area: Family and Leisure	0.35	Decorative/Display	0.25		

With this new approach for fine dining and with the new proposed formatting of the Area Category Method LPD table standard, what used to take eight rows to describe the lighting power allowance for fine dining would now take only one row of allowances, a baseline LPD, a combined decorative/display allowance and a task lighting allowance similar to pendants one would see over tables or downlights over the bar and reception areas.

# Appendix H: Retail Lighting Evaluation and Allowances

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The goals for developing retail allowances were to simplify the methodology, while representing the major factors that determine the maximum amount of lighting wattage necessary to achieve both energy efficiency and achieving the goals of retail lighting which according to IES RP-2-20 are<sup>14</sup>.

- Attract and Guide the Customer
- Evaluate the Merchandise and Initiate Purchases
- Facilitate Completion of the Sale

To inform these considerations, twelve prototypes were developed to represent typical design practices, including designs with multiple features, to exercise the capability of the lighting allowances to allow sufficient lighting power over the range from simple to very demanding sales tasks. These prototypes were based on real projects that were illuminated with commercially available, high efficacy luminaires.

## H.1 Overview of Retail Models

Thumbnail models were created to assist in establishing the appropriate baseline LPD for the general lighting component of retail spaces. Additionally, the models were used to test various use-it-lose-it LPD adder options being explored for decorative, display and task lighting. Models developed for the analysis of baseline/general lighting and use-it-lose-it adders are as follows.

1. Mom & Pop stores represent small local retailers and simple less complex retail spaces. Three model variations of Mom & Pop stores were explored.
2. Big box retailers such as warehouse stores usually display merchandise with little or no accent or feature lighting. In place of accent lighting these stores depend on a high level of general lighting.
3. Designer shops with illuminated shelves and wall mounted case work. A subset of this space type also included a high ceiling variation. The designer shops typically use less baseline/general lighting offset by higher accent and display illumination.
4. High end designer brand/specialty shops such as a Giorgio Armani or Louis Vuitton store.

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<sup>14</sup> There are many details behind each of these goals. The reader is directed to IES RP2-20 *Recommended Practice: Lighting Retail Spaces*. Illuminating Engineering Society. New York.

5. Large high-end women's luxury shoe department with the challenge of addressing both low and high ceiling components within the department's footprint.
6. Very tall (17-foot ceiling) fashion wear sales area flanking a series of high-end luxury brand specialty shops.
7. Precious Jewelry department, luxury brand featuring significant valuable merchandise displayed in showcases and vitrines.

Data from this collection of models was used to determine the proposed lighting power density (LPD) for baseline/general lighting as well as the use-it-lose it floor task/display lighting, wall display lighting, value merchandise showcase/vitrine lighting and decorative lighting adders.

Several models, such as designer shops with illuminated shelves and wall mounted case work, high-end women's luxury shoe department the low and high ceilings and very tall (17-foot ceiling) fashion wear sales area were also instrumental in determining maximum allowed lighting power density for baseline/general lighting as well as the adders for accent and display lighting that allow these spaces to comply with code yet maintain an energy efficient profile.

Some of these designers were also evaluated as partial remodels to exercise the potential difficulties of having a high intensity sales task but without all of the wall area to accommodate the wall allowances under the current implementation of the tailored lighting method and its modification to be used in the 2025 version of the area category method.

The proposed lighting power density's (LPD's) for retail lighting in the Title 24-2028 case report represents maximum allowed lighting power targets that allows for the lighting needed to properly illuminate a wide range of retail spaces. The use-it-lose-it allowed maximum power density adders developed for accent, display and decorative lighting include consideration for the needs of those spaces with high ceilings and/or multiple levels of illuminated shelves.

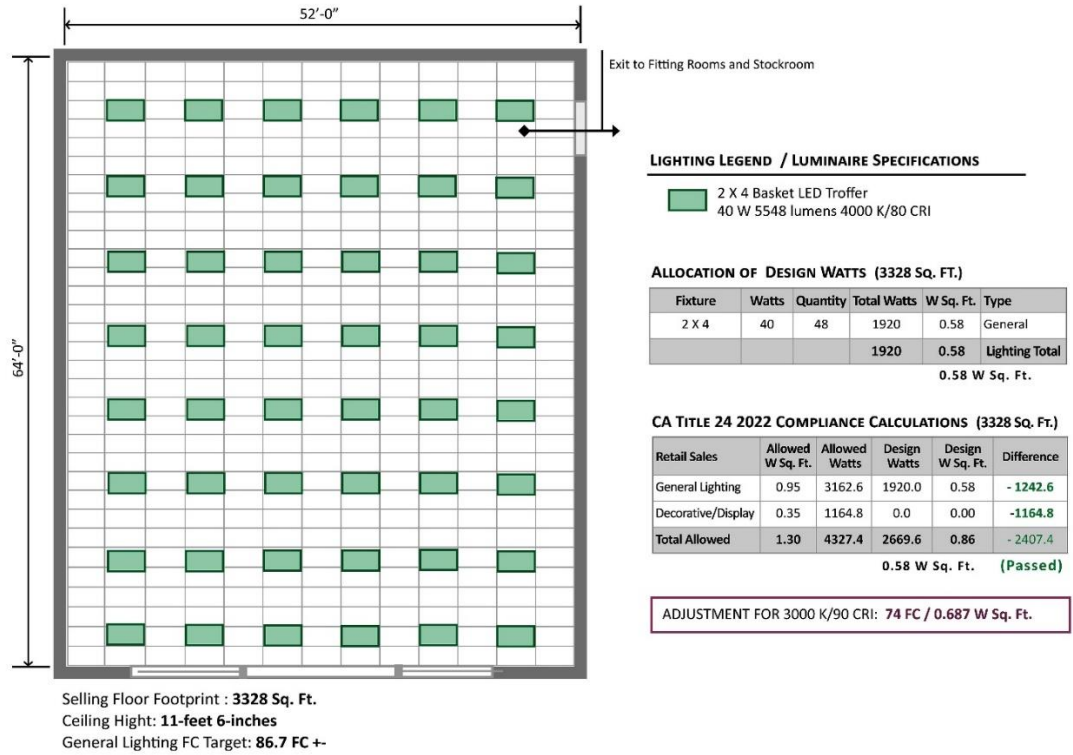
## **H.2 Mom and Pop (Simple Design) Stores**

The mom and pop models represent a moderate 3,328 square foot space with a 11'-6" acoustic tile ceiling. Three subsets of this model are a basic design with a monolithic lighting scheme, a scheme with uniform general illumination and a wall-washing component and a scheme that includes a moderate level of display and accent lighting.

### **H.2.1 Monolithic Lighting Scheme**

The monolithic mom-and-pop model represents a most basic lighting scheme. One luminaire type, 2 X 4 troffer is the basis for this model. It only uses baseline/general

lighting illumination. A targeted 86 foot-candles provide more than sufficient illumination to perform visual tasks as well as adequately illuminating the store’s merchandise. This designs 2 X 4 4000 K /80 CRI luminaires are representative of those often used when high levels of baseline/general illumination are selected.



**MOM & POP RETAIL MODEL WITH HIGH ILLUMINANCE MONOLITHIC SINGLE LUMINAIRE TYPE**

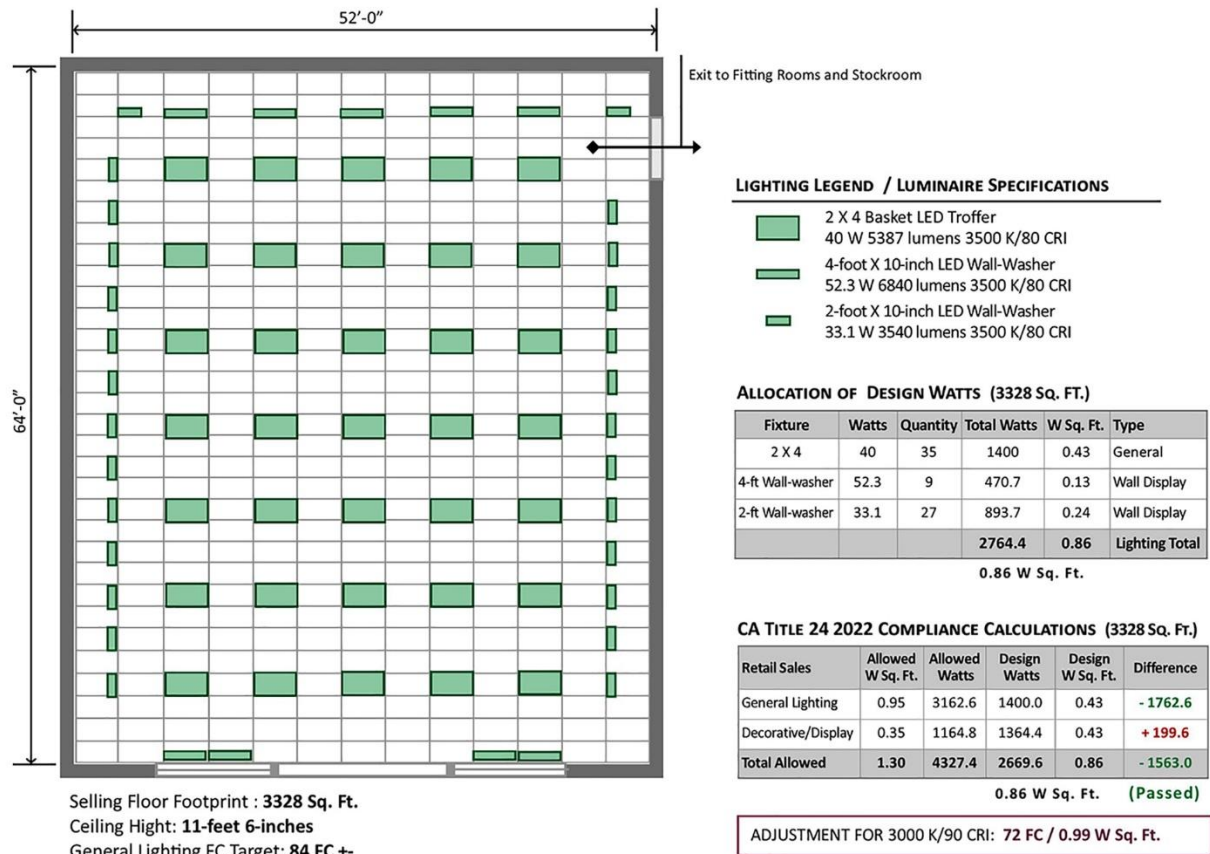
**Figure 5: Mom and Pop Retail Model with Monolithic (Single Luminaire) Design**

The lighting power density (LPD) 0.58 W per square foot design easily passed Title 24-2022 compliance as well as Title 24-2025 compliance. While not often found in this design if a warmer 3500 K or 3000 K 90 CRI is desired the designs LPD increase to 0.67 W with a 74 foot- candle target. A warmer color temperature (CCT) with higher 90 CRI would still meet compliance under with both Title 24-2022 as well as Title 24-2025.

**H.3 Two System High Illuminance System Lighting Scheme**

This version of the mom-and-pop model adds a second luminaire, linear wall-washer, in addition to the 2 X 4 troffer which provides baseline/general lighting illumination. The wall-washer luminaires provide higher level vertical illumination on the wall merchandise as well as the upper wall. The illuminated wall results in a higher perceived brightness with the space. The targeted 84 foot-candles are like that of the monolithic design and

more than sufficient illumination to perform visual tasks as well as adequately illuminating the store’s merchandise. The walls higher vertical illumination accents the wall merchandise. This designs 2 X 4 and wall-washer luminaires use a warmer 3500 K CCT while the color rendering remains at 80 CRI.

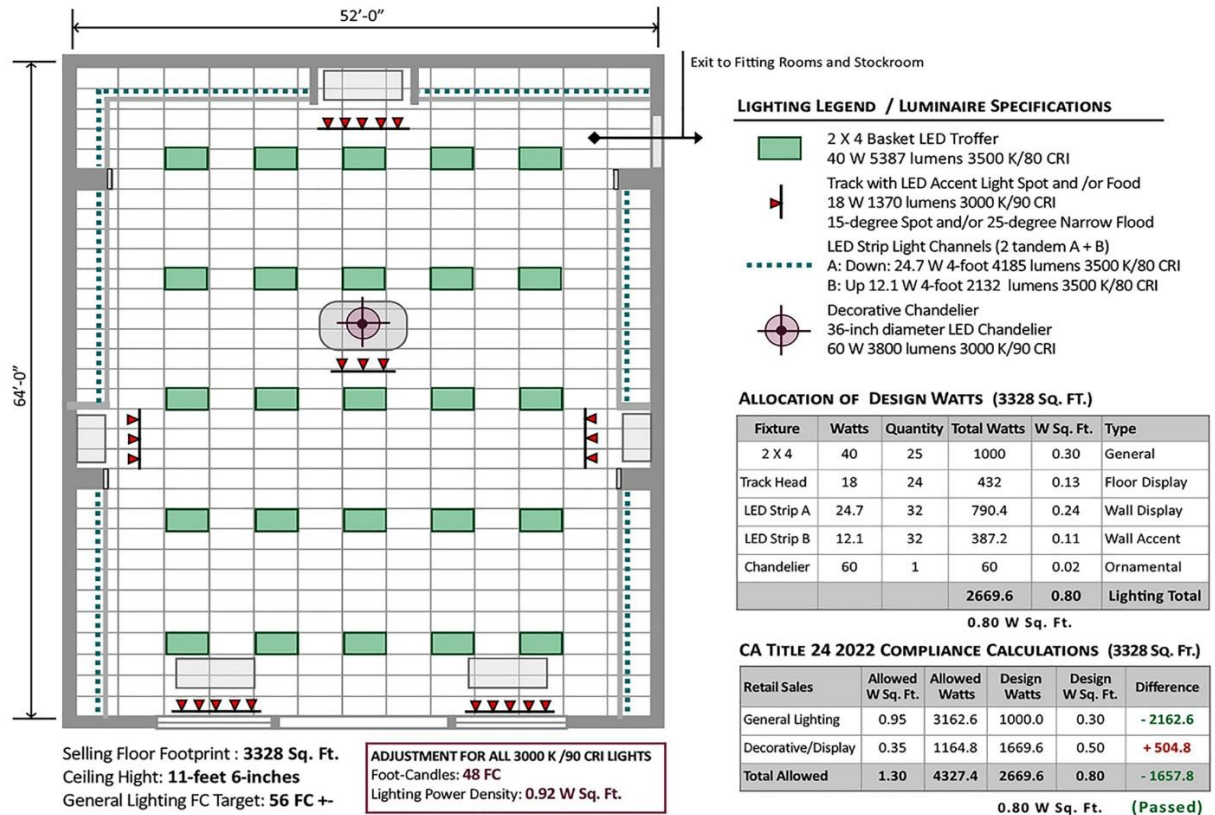


**Figure 6: Mom and Pop Retail Model Two System with Wall Washers**

The lighting power density (LPD) 0.86 W per square foot design easily passed Title 24-2022 compliance as well as Title 24-2025 compliance. While not often found in this design if a higher color rendering 90 CRI with a CCT of 3000 K is desired the designs LPD increase to 0.99 W with a 72 foot-candle target. A warmer color temperature (CCT) with higher 90 CRI would still meet compliance under Title 24-2022 and Title 24-2025 by using the fill baseline/general lighting allowance as well as drawing from the use-it-lose it wall accent lighting allowance.

### H.3.1 Moderate Level of Display and Accent Lighting Scheme

The mom-and-pop moderate display lighting model was created to demonstrate the effects of a retail environment with highs, lows and an accent lighting component. The model also demonstrates how the total lighting power is distributed between baseline/general, accent and decorative lighting allocations.



**MOM & POP RETAIL MODEL WITH MODERATE DISPLAY & ACCENT LIGHTING**

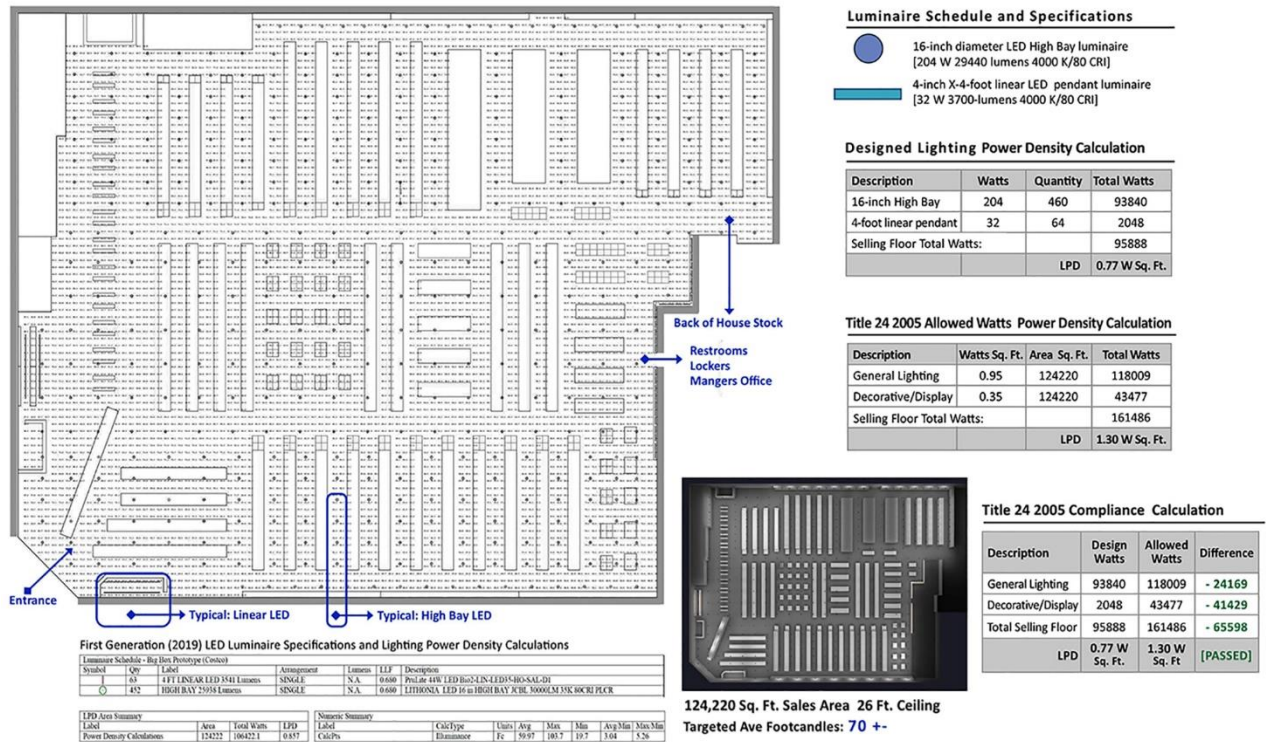
**Figure 7: Mom and Pop model with moderate level of display and accent lighting.**

General lighting is provided by 3500 K 80 CRI 2 X 4 troffers while perimeter display lighting uses two linear 3500 K / 80 CRI LED strip channels (one for highlighting the wall merchandise and the other for up-light wall grazing). The two channels are masked by an architectural valence. Light track with 3000 K / 90 CRI track heads is located at several places throughout the store to accent light mannequin platform focal points. The platforms with accent light at the store entrance create a first impression with the additional platforms and accent lighting helps to define the space and draw shoppers further into the store. The lower targeted 56 foot-candles are still sufficient illumination to perform visual tasks as well as adequately illuminate the merchandise. The walls higher vertical illumination accents the wall merchandise and the mannequin platforms with visual displays are highlighted with the track mounted accent light track heads. This design, while somewhat more elaborate than the other two Mom & Pop designs, is still energy efficient. With a lighting power density (LPD) 0.80 W per Sq. Ft. it easily passed Title 24-2022 as well as Title 24-2025 compliance. If a design with a higher color rendering 90 CRI with a CCT of 3000 K throughout the store is desired the designs LPD increases to 0.92 W with a 48 foot-candle target. The warmer color temperature (CCT) with higher 90 CRI would still meet compliance under Title 24-2022 and Title 24-2025

by using the full baseline/general lighting allowance and if need be drawing from the use-it-lose it accent lighting allowances.

## H.4 Big Box Retailer Warehouse Store

The big box warehouse model represents a large 124,220 square foot space with a 26-foot exposed structure ceiling. The lighting scheme is high level of baseline/general lighting (uniform illumination) with only minimal to no accent lighting component.



### 2026 BIG BOX RETAIL MODEL [2019 MODEL UPDATED TO CURRENT LED PERFORMANCE]

Figure 8: Big box retail design updated to current LED performance.

#### 2026 Big Box Retailer Warehouse Store Scheme

An updated 2026 Big Box model was created by modifying the 2019 Big Box AGI-32 model with current LED technology luminaires. As with the 2019 Big Box model, this updated version still assumes that the design uses very high-level 70+ foot-candles of baseline/general illumination with little or no accent lighting component. The baseline/general lighting at 70+ foot-candles is more than sufficient illumination to perform visual tasks as well as illuminate the store's merchandise. This design's 4000 K /80 CRI luminaires are representative of typical Big Box lighting designs with high levels of baseline/general illumination. The lighting power density (LPD) 0.77 W per square foot design easily passed Title 24-2022 compliance as well as Title 24-2025

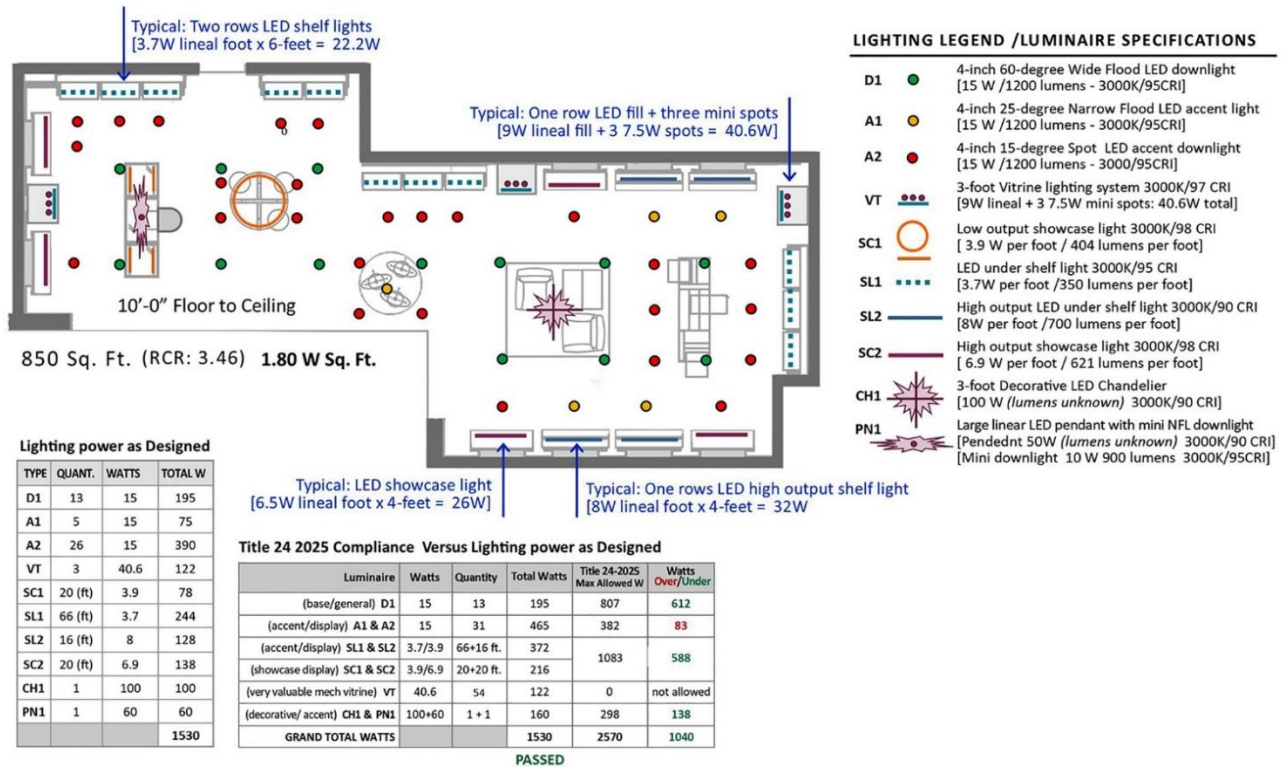
compliance. Of special interest is that the 2026 designs 70+ FC /0.77 LPW are 10 percent more efficacious with 20 percent higher illumination than the 2019 models 60 FC / 0.86 LPW. While rarely applied to Big Box lighting applications if a higher color rendering 90 CRI with a CCT of 3000 K is desired the designs LPD increase to 0.96 W with a 60 foot- candle target. A warmer color temperature (CCT) with higher 90 CRI would still meet compliance under Title 24-2022 and Title 24-2025 by using the fill baseline/general lighting allowance as well as, if needed, drawing from the use-it-lose accent lighting allowance.

## **H.5 Designer Shops with Illuminated Shelves**

There are two variants of the Designer shops with illuminated shelves. One model has a 10-foot ceiling and the other a higher 12-foot ceiling. Both models represent small 850 square foot designer boutiques selling high-end fashion merchandise illuminated with a level of significant accent and display lighting.

### **H.5.1 Low Ceiling Designer Shop with Illuminated Shelves**

Designer Shops with Illuminated Shelves were created to analyze small retail spaces with an environment of highs, lows and significant accent lighting component. Of special interest was how multi layers of wall lighting systems affect the wall lighting power density requirements as well as the overall lighting power density of the space. These models also demonstrate how the total lighting power is distributed between baseline/general, accent and decorative lighting allocations. The low ceiling design uses 4-inch aperture downlight for baseline/general illumination and 4-inch aperture accent lights for both wall and floor accent lighting. In addition, illuminated shelves and wall cases provide additional wall accent lighting. The space includes a chandelier and pendant decorative lighting. All the lighting uses 3000 K /90 CRI LED sources to provide the shops total illumination. The total LPD of the shop is 1.80 W per square foot with baseline/general illumination only a low 0.23 W per square foot which is understandable given the high level of accent/display illumination. The shops' lighting power density (LPD) 1.80 W per square foot design easily passed Title 24-2025 compliance with only a minimal portion of the allowed baseline/general lighting and available wall accent lighting. Floor accent lighting was slightly higher than the allowed maximum which was offset by available watts from baseline/general lighting.



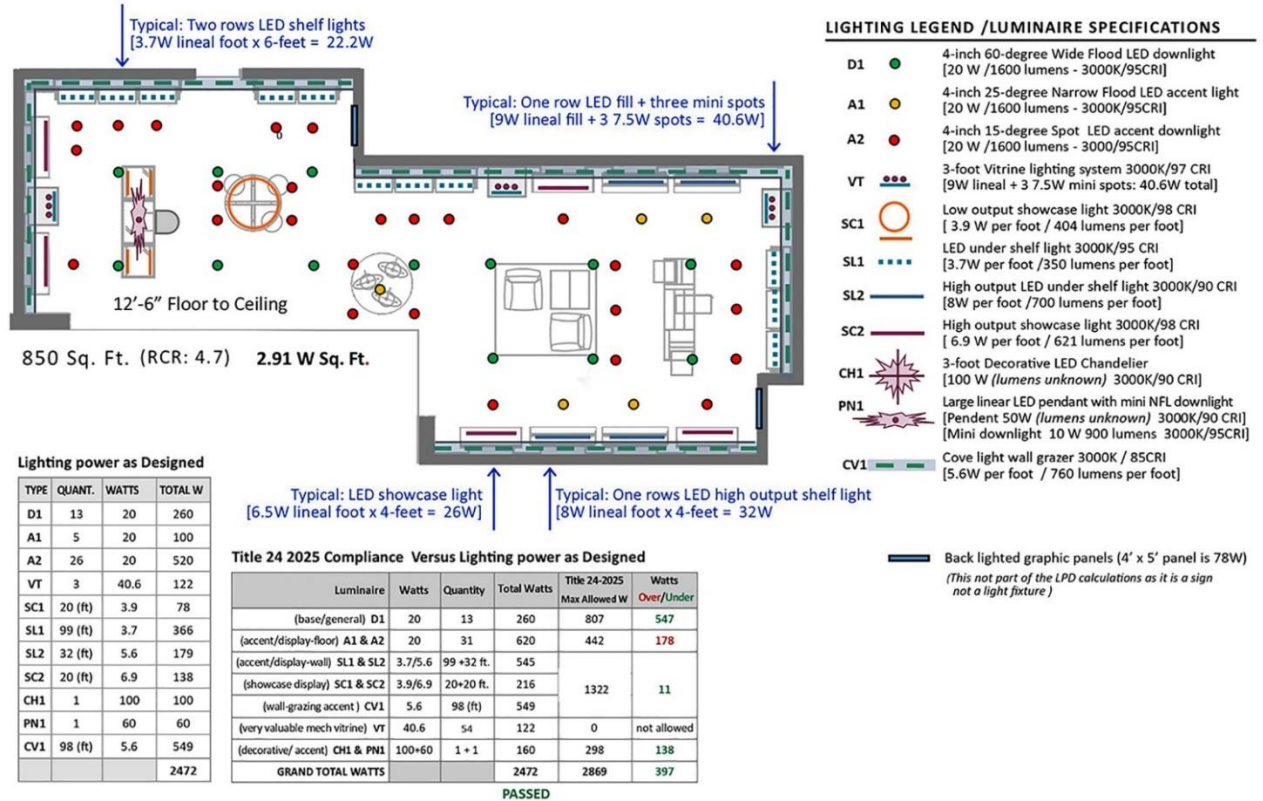
## DESIGNER BOUTIQUE SHOP WITH ILLUMINATED SHELVES & WALL MOUNTED CASEWORK

Figure 9: Designer boutique shop with illuminated shelves and wall mounted casework.

### H.5.2 High Ceiling Designer shop with Illuminated Shelves

The high ceiling variant Designer Shops with Illuminated Shelves was created in addition to analyzing small retail spaces with an environment of high, lows and significant accent lighting component. Also explored was how multi layers of wall lighting affect the wall lighting power density requirements as well as the overall lighting power density of the space. The added higher ceiling element in this model resulted in the addition of wall-grazer luminaires to illuminate the upper portion of the taller walls. This model also demonstrates how the total lighting power is distributed between baseline/general, accent and decorative lighting allocations. The High ceiling design also uses 4-inch aperture downlight for baseline/general illumination and 4-inch aperture accent lights for both wall and floor accent lighting. However, because the ceiling is higher the wattage of the ceiling luminaires increased. In addition, illuminated shelves and wall cases provide additional wall accent lighting. While the wattage of those luminaires was not increased there is another layer added because of the higher ceiling which contributes to the total wall lighting power. In addition, the wall-grazers

also added to the wall lighting power. This space includes the same chandelier and pendant decorative lighting as is in the low ceiling model.



### DESIGNER BOUTIQUE SHOP WITH ILLUMINATED SHELVES & WALL MOUNTED CASEWORK [HIGH CEILING]

Figure 10: Higher ceiling version of designer boutique shop with illuminated shelves and wall mounted casework.

All the lighting uses 3000 K /90 CRI LED sources to provide the total illumination. The LPD of the high ceiling shop is 1.80 W per square foot with baseline/general illumination a low 0.33 W per square foot which is understandable given the high level of accent/display illumination. The shops' lighting power density (LPD) 2.91 W per square foot design passed Title 24-2025 compliance with the use of the allowed baseline/general lighting and available wall accent lighting allocation. Floor accent lighting was higher than the allowed maximum which was offset by available watts from baseline/general lighting.

### H.5.3 Evaluation of 2028 Proposal

This design passes by folding the decorative element into floor accent as provided for under the Title 24 2028 proposed allowed LPD's for retail lighting. The design passes with both the physical walls used to calculate the wall accent comment or more generous perimeter use of full walls, partial walls, soffits and/or bulkheads.

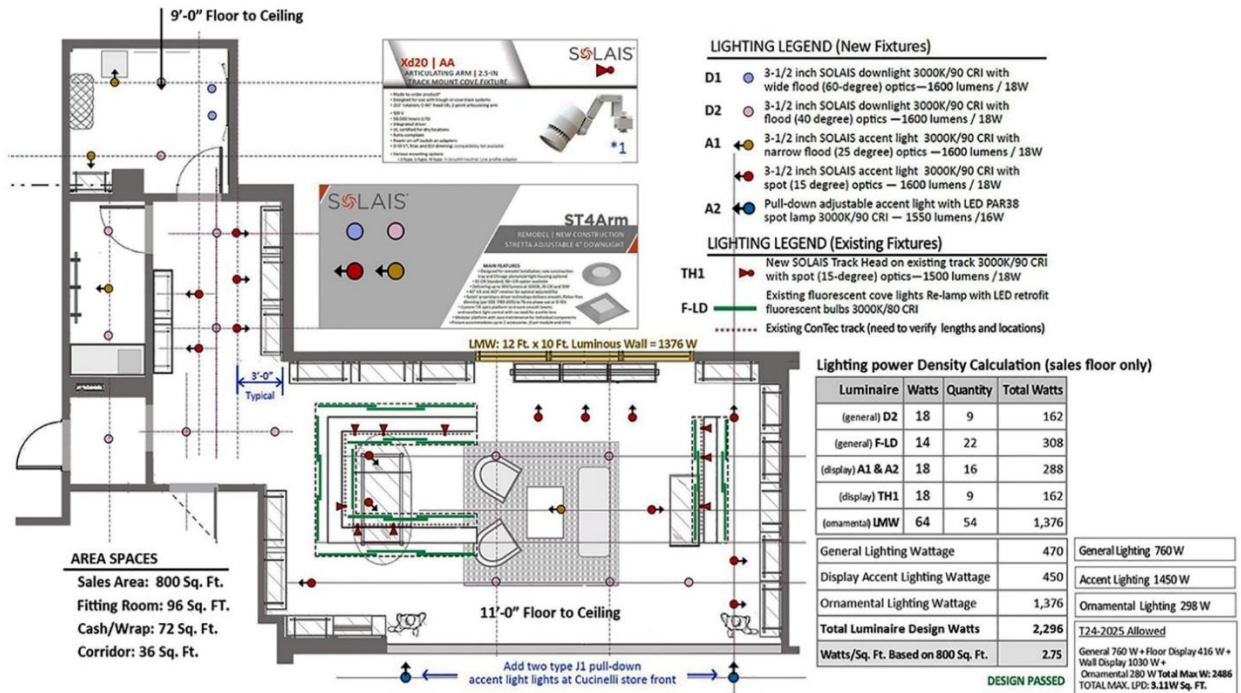
**Table 36: Proposed 2028 Retail LPD Compliance Evaluation: High ceiling Designer Shops with Illuminated Shelves**

Function	Design Watts (850 Sq. Ft. / 12.6 Ft. Ceiling )	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/General	260	638	638	378	888	888	628
Floor Accent	780	765	765	15	442	442	178
Wall Accent	1310	1040 [1440]*	1040 [1310]*	270 [0]	1165	1165	145
Decorative	0	0	0	0	298	160	0
Very Valuable	122	90	90	32	424	122	303
Design Total	2472	2533 [2933]	2533 [2803]*	61 [331]*	3217	2777	608
Watts Sq. Ft.	2.91 W	2.98 W [3.45 W]*	2.98 W [3.30 W]*	Passed	3.78 W	3.27 W	Passed

\* Perimeter area of space that has either full walls or partial walls and/ or soffits and bulkheads

## H.6 High End Designer Brand/Specialty Shop

This model is like the designer shop with illuminated shelves as it also represents a boutique space of 800 square foot with a high level of accent and display illumination. This design also introduces cove lighting in the 11’-6” ceiling and the element of retrofit LED luminaires in the mix with new LED luminaires. Suggested merchandise housed in space is premium designer brands items such as found in Giorgio Armani or Louis Vuitton stores. Significant accent and display lighting are used to highlight the merchandise. The design also includes a luminous wall section that creates dynamic visual interest and also serves as branding element.



UPSCALE RETAIL MODEL: DESIGNER SHOP WITH ACCENT/DISPLAY PLUS ORNAMENTAL (LUMINOUS WALL) LIGHTING

Figure 11: Upscale retail model: designer shop with accent/display plus ornamental (luminous wall) lighting.

The High-End Designer Brand/Specialty Shop was created to analyze small retail spaces with an environment of high, lows and significant accent lighting. Also explored was how additional layers of a ceiling cove lighting and a luminous wall section affects the overall lighting power density of the space. This mode demonstrates how the total lighting power is distributed between baseline/general, accent and decorative lighting allocations. The ceiling design uses 4-inch aperture downlights as well as the cove lighting for baseline/general illumination and a mix of 4-inch aperture accent lights and track mounted accent lights within the cove for both wall and floor accent lighting. The luminous wall is constructed of a series of LED luminous panels with the translucent branding image material applied over the panels. All the lighting uses 3000 K /90 CRI LED sources to provide the total illumination. The High-End Designer Brand/Specialty Shop total LPD is 2.75 W per square foot with baseline/general illumination 0.59 W per square foot which is understandable given the addition of the cove lighting. The accent/display LPD is 0.56 W per square foot and the decorative lighting LPD is 1.72 W per square foot because of the luminous wall. However, the shops' 2.75 W per square foot design still managed to pass Title 24-2025 compliance with the use of most of allowed baseline/general lighting, all available wall and accent lighting and the adjustment allowed for the higher than 10-foot ceiling and display higher ceiling adjustments.

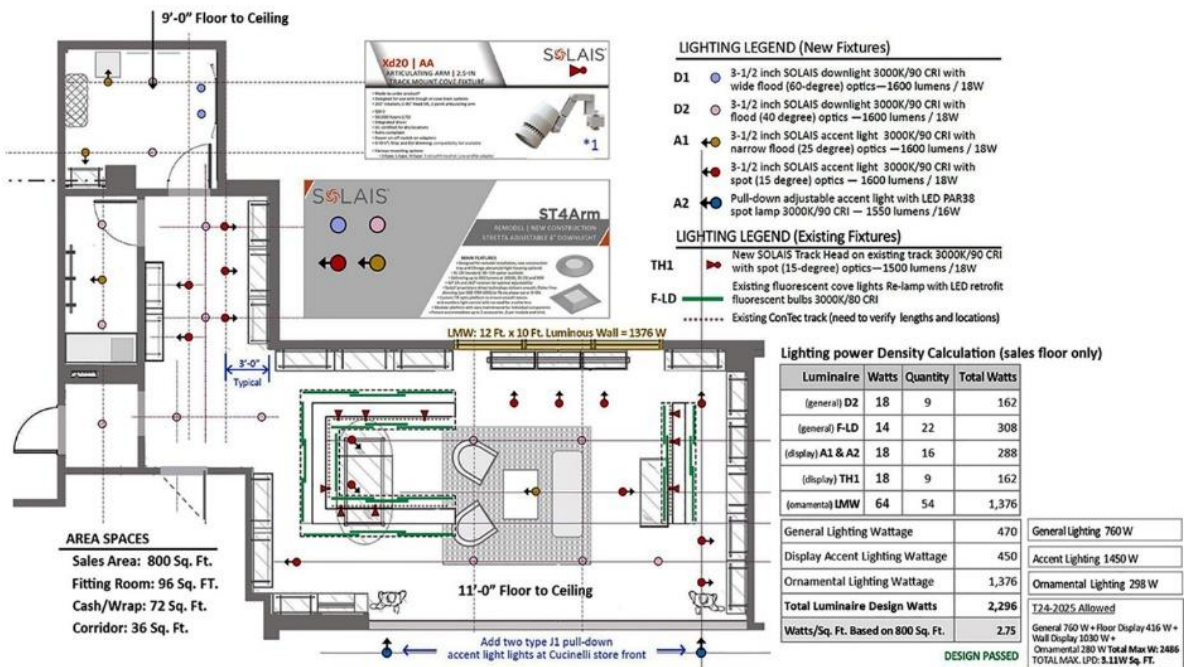
## H.6.1 Evaluation of 2028 Proposal

**Table 37: 2028 Proposal Evaluation High End Designer Brand/Specialty Shop / (88-ft of wall) (104-ft perimeter) – Sale Floor Only**

Function	Design Watts (800 Sq. Ft. / 11.6 Ft. Ceiling )	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/Geneal	470 / 162	600	600	130 / 438	836	836	366
Floor Accent	450 / 758	720	450	0 / 38	442	442	8
Wall Accent	1376	880 [1040]*	880 [1040]	496 / 336	986	986	390
Decorative	0	0	0	0	280	160	0
Very Valuable	0	0	0	0	400	0	0
Design Total	2296	2200 [2360]	1930 [2090]	366 / 64	2944	2424	34
Watts Sq. Ft.	2.87 W	2.75 W [2.95 W]*	2.41 W [2.61 W]*	Failed / Passed	3.68 W	3.03 W	Passed

\* Perimeter area of space that has either full walls or partial walls and/ or soffits and bulkheads

The High-End Designer Brand/Specialty Shop design fails even by folding the decorative element into wall accent as provided for under the Title 24 2028 proposed, allowing LPD's for retail lighting when the cove lighting is assigned to baseline/general lighting. However, if the cove lighting is classified as floor display, the design passes with both the physical walls used to calculate the wall accent comment or more generous perimeter use of full walls, partial walls, soffits and/ or bulkheads



UPSCALE RETAIL MODEL: DESIGNER SHOP WITH ACCENT/DISPLAY PLUS ORNAMENTAL (LUMINOUS WALL) LIGHTING

**Figure 12: High end designer brand/specialty shop / (163-ft of wall) (194-ft perimeter) – entire shop 1,004 square feet.**

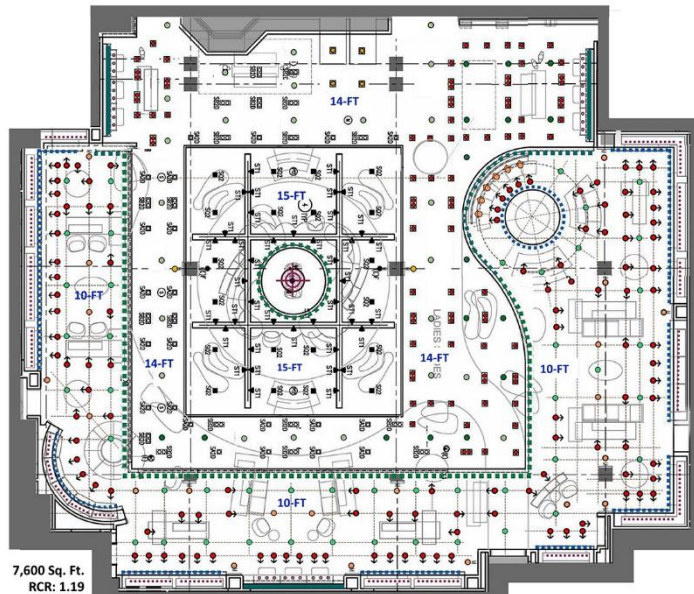
In the scenario where the High-End Designer Brand/Specialty Shop design adds the fitting room, cash wrap room and corridor to the plan (which would be the case if permitting the entire space) The design passes with both the physical walls used to calculate the wall accent comment or more generous perimeter use of full walls, partial walls, soffits and/or bulkheads.

**Table 38: 2028 Retail Proposal Evaluation: High End Designer Brand/Specialty Shop / (163-ft of wall) (194-ft perimeter) – Entire Shop 1004 Sq. Ft**

Function	Design Watts (1004 Sq. Ft. / 11.6 Ft. Ceiling)	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse-it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/General	578	743	743	165	1030	1030	452
Floor Accent	596	720	596	0	534	534	62
Wall Accent	1376	1330 [1580]*	1330	46 [0]	1698	1376	0
Decorative	0	0	0	0	280	0	0
Very Valuable	0	0	0	0	502	0	0
Design Total	2296	2793 [3043]	2669	119 [165]	4004	2940	34
Watts Sq. Ft.	2.31 W	2.78 W [3.06 W]*	2.62 W	Passed	3.99 W	2.93 W	Passed

## H.7 Large High-End Women’s Shoe Department

There are two significantly different ceilings heights within this model. A low 10-foot ceiling at the perimeter and high 14-foot/15-foot center space. The overall footprint is 6800 square foot. With 2840 square foot low ceiling and 3,760 square foot tall ceiling. The merchandise, luxury brand designer shoes is illuminated with significant accent and display lighting including illuminated shelves.



**EXISTING LUMINAIRES LEGEND & SPECIFICATIONS**

- (E)F ● 8-inch PAR-38 downlight re-lamped with LED Par lamp [26W 2040 lumen 3000K/90CRI 24-degree narrow flood]
- SQ2 ■ 8-inch sq. 2 lamp CFL downlight re-lamped with LED CFL [15.5W 1850 lumens Type B LED retrofit 3000K/82CRI]
- SA2D □ 8-inch sq. 1 PAR-38 accent light re-lamp with LED Par lamp [26W 2040 lumen 3000K/90CRI 15-degree spot]
- SB2D ○ 8x16-inch sq. 2 PAR-38 accent light re-lamp with LED Par lamps [Two 26W 2040 lumen 3000K/90CRI 15-degree spots] 52W
- ST1 ⚡ PAR-38 Track head accent light re-lamp with LED Par lamp [26W 2040 lumen 3000K/90CRI 15-degree spot]

**NEW LUMINAIRES LEGEND & SPECIFICATIONS**

- D1 ● 6-inch LED downlight 25W 2160 lumens 3000K/90CRI
- D2 ● 8-inch LED downlight 25W 2160 lumens 3000K/90CRI
- D3 ● 8-inch LED downlight 44W 3580 lumens 3000K/90CRI
- D4 ● 6-inch PAR-30 downlight with LED narrow flood lamp [14W xxx lumen 3000K/90CRI 24-degree narrow flood]
- DW ○ 6-inch LED wall-washer 25W 2160 lumens 3000K/90CRI]
- A1 ● 6-inch PAR-30 accent light with LED spot lamp [14W xxx lumen 3000K/90CRI 15-degree spot]
- SD1 □ 8-inch sq. 1 PAR-38 downlight with LED Par lamp [26W 2040 lumen 3000K/90CRI 24-degree narrow flood]
- SD2 □ 8-inch sq. 1 PAR-38 accent light lamped with LED Par-38 [26W 2040 lumen 3000K/90CRI 15-degree spot]
- 2SD □ 8x16-inch sq. 2 PAR-38 accent light lamped with 2 LED Par-38 [Two 26W 2040 lumen 3000K/90CRI 15-degree spots] 52W
- PK ○ 2-inch mini downlight (puck light) 3000K/90CRI
- SL \*\*\*\*\* Under shelf linear LED 3.7W ft. 350 lumens ft. 3000K/95CRI
- CV1 ● Direct wall cove wall 5.5W ft. /540 lumens ft. 3000K/90CRI
- CV2 ● Wall—Grazer cove 8W ft. /720 lumens ft. 3000K/82CRI
- WG ● 4-inch HO Wall-Grazer 10W ft. /900 lumens ft. 3000K/90CRI
- DC1 ● 5-foot diameter LED decorative chandelier [345W 15,500 lumens 3000K/90 CRI Note: On Dimmer circuit]

**LIGHTING POWER AS DESIGNED**

Fixture	Watts	Quant.	Total W	Type
(E)F	26	4	104	Task
SQ2	31	20	620	General
SA2D	26	21	546	Display
SB2D	52	20	1,040	Display
ST1	26	40	1,040	Display
D1	25	46	1150	General
D2	25	26	650	General
D3	44	14	616	General
D4	14	21	294	Task
DW	25	6	150	Accent
A1	14	59w + 54f	1,582	Display
SD1	26	4	104	Task
SD2	26	4w + 42f	1,196	Display
2SD	52	4w + 15f	988	Display
PK	7.5	27	202	Display
SL	3.7 (ft)	148	548	Display
CV1	5.5 (ft)	196	1,078	Accent
CV2	8.0 (ft)	218	1744	Accent
WG	10.0 (ft)	38	380	Accent
DC1	345	1	345	Ornamental
<b>TOTAL WATTS</b>			<b>14,377</b>	<b>1.89 W Sq. Ft.</b>

Fixture Type	Actual W	T-24 Max W	Difference
General	3036	6080	-3044
Task/Floor Acc	3130	5320	+2190
Wall Display	4514	2967	+1547
Accent/ornament	3697	2660	+1037
<b>TOTAL WATTS</b>	<b>14377</b>	<b>17,027</b>	<b>-2650</b>

**PASSED T24-2022**

**TITLE 24-2025 COMPLIANCE CHECK**  
 General Lighting: 7581 W / Floor Display: 3990 W / Wall Display: 2598 W / Decorative: 2660 W  
 TOTAL MAXIMUM ALLOWED WATTS: 16829 W [Watt Sq. Ft. = 2.21 W]  
 TOTAL AS GENERAL, DISPLAY & DECORATIVE DESIGN WATTS: 14377W [Watt Sq. Ft. = 1.89 W]  
PASSED T24-2025

**NOTE: Additional wattage T24-2022 adjustments, not used, that could have been used for compliance**

- Mounting height adjustment 0.85 for 14 ft ceiling & 0.75 for 15 ft ceiling
- Separate RCR for high and low ceilings (low ceiling over 2.0 RCR. 90 W gen.)
- Wall accent light versus floor accent light tradeoffs (10-foot/ 2-foot rule)

**UPSCALE RETAIL MODEL: LARGE SHOE DEPARTMENT WITH ACCENT/DISPLAY AND ORNAMENTAL LIGHTING**

**Figure 13: Large shoe department with accent/display and ornamental lighting.**

The large upscale shoe department model was created to study the designs' ability to meet code compliance with a space that had a mix of low and high ceilings with the high ceiling having little to no wall lighting. The design has significant floor and wall accent lighting.

A 10-ft low ceiling perimeter has 6-inch 25 W downlights and 6-inch 14 W accent lights in the ceiling and illuminated shelves on the wall. There is also wall cove to provide wall illumination.

The 14-foot and 15-foot ceiling high ceiling in the center of the department has a mix of ceiling luminaires consisting of 25 W and 44 W 8-inch downlights with multi-head one 26 W lamp and two 26 W lamp accent light luminaires. Additional accent lighting is provided by a grid of track with track mounted 26 W accent light track heads. There is limited wall accent lighting consisting of illuminated shelves on the wall and a ceiling mounted wall -grazer luminaire. Within the high ceiling there's also decorative lighting consisting of light cove, Upper wall grazing and a chandelier. All the lighting uses 3000 K /90 CRI LED sources.

As a total project, the large upscale shoe department model LPD is 1.89 W per square foot. Breakdown of the lighting power density by category is baseline/general illumination 0.40 W per square foot, floor display/task LPD 0.42 W per square foot, wall display LPD 0.58 W per square foot and decorative lighting LPD 0.49 W per square

foot. The design passed Title 24-2025 compliance with use of allowed baseline/general lighting, available floor and wall accent lighting plus adjusted higher LPD's allowed for the 14/15-foot ceiling area.

## H.8 Large High-End Women’s Shoe Department Low Ceiling Standalone

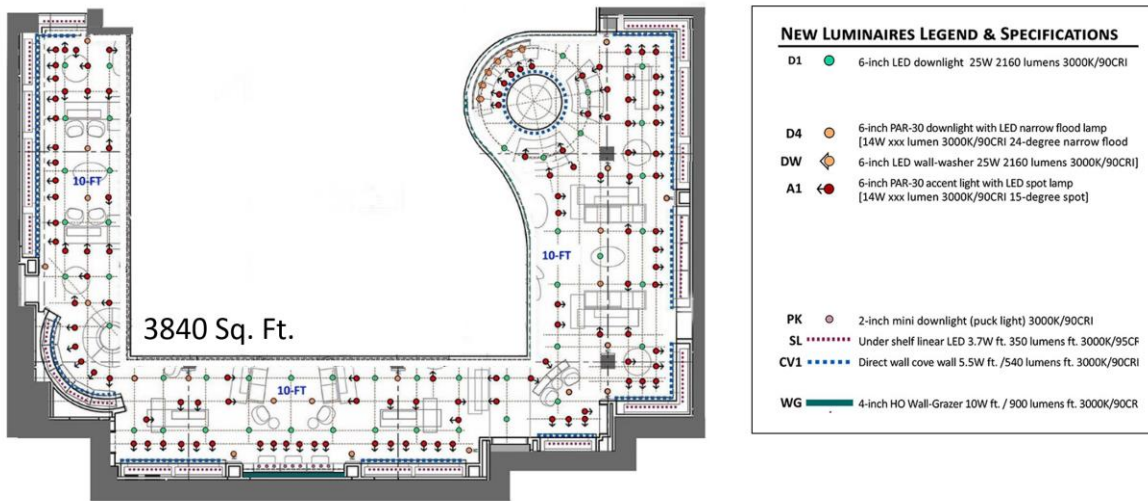


Figure 14: Reflected ceiling plan low ceiling women’s shoes.

The large upscale shoe department model low ceiling component was modeled as if it were a standalone space for the purpose of its ability to meet Title 24 compliance. Lighting in this design consists of 6-inch 25 W downlights and 6-inch 14 W accent lights in the ceiling and illuminated shelves on the wall. There's also wall cove to provide wall illumination and a wall grazer decorative lighting element. Title 24 2022 and Title 24 2025 maximum allowed watts versus design watt is shown in the tables below.

Table 39: Code Compliance Evaluation of Low Ceiling Women’s Shoes Design

Function	Design Watts (3840 Sq. Ft. / 10 Ft. Ceiling)	Max Allowed (Title 24 2022 Tailored)	Use-it Louse -it (Title 24 2022 Tailored)	Plus/Minus (Title 24 2022 Tailored)	Max Allowed (Title 24 2025 Area Category)	Use-it Louse -it (Title 24 2025 Area Category)	Plus/Minus (Title 24 2025 Area Category)
Baseline/General	1708	3072	3072	1384	3648	3648	1940
Floor Accent	756	2688	756	0	1728	756	0
Wall Accent	1430	2795	1430	0	2309	1430	0
Decorative	270	1344	270	0	1344	270	0
Design Total	4164	13739	5528	1384	9029	6104	1940
<b>Watts Sq. Ft.</b>	<b>1.08 W</b>	<b>3.58 W</b>	<b>1.44 W</b>	<b>Passed</b>	<b>2.35 W.</b>	<b>1.59 W</b>	<b>Passed</b>

The low ceiling upscale shoe department model passed CA Title 24 2022 Tailored compliance as well as the CA Title 24 2025 modified Area Category compliance developed for retail lighting that replaced Title 24 2022 Tailored compliance.

While the low ceiling designs passed both the Title 24 2022 and Title 24 2025 the scenario for the high ceiling design had a different outcome. (Refer to the high ceiling women’s shoes model).

## H.9 Large High-End Women’s Shoe Department High Ceiling as a Standalone

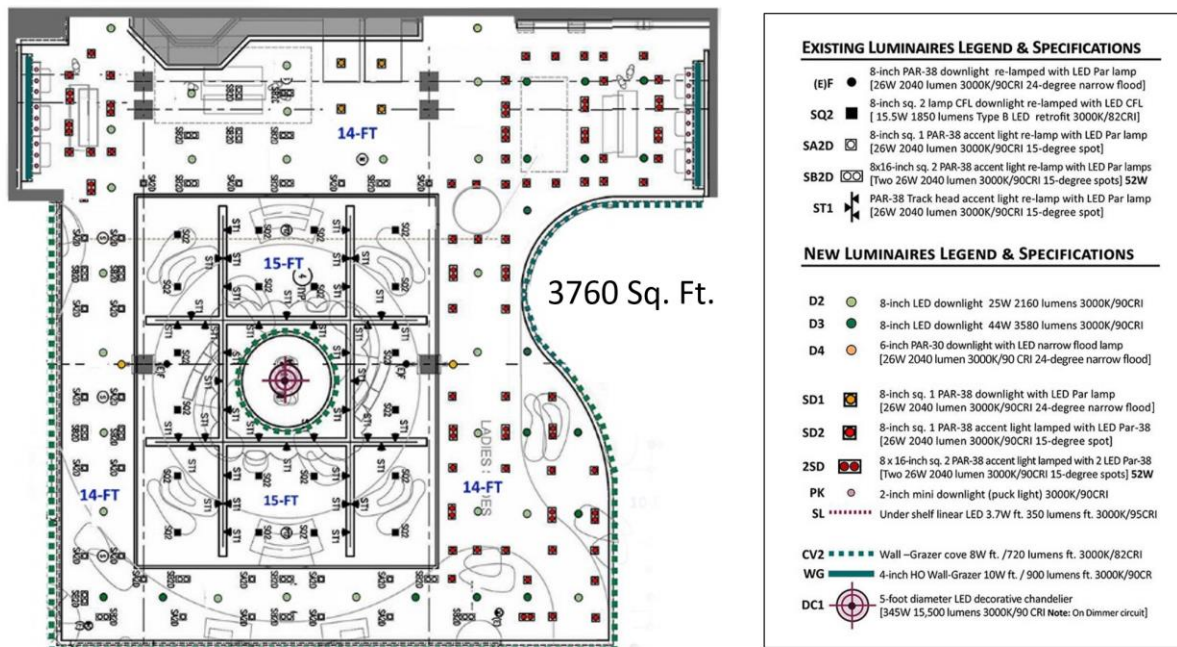


Figure 15: Reflected ceiling plan high ceiling women’s shoes.

The large upscale shoe department model high ceiling component was also modeled as if it were a standalone space for the purpose of its ability to meet Title 24 compliance. Lighting in this design consists of 25 W and 44 W 8-inch round aperture downlights and 31 W 8-inch square aperture downlights. There are also multi-head one 26 W lamp and two 26 W lamp accent light luminaires and additional accent lighting provided by a grid of track with track mounted 26 W accent light track heads. In addition to ceiling mounted luminaires there are illuminated shelves on the wall, wall cove to provide wall illumination and a wall grazer decorative lighting. All the lighting uses 3000 K /90 CRI LED sources.

Title 24 2022 and Title 24 2025 maximum allowed watts and allowed adjusted for use-it lose it adders versus the high ceiling design watt is shown in the table below.

**Table 40: Code Compliance Evaluation of High Ceiling Women’s Shoes Design**

Function	Design Watts (3760 Sq. Ft. / 14 + Ft. Ceiling)	Max Allowed (Title 24 2022 Tailored Method)	Use-it Louse -it (Title 24 2022 Tailored Method)	Plus/Minus (Title 24 2022 Tailored Method)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/General	1068	3384	3384	2316	3929	3929	2861
Floor Accent*	4498 [3374]	2632	2632	742	2256	2256	2242
Wall Accent*	447 [335]	851	335	0	940	447	0
Decorative	2090	1344	1344	0	1344	1344	746
Design Total	8103 [6867]	8211	7695	1384	8469	7976	127
Watts Sq. Ft.	2.16 W [1.83 W]	2.18 W	2.05 W	Passed	2.25 W.	2.12 W	Failed

\* Square brackets indicates design watts that can be allocated floor accent and wall accent using the 2022 Tailored lighting approach.

Refer to analysis of Title 24-2022 versus Title 24-2025 compliance for the high ceiling model.

As a standalone, the 14-foot /15-foot ceiling design passed Title 24 2022 tailored compliance however it failed the Title 24 2025 expanded retail area category method which introduced into the 25 code cycle to replace the 2022 Tailored lighting method.

The designs’ ability to comply with the Title 24 2022 Tailored lighting Method was the ability use to the allowed mounting height adjustment factor clause in the tailored method. This allowed for the actual display/accent lighting wattage to be reduced by a 0.75 adjustment which resulted in a lower wattage for display/accent lighting (then the actual watts) to be entered into the compliance forms.

While Title 24 2025 also allows a higher lighting power density (LPD) for higher ceilings its formula does not adequately address higher ceiling designs that have little or no walls.

This standalone, the 14-foot /15-foot ceiling design subset model of the large high-end women’s shoes as well as the Very Tall [17-foot] Fashion Wear Sales Area model were used to assure the proposed 2028 LPD’s for retail lighting adequately addresses higher ceiling designs with minimal to no walls.

### H.9.1 Evaluation of 2028 Proposal

The high-end women’s shoes high ceiling area with minimal walls fails under Title 24 2025 Area Category Method. However, by folding the decorative element into wall accent as provided for under the Title 24 2028 proposed allowed LPD’s for retail lighting the design passes even if only physical walls are used to calculate the wall accent and decorative allowance. This evaluation found that the more generous perimeter

allowance was not necessary that would make use of full walls, partial walls, soffits and/or bulkheads.

The simplification that allowed the combination of decorative and display allowances was useful for simplifying enforcement as often the same type of luminaires that are used for highlighting architectural features (decorative) are also used for highlighting products (display). Thus flexibility is increased and this in turn makes it possible to decrease the lighting power allowances as developing these allowances does not rely on making predictions of the split between decorative and display lighting.

**Table 41: Proposed 2028 Retail LPD Compliance Evaluation High-End Women’s Shoes High Ceiling with Minimal Walls**

Function	Design Watts (3760 Sq. Ft. / 14+ Ft. Ceiling)	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/Geneal	1068	3998	3998	2930	3929	3929	2861
Floor Accent	4498	3572	3572	926	2256	2256	2242
Wall Accent	2537	816 [2400]*	816 [2400]*	1721 [137]*	940	447	0
Decorative	0	0	0	0	1344	1344	746
Design Total	8103	8386 [9970]*	8386 [9970]*	253 [1867]*	8469	7976	127
Watts Sq. Ft.	2.16 W	2.23 W [2.65 W]*	2.23 W [2.65 W]*	Passed	2.25 W.	2.12 W	Failed

The next level of simplification was to allow decorative lighting to be allocated relative to how close it was adjacent to walls. The wall allowance was for all decorative/display fixtures within 10 feet of the walls. The rest of decorative lighting allocated to the floor display.

**Table 42: Proposed 2028 Retail LPD Compliance Evaluation High-End Women’s Shoes High Ceiling with Minimal Walls – Wall Accent within 10 feet of walls**

Function	Design Watts (3760 Sq. Ft. / 14+ Ft. Ceiling)	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/Geneal	1068	3998	3998	2930	3929	3929	2861
Floor Accent	5151	3572	3572	1579	2256	2256	1878
Wall Accent	1884	816 [2400]*	816 [1884]	1068 [0]*	940	811	0
Decorative	0	0	0	0	1344	1344	746
Design Total	8103	8386	386 [9454]*	83 [1351]*	8469	8340	240
Watts Sq. Ft.	2.16 W	2.23 W [3.32 W]*	2.23 W [2.51 W]*	Passed	2.25 W.	2.22 W	Passed

\* Perimeter area of space that has either full walls or partial walls and/ or soffits and bulkheads

The high-end women's shoes high ceiling area with minimal walls (if only the lighting directly positioned toward the walls are used to demonstrate compliance) failed under Title 24 2025 Area Category Method. However, the model passed under Title 24 2028 Proposed if only physical walls directly illuminated are used to calculate the wall accent component. It also passed if the more generous perimeter use of full walls, partial walls, soffits and/or bulkheads were applied.

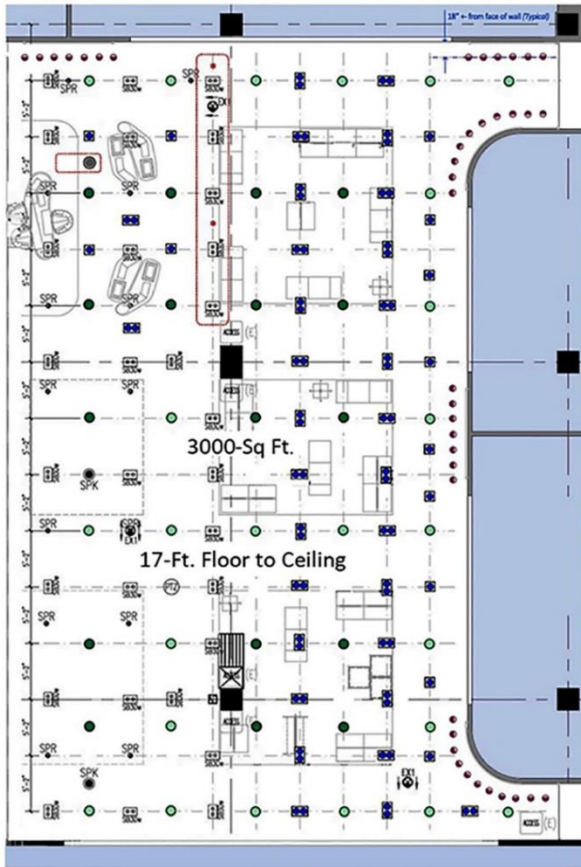
However, if 10-foot rule for wall accent lighting is applied the design passes compliance with both the 2025 code and 2028 proposed code LPD's. Luminaires located anywhere can be considered part of floor display as long as they are not also allocated to the wall display (no double counting).

## **H.10 Very Tall [17-foot] Fashion Wear Sales Area**

The very tall ceiling model was built to explore the challenges of providing the desired accent and display lighting from a 17-foot ceiling with a space that had minimal walls which thereby did not afford full use of the wall accent lighting adder. This model helped develop baseline/general and decorative/display accent lighting power density targets for high ceiling applications that balance energy efficiency and design performance. The model's footprint is 3000 square feet.

The ceiling has a mix of luminaires consisting of 25 W and 40 W 8-inch downlights with multi-head one 32 W lamp and two 32 W lamp accent light luminaires. In addition, there 4-inch aperture wall-washer luminaires that graze the walls that flank the entrances to a series of high-end designer brand shops. The material finishes on these walls is highly decorative and provide an upscale ambiance. All the lighting uses 3000 K /90 CRI LED sources.

This design passed CA Title-24 2022 Tailored Lighting Method by using Tailored Lightings RCR adjustment factor and display and accent lighting mounting height lighting power adjustment. However, the design failed CA Title-24 2025 compliance. While Title 24-2025 allows higher maximum lighting power density for high ceilings it appears it does not adequately prove for those taller ceiling environment that have little or no walls. Lessons learned from this model were applied to the proposed Title 24 2028 lighting maximum power densities (LPW's) that include consideration for those taller ceiling spaces with little or no walls.

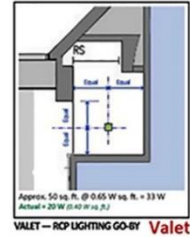


**LUMINAIRE SCHEDULE/SPECIFICATIONS**

- ADW ● 4-inch LED wall-washer 3000 K/90 CRI [24 W/1850 lumen's]
- SQ6 ■ 6-inch square LED down-light 3000 K/90 CRI [20 W/2000 lumen's] **Valet**
- C1 ● 8-inch round LED down light 3000 K/90 CRI [ 25 W/2150 lumen's]
- C2 ● 8-inch round LED down-light 3000 K/90 CRI [ 40 W/3450 lumen's]
- SA3Dw ■ Existing/Relocated 1 lamp PAR 38 multi head — Rel-amp as needed  
(Re-lamp: LED PAR-38 15-degree spot 3000 K/80 CRI 32 W/3000 lumen's)  
[Luminaire watts: 32]
- SB3Dw ■ Existing/Relocated 2 lamp PAR 38 multi head — Rel-amp as needed  
(Re-lamp: LED PAR-38 15-degree spot 3000 K/80 CRI 32 W/3000 lumen's)  
[Luminaire watts: 64]
- SB3Dw ■ Existing 2 lamp PAR 38 multi head — Re-lamp as needed  
(Re-lamp: LED PR-38 15-degree spot 3000K/80 CRI 32W/3000 lumens)  
[Luminaire watts: 64]

**Lighting power Density Calculation**

Luminaire	Watts	Quantity	Total Watts
(accent) ADW	24	41	984
(general) C1	25	25	625
(general) C2	40	17	680
(display) SA3Dw	32	14	448
(display) SB3Dw	64	54	3,456



General Lighting Wattage	1,305	General Lighting 0.435 W Sq. Ft.
Architectural Accent Lighting Wattage	(738) 984	Accent Lighting 1.627 W Sq. Ft.
Display Accent Lighting Wattage	(2928) 3,904	T24-2022 Allowed General 0.90 + Floor Display 0.70 Wall Display 11.5 in ft to Sq. Ft = 0.24 TOTAL MAX ALLOWED: 1.84 W Sq. Ft.
Total All Ceiling Luminaires	(4971) 6,193	
Watts/Sq. Ft. Based on 3000 Sq. Ft.	(1.657) 2.064	

Design Passed Using Title 24-2022 Tall Ceilings 0.75 Mounting Height Adjustment

**TITLE 24-2025 COMPLIANCE CHECK**

General Lighting: 3135 W / Floor Display: 1800 W / Wall Display: 1092 W / Decorative: 0 W  
 TOTAL MAXIMUM ALLOWED WATTS: 6027 W [Watt Sq. Ft. = 2.0 W]  
 TOTAL GENERAL, DISPLAY & DECORATIVE DESIGN WATTS: 6193 W [Watt Sq. Ft. = 2.06 W]  
**FAILED T24-2025 (+166W)**

High Ceiling Upscale Retail Model with Architectural Wall-Washing + Display & Accent Lighting

Figure 16: High ceiling upscale retail model and Title 24 2022 and Title 24 2025 compliance comparison.

**H.10.1 Evaluation 2028 Code Compliance**

The High Ceiling [17-foot] with Minimal Walls fails under Title 24 2025 Area Category Method as shown in Figure 16. However, this model passes under Title 24 2028 Proposed LPD's even if only physical walls are used to calculate compliance. Thus, it is not necessary to apply the more generous perimeter use of full walls, partial walls, soffits and/ or bulkheads to the calculation of wall decorative/display allowance. Furthermore, even with the use of allowing all display luminaires within 10 feet of walls regardless of where they are aimed, the High Ceiling [17-foot] with Minimal Walls fails compliance under Title 24 2025 Area Category Method.

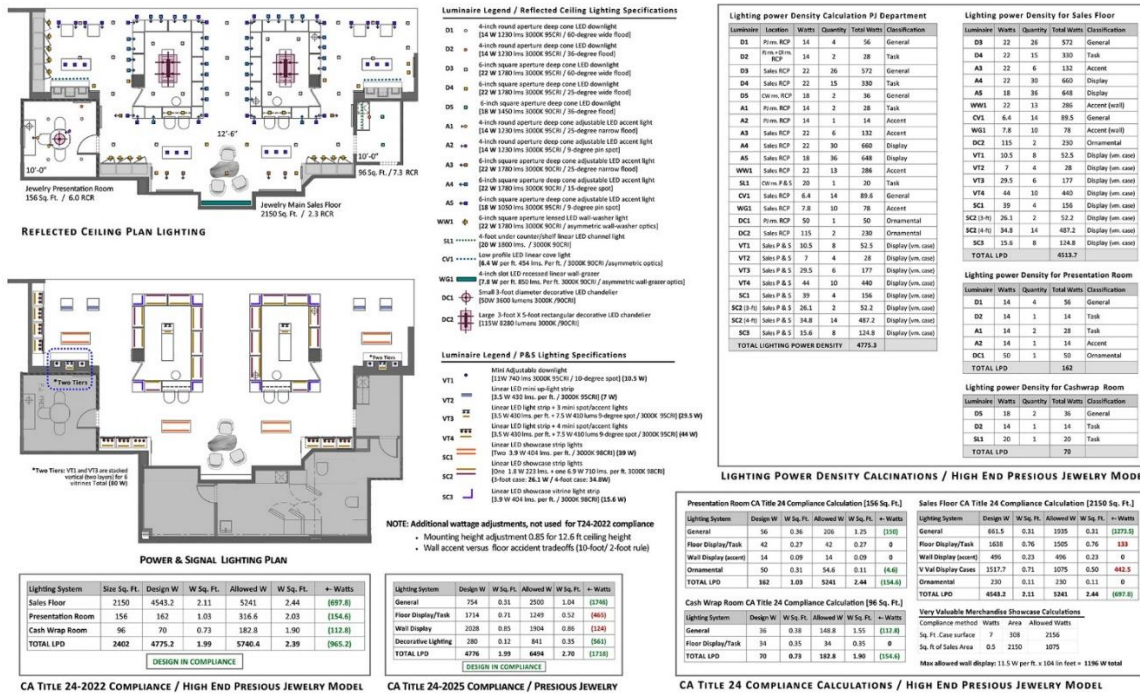
**Table 43: Proposed 2028 Retail LPD Compliance Evaluation: High Ceiling [17-foot] with Minimal Walls (82 feet of full wall)**

Function	Design Watts (3000 Sq. Ft. / 17 Ft. Ceiling)	Max Allowed (Title 24 2028 Proposed)	Use-it Louse -it (Title 24 2028 Proposed)	Plus/Minus (Title 24 2028 Proposed)	Max Allowed (Title 24 2025 Area Category Method)	Use-it Louse -it (Title 24 2025 Area Category Method)	Plus/Minus (Title 24 2025 Area Category Method)
Baseline/General	1305	2400	2400	1095	3135	3135	1830
Floor Accent	3904	2870	2870	1034	1800	1800	2100
Wall Accent	984	1080 [1920]*	984	0 [0]*	1041	984	0
Decorative	0	0	0	0	1050	0	0
Design Total	6193	6350 [7190]	6254	61	7026	5991	270
Watts Sq. Ft.	2.07 W	2.12 W [2.40 W]*	2.08 W	Passed	2.34 W	2.00 W	Fail

## H.11 Precious Jewelry department

This model was created to explore the potential higher lighting power density (LPD) required to illuminate very valuable merchandise such as diamonds, silver and gold as well as high end accessories such as Rolex watches. The models design relies heavily on internal illuminated showcases and vitrines as well as ceiling mounted accent and display lighting.

The footprint of this model is 2,150 square feet with a 12'6" ceiling height.



**HIGH END PRECIOUS JEWELRY MODEL / VERY VALUABLE MERCHANDISE SHOWCASES/VITRINES & ART FEATURES**

**Figure 17: High-end precious jewelry store with very valuable display cases.**

Baseline/general lighting for the precious jewelry model is provided by 6-inch 22 W square aperture downlight on the sales floor and 4-inch aperture 14 W downlight in the jewelry presentation room. Sales floor accent and display lighting is provided by ceiling mounted luminaires and internally lit showcase and vitrines. Showcase and vitrines with a mix of high color rendering LED linear channels and miniature track heads. Accent and display lighting in the jewelry presentation room is provided by 14 W 4-inch aperture accent light luminaires. In addition to accent and display lighting for the merchandise there are accent lights to illuminate artwork, wall-washers, wall-grazers and decorative chandeliers. This additional lighting provides visual ambiance and character associated with high-end retail environments.

This design passed with approximately 18 percent less lighting power than the allowed maximum lighting power for CA Title-24 2022 Tailored Lighting Method. The Tailored Lighting RCR adjustment factor and display and accent lighting mounting height lighting power adjustments as well as the valuable merchandise casework allowance were used to meet compliance. The design also passed CA Title-24 2025 compliance with designs LPD at approximately 24 percent less than the maximum allowed LPD.

## H.12 Outcome of Retail Analysis

The preceding presentations of designs and their installed power evaluation is intended to cover the broad range of retail designs, the energy code can accommodate the varying needs for light while placing an upper limit of the installed watts. The designs presented are using efficient sources and are judiciously applied so that light is placed on sales objects and the store architectural features to attract the consumer and provide light to help inspect the products. These designs are evaluated in terms of general lighting, ornamental lighting, accent or display lighting and display case lighting. Because displays are often stacked against the walls, and because small spaces have more wall areas per square foot of floor area, we consider wall display separately from floor display and consider methods of allocating lighting power to wall areas.

The relatively simple designs such as used for the Mom & Pop sales and the Big Box Retail designs rely heavily on general lighting to provide most of the illumination in the store. These stores require the highest general lighting power allowance. Historically general lighting wattage cannot make use of additional lighting power allowances for decorative or display lighting but must make trade-offs between general lighting in other spaces. The more layered designs actually do not use much general lighting because most of the light is used for highlighting products and if ambient light levels are too high it only makes it that much harder to develop luminance contrast with the rest of the space. Thus for these designs, much of the ambient lighting is a result of “spill light” that reflects off of the highlighted target or the beam spread is higher than the product highlighted.

Table 44 demonstrates the ability of simple Mom & Pop lighting designs to comply relatively readily. The primary workhorse of this design is the high efficiency troffer that provides a moderate amount of light fairly evenly. Ceiling heights at 11 feet and 6 inches are relatively low so there are not major losses either from the area light sources or the display lighting.

The big box retail store has relatively high general lighting illuminance targets that are provided diffusely across the space. This has one of the highest installed general lighting power densities and helped set the target baseline LPD allowance, display/decorative lighting has a minor contribution to the overall lighting budget.

The very valuable display case model is relatively evenly balanced between display case lighting, wall display lighting and the remainder of decorative/display lighting. Not much of the general lighting budget is used.

**Table 44: Summary Results and Applying Proposed Allowances: Mom & Pop, Big Box Retail and Jewelry**

Variables	Mom & Pop	Mom & Pop	Mom & Pop	Big Box Retailer	Precious Jewelry department
Description	Monolithic	2 system w/ wall washers	Moderate Level of Display and Accent Lighting	Warehouse Store	Main sales areas
Average ceiling height (ft)	11'-6"	11'-6"	11'-6"	26'-0"	12'-6"
Floor Area (ft2)	3,828	3,828	3,828	124,220	2,150
Wall length lineal foot (ft)	190	190	190	1,200	312
Plan view very valuable display case area (ft2).	0	0	0	0	298
General Lighting Power (W)	1,920	1,400	1,000	93,840	572
Rest of ornamental/display, (W)	0	0	294	0	1,364
Ornamental/display within 10 ft of wall, (W)	0	1,364	1,376	2,048	1,090
Display case, W	0	0	0	0	1,518
<b>Total Installed Power (W)</b>	<b>1,920</b>	<b>2,764</b>	<b>2,670</b>	<b>95,888</b>	<b>4,543</b>
Baseline LPD Allowance	2,871	2,871	2,871	99,376	1,613
Max decorative/display allowance	3,445	3,445	3,445	118,009	1,935
Max wall decorative/display allowance	1,900	1,900	1,900	14,400	3,120
Max Very valuable display case	0	0	0	0	1,490
Allowed Decorative/Display	0	0	294	0	1,364
Allowed wall decorative/display	0	1,364	1,376	2,048	1,090
Allowed display case allowance	0	0	0	0	1,490
<b>Baseline + all additional allowances</b>	<b>2,871</b>	<b>4,235</b>	<b>4,541</b>	<b>101,424</b>	<b>5,556</b>
Installed - (Baseline + additional Allowances)	-951	-1,471	-1,871	-5,536	-1,013
Percent over budget	-33%	-35%	-41%	-5%	-18%

As shown in Table 45, the designer shops and fashion war stores are more challenging to comply with the new standard as the spaces are relatively small and the sales task calls for relatively high light levels.

**Table 45: Summary Results and Applying Proposed Allowances: Designer Shops and Fashion Wear with Range of Space Heights**

Variables	Designer Shops with Illuminated Shelves	Designer Shops with Illuminated Shelves	Designer Brand/Specialty Shop	Designer Brand/Specialty Shop	Fashion Wear Sales Area
Description	10 foot ceiling	12 foot ceiling	Accent/Display Plus Ornamental (Luminous Wall) Lighting (800 sf)	Accent/Display Plus Ornamental (Luminous Wall) Entire Shop (1004 sf)	Very Tall [17-foot]
Average ceiling height (ft)	10'-0"	12'-6"	11'-0"	10'-8"	17'-0"
Floor Area (ft2)	850	850	800	1,004	3,000
Wall length lineal foot (ft)	104	104	96	184	90
Plan view very valuable display case area (ft2)	18	18	0	0	0
General Lighting Power (W)	195	260	470	560	1,305
Rest of ornamental/display, (W)	199	219	36	36	2,134
Ornamental/display within 10 ft of wall, (W)	1,014	1,871	1,790	1,880	2,754
Display case, W	122	122	0	0	0
<b>Total Installed Power (W)</b>	<b>1,530</b>	<b>2,472</b>	<b>2,296</b>	<b>2,476</b>	<b>6,193</b>
Baseline LPD Allowance	595	638	600	753	2,400
Max decorative/display allowance	723	765	720	904	2,850
Max wall decorative/display allowance	624	1,040	960	1,840	1,080
Max Very valuable display case	90	90	0	0	0
Allowed Decorative/Display	589	765	720	76	2,850
Allowed wall decorative/display	624	1,040	960	1,840	1,080
Allowed display case allowance	90	90	0	0	0
<b>Baseline + all additional allowances</b>	<b>1,898</b>	<b>2,533</b>	<b>2,280</b>	<b>2,669</b>	<b>6,330</b>
Installed - (Baseline + additional Allowances)	-368	-61	16	-193	-137
Percent over budget	-19%	-2%	1%	-7%	-2%

General lighting is a small fraction of the overall lighting uses in the designer shops so that most of the baseline lighting power allowance is used for offsetting lighting power that is not fully offset by display/ornamental lighting allowances. The taller the space, the more challenging it is to highlight the task. There are a limited number of beam spread patterns and this results in more power to illuminate to the desired footcandle level the higher the mounting height of lighting. The increased power requirement the higher the mounting height has resulted in the format of the retail lighting power allowances increasing with increasing ceiling height.

The designer brand shop has a massive 10 foot x 12 foot luminous display that consumes 1,376 Watts or about half the wattage of all the lighting in shop! Though this display is permanently connected, this can be treated as an internally illuminated sign. However, if it was removed one would likely replace this with additional decorative and display lighting but not likely as much. This highlights a corner case of where does signage leave off and lighting begin?

The final set of designs in Table 46, evaluate not only the ability of new designs to comply with the proposed 2028 lighting standard but also the capability of the energy code to accommodate the challenges of alterations especially those partial alterations that do not have walls on all sides. The design is a high end show shoe store with lots of nooks and crannies and illuminated shelves. The main portion of the store has a ceiling that is 14 to 15 feet tall, where as the selling areas off to the sides have 10-foot ceiling heights. When the compliance analysis is conducted for the entire store, the store easily complies. There is plenty of wall area to generate the decorative/display budget in addition to the decorative/display budget that is a function of floor area. If the 10-foot ceiling sections of the store were to be remodeled alone, this relatively narrow section of store has a fairly good ratio of wall length to floor area. And compliance with the new code is easily met.

But when the tall central portion of the store is evaluated as stand-alone remodel, compliance is difficult. The low ceiling areas that wraps around the central areas of store results in this store areas not having much wall areas to allocate decorative lighting power to. Additionally, the high bulkhead or elevated wall areas associated with the step change in ceiling heights is illuminated with cove lighting that does not have any special allowance allocated to it. The technical team considered two options: 1) rip out all the existing downlights and replace with dedicated high efficiency integral downlights and use lower wattage cove lighting or 2) consider changing the requirement for alterations that would base the wall decorative/display component of allowed lighting power on the length of the perimeter of the space. Even with the new luminaire classification that allows making use of lamp wattage, the first option would be prohibitively expensive for this particular design. For many designs this would be the lowest cost option to comply with code.

**Table 46: Summary Results and Applying Proposed Allowances: High End Shoe – Whole Store and Partial Retrofit Scenarios (Low Ceiling Designers Shops, High Ceiling Refresh with Wall Length versus Perimeter Length Allowance)**

Variables	Large High-End Women's Shoe	Large High-End Women's Shoe	Large High-End Women's Shoe	Large High-End Women's Shoe	Large High-End Women's Shoe
Description	Entire Store	Low Ceiling Standalone	High Ceiling Standalone	High Ceiling as a Standalone (5.6 W/ft cove)	High Ceiling Standalone (Perimeter)
Average ceiling height (ft)	12'4"	10'0"	14'-4"	14'-4"	14'-4"
Floor Area (ft2)	7,600	3,840	3,760	3,760	3,760
Wall length lineal foot (ft)	317	243	88	88	265
Plan view very valuable display case area (ft2).	0	0	0	0	0
General Lighting Power (W)	3,036	1,150	1,886	1,886	1,886
Rest of ornamental/display, (W)	7,015	532	6,391	5,911	3,295
Ornamental/display within 10 ft of wall, (W)	4,326	3,327	923	899	4,019
Display case, W	0	0	0	1	0
<b>Total Installed Power (W)</b>	<b>14,377</b>	<b>5,009</b>	<b>9,200</b>	<b>8,696</b>	<b>9,200</b>
Baseline LPD Allowance	5,700	2,688	3,008	3,008	3,008
Max decorative/display allowance	6,840	3,264	3,572	3,572	3,572
Max wall decorative/display allowance	3,170	1,458	1,056	1,056	3,180
Max Very valuable display case	0	0	0	0	0
Allowed Decorative/Display	6,840	2,401	3,572	3,572	3,572
Allowed wall decorative/display	3,170	1,458	923	899	3,180
Allowed display case allowance	0	0	0	0	0
<b>Baseline + all additional allowances</b>	<b>15,710</b>	<b>6,547</b>	<b>7,503</b>	<b>7,479</b>	<b>9,760</b>
Installed - (Baseline + additional Allowances)	-1,333	-1,538	1,697	1,217	-560
Percent over budget	-8%	-23%	23%	16%	-6%

Thus, the general, decorative/display and very valuable display lighting allowances is designed to be applicable across all designs. Key issues are:

- General lighting allowance is set by the need for relatively high general light levels for simple retail designs.
- For layered designs the decorative/display allowances may cover only part of the needed power budget for decorative/display lighting with the expectation that lighting budget left over from general lighting is allowed to be used for decorative/display lighting.
- The taller the space, the greater the wattage needed to obtain the design center beam candlepower on the product. Thus, the retail lighting allowances increase with space size.
- The smaller the space the greater the ratio of wall areas to floor area. To account for this the lighting budget includes a decorative/display lighting budget that is a function of the floor and the length of the illuminated wall.

As described in the beginning of this appendix, this proposal recommends having two additional lighting power allowances per row and their qualifications. Additionally, this proposal is recommending a simplification of the calculation method that combines some of the additional lighting allowances which allows the designer more flexibility for realizing their design intent within the Title 24 lighting budget. With more flexibility, it is possible to have more restrictive limits as the fixed budget based on space geometry allows trade-offs within the space for decorative and display lighting, the alternative is to have higher fixed budget by space component walls versus floors and by luminaire type decorative versus display.

**Table 47: Retail Sales LPDs extracted from 2025 T-24 Table140.6-C**

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
Retail Sales Area	Grocery Sales	1.00	Decorative	0.35
Retail Sales Area	Grocery Sales	1.00	Wall Display MH <= 10'6"	6.6 W/ft
Retail Sales Area	Grocery Sales	1.00	Wall Display MH 10'7" - 14'	7.76 W/ft
Retail Sales Area	Grocery Sales	1.00	Wall Display MH > 14'	8.8 W/ft
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH <= 10'6"	0.60
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH 10'7"- 14'	0.70
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH > 14'	0.80
Retail Sales Area	Grocery Sales	1.00	General Lighting in the enclosed space of ceiling height > 10'	0.10

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Retail Sales Area	Retail Merchandise Sales	0.95	Decorative	0.35
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH <= 10'6"	9.5 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH 10'7"- 14'	11.2 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH > 14'	12.7 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH <= 10'6"	0.45
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH 10'7"- 14'	0.52
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH > 14'	0.60
Retail Sales Area	Retail Merchandise Sales	0.95	Valuable Display Case	0.50
Retail Sales Area	Retail Merchandise Sales	0.95	General Lighting in the enclosed space of ceiling height > 10'	0.10

What is proposed is that the allowed lighting allowance for retails and grocery spaces is there is a baseline allowance per room which is allocated to:

- General lighting which is defined as relatively uniform lighting.
- When general lighting does not exist in the space, then the lighting systems which are providing circulation lighting is allocated to the baseline allowance without qualifying for the additional lighting power allowance. Circulation lighting is what allows one to navigate around the space without tripping but is not necessarily enough lighting to perform the tasks in the space.
- Normally cove lighting is considered decorative lighting but if cove lighting is the only lighting in the space, this would be allocated to the baseline lighting allowance.<sup>15</sup>
- The baseline lighting allowance also accounts for installed decorative and display lighting wattage that is greater than the decorative/display lighting allowance for the space.
- Any extra baseline lighting allowance that is left over after accounting for all lighting in the room is available to be used in another room. Unlike the additional

<sup>15</sup> See example 5.2 "Cove Lighting" on pages 5-8 and 5-9 of the 2025 Nonresidential Compliance Manual for the 2025 Building Energy Efficiency Standards. CEC-400-2025-008

lighting power allowances, the general lighting power allowance is considered on a whole building basis.

Retail sales spaces have two types of additional lighting power allowances:

- Decorative/display allowance
- Very valuable display case allowance

The Decorative/display lighting allowance, DDLA, is calculated as follows:

$$\text{DDLA} = \text{Floor Area} \times \text{DDFA} + \text{Wall Length} \times \text{DDWL}$$

Where

DDFA = decorative/display floor area allowance, W/sf of floor

DDWL = decorative/display wall length allowance, W/lin ft of wall

The decorative display allowance is compared against the all of the decorative and floor lighting wattage. This allowance is use it or lose it. If one has extra allowances once can not use this general lighting or task lighting or allocate this allowance to another space. Thus the decorative/display allowance is the lesser of the allowed wattage and the installed decorative/display wattage. If the installed decorative/display wattage in a space is greater than the decorative/display allowance, this can be allocated against the whole building baseline lighting allowance.

The very valuable display case allowance is based on a 5 Watt per square foot allowance for the plan view areas (horizontal projection) of the very valuable display case. To qualify as a very valuable display case, the defined term is added as follows:

**Very Valuable Display Case Lighting** is lighting contained inside of a display case containing rare or precious objects, including, but not limited to, jewelry, coins, small art objects, crystal, ceramics, or silver, the selling of which involves customer inspection of very fine detail from outside of a locked case.

This additional lighting allowance for very valuable display cases is use-it or lose-it. The allowance is the lesser of the 5 Watt per square foot of display case area and the installed wattage of lighting inside the display case. If the installed wattage inside the display case is greater than the allowance, the additional wattage can be allocated to the baseline lighting of the building. It cannot be allocated to the display/decorative allowance. However other display case lighting and under cabinet lighting is appropriately allocated to the decorative/display lighting allowance.

To address the consideration associated with partial lighting retrofits, this proposal recommends having an exception to 601.5.2.2.4(1) [Section 141.0(b)2li] which would allow the wall decorative/display allowance to be based upon the perimeter length of the retrofit which includes walls but also the imaginary boundary between the retrofit portion of a space and the surrounding portion of the space not receiving the retrofit.

This exception must be considered in the context of the current triggering event of Section 601.5.2.2.4 [Section 141.0(b)2I] ***“Altered Indoor Lighting Systems. Alterations to indoor lighting systems that include 10% or more of the luminaires serving an enclosed space shall meet the requirements of i, ii, or iii below:...”***

**Table 48: Proposed 2028 Updated Format and Values for Retails LPDs Table 601.3-C1 [Table 140.6-C1] Area Category Method**

Primary Function Areas	Baseline LPD Allowance (W/sf)	Additional Qualified Lighting System 1	Additional Allowance 1 (W/ft <sup>2</sup> unless other units)	Additional Qualified Lighting System 2	Additional Allowance 2 (W/ft <sup>2</sup> unless other units)
Retail: Grocery Sales CH ≤10'6"	0.80	Decorative/Display	0.45	Decorative/display per ft of wall length	3 W/ft
Retail: Grocery Sales CH -10'7"-14'	0.85	Decorative/Display	0.50	Decorative/display per ft of wall length	5 W/ft
Retail: Grocery Sales CH >14'	0.90	Decorative/Display	0.55	Decorative/display per ft of wall length	6 W/ft
Retail: Merchandise Sales CH ≤10'6"	0.70	Decorative/Display	0.85	Decorative/display per ft of wall length	6 W/ft
Retail: Merchandise Sales CH -10'7"-14'	0.75	Decorative/Display	0.90	Decorative/display per ft of wall length	10 W/ft
Retail: Merchandise Sales CH >14'	0.80	Decorative/Display	0.95	Decorative/display per ft of wall length	12 W/ft
Retail: Merchandise Sales (all space heights) additional power for very valuable display case, W/sf of display case	N/A	Very valuable display case interior lighting	5 W/ sf		

## Appendix I: 2025 Area Category Method LPDs in the 2025 Energy Code Format

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As part of the code change proposal for 2028 Title 24, part 6 Area Category Method, two Area Category Method Tables are published. The first one for nonresidential buildings, *Table 601.3-C1 [Table 140.6-C1] Area Category Method—Lighting Power Density Values (Watts/Ft<sup>2</sup>) For Nonresidential Buildings Not Including Group R Occupancies And Common Use Or Public Use Areas* has changed lighting power density values based on the analysis detailed in this report. The second table, for residential buildings, *Table 601.3-C2 [Table 140.6-C2] Area Category Method—Lighting Power Density Values (Watts/Ft<sup>2</sup>) For Group R Occupancies And Common Use Or Public Use Areas* is reformatted to match the formatting of the Nonresidential table. These tables are in the section with the edited code language in *Section 7.3.3: Proposed Changes to Lighting Power Density (LPD)*

For reference Table 49 contains the 2025 Area Category Method LPDs. It is not recommended to continue using this format. It is difficult to use and would not match the format for the proposed 2028 nonresidential 2025 Area Category Method LPDs.

**Table 49: Table 601.3-C [Table 140.6-C] Area Category Method—Lighting Power Density Values (Watts/Ft<sup>2</sup>) with 2025 LPDs and Displayed in the 2025 Format.**

<b>Building Type/Use</b>	<b>Primary Function Area</b>	<b>Allowed Lighting Power Density for General Lighting (W/ft<sup>2</sup>)</b>	<b>Additional Lighting Power Qualified Lighting Systems</b>	<b>Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft<sup>2</sup>, unless noted otherwise)</b>
<b>Aging Eye/Low-vision<sup>10</sup></b>	Corridor Area	0.70	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	Dining	0.80	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	NA	0.80	Tunable white or dim-to-warm <sup>9</sup>	0.10
<b>Aging Eye/Low-vision<sup>10</sup></b>	Lobby, Main Entry	0.85	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	Lobby, Main Entry	0.85	Transition Lighting OFF at night <sup>11</sup>	0.95
<b>Aging Eye/Low-vision<sup>10</sup></b>	Lobby, Main Entry	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10
<b>Aging Eye/Low-vision<sup>10</sup></b>	Lounge/Waiting Area	0.80	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	Lounge/Waiting Area	0.80	Tunable white or dim-to-warm <sup>9</sup>	0.10
<b>Aging Eye/Low-vision<sup>10</sup></b>	Multipurpose Room	0.85	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	Multipurpose Room	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10
<b>Aging Eye/Low-vision<sup>10</sup></b>	Religious Worship Area	1.00	Decorative/Display	0.30
<b>Aging Eye/Low-vision<sup>10</sup></b>	Religious Worship Area	1.00	Tunable white or dim-to-warm <sup>9</sup>	0.10
<b>Aging Eye/Low-vision<sup>10</sup></b>	Restroom	1.00	Decorative/Display	0.20
<b>Aging Eye/Low-vision<sup>10</sup></b>	Stairwell	0.80	Decorative/Display	0.30
<b>Audience Seating Area</b>	NA	0.50	Decorative/Display	0.25
<b>Auditorium Area</b>	NA	0.70	Decorative/Display	0.45

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Auto Repair / Maintenance Area	NA	0.55	Detailed Task Work <sup>6</sup>	0.20
Barber, Beauty Salon, Spa Area	NA	0.70	Detailed Task Work <sup>6</sup>	0.30
Barber, Beauty Salon, Spa Area	NA	0.70	Decorative/Display	0.25
Civic Meeting Place Area	NA	0.90	Decorative/Display	0.25
Classroom, Lecture, Training, Vocational Area	NA	0.60	White or Chalk Board <sup>1</sup>	7 W/ft
Concourse and Atria Area	NA	0.60	Decorative/Display	0.25
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Decorative	0.25
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Wall Display MH <= 10'6"	2 W/ft
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Wall Display MH 10'7"- 14'	2.35 W/ft
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Wall Display MH > 14'	2.66 W/ft
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Floor Display and Task MH <= 10'6"	0.30
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Floor Display and Task MH 10'7"- 14'	0.35

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Convention, Conference, Multipurpose and Meeting Area	NA	0.75	Floor Display and Task MH > 14'	0.40
Copy Room	NA	0.50	NA	NA
Corridor Area	NA	0.40	Decorative/Display	0.25
Dining Area	Bar/Lounge and Fine Dining	0.45	Decorative	0.35
Dining Area	Bar/Lounge and Fine Dining	0.45	Wall Display MH ≤ 10'6"	1.25 W/ft
Dining Area	Bar/Lounge and Fine Dining	0.45	Wall Display MH 10'7" - 14'	1.5 W/ft
Dining Area	Bar/Lounge and Fine Dining	0.45	Wall Display MH > 14'	1.7 W/ft
Dining Area	Bar/Lounge and Fine Dining	0.45	Floor Display and Task MH ≤ 10'6"	0.45
Dining Area	Bar/Lounge and Fine Dining	0.45	Floor Display and Task MH 10'7" - 14'	0.52
Dining Area	Bar/Lounge and Fine Dining	0.45	Floor Display and Task MH > 14'	0.60
Dining Area	Bar/Lounge and Fine Dining	0.45	General Lighting in the enclosed space of ceiling height > 10'	0.25
Dining Area	Cafeteria/Fast Food	0.45	Decorative/Display	0.25
Dining Area	Family and Leisure	0.40	Decorative/Display	0.25
Electrical, Mechanical, Telephone Rooms	NA	0.40	Detailed Task Work <sup>6</sup>	0.20

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Exercise/Fitness Center and Gymnasium Area	NA	0.50	NA	NA
Financial Transaction Area	NA	0.70	Decorative/Display	0.25
Healthcare Facility and Hospitals	Exam/Treatment Room	1.15	NA	NA
Healthcare Facility and Hospitals	Imaging Room	0.60	Decorative/Display	0.20
Healthcare Facility and Hospitals	Imaging Room	0.60	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Medical Supply Room	0.55	NA	NA
Healthcare Facility and Hospitals	Nursery	0.80	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Nurse's Station	0.85	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Nurse's Station	0.85	Detailed Task Work <sup>6</sup>	0.20
Healthcare Facility and Hospitals	Operating Room	1.90	NA	NA
Healthcare Facility and Hospitals	Patient Room	0.70	Decorative/Display	0.15
Healthcare Facility and Hospitals	Patient Room	0.70	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Physical Therapy Room	0.75	Tunable white or dim-to-warm <sup>9</sup>	0.10
Healthcare Facility and Hospitals	Recovery Room	0.90	Tunable white or dim-to-warm <sup>9</sup>	0.10

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Hotel Function Area	NA	0.85	Decorative/Display	0.25
Kitchen/Food Preparation Area	NA	0.95	NA	NA
Laboratory, Scientific	NA	0.90	Specialized Task Work <sup>8</sup>	0.35
Laundry Area	NA	0.45	-	-
Library	Reading Area	0.80	Decorative/Display	0.25
Library	Stacks Area	1.00	NA	NA
Lobby, Main Entry	NA	0.70	Decorative	0.25
Lobby, Main Entry	NA	0.70	Wall Display MH <= 10'6"	3 W/ft
Lobby, Main Entry	NA	0.70	Wall Display MH 10'7"- 14'	3.5 W/ft
Lobby, Main Entry	NA	0.70	Wall Display MH > 14'	4 W/ft
Locker Room	NA	0.45	NA	NA
Lounge, Breakroom, or Waiting Area	NA	0.55	Decorative/Display	0.25
Manufacturing, Commercial and Industrial Work Area	Low Bay	0.60	Detailed Task Work <sup>6</sup>	0.20
Manufacturing, Commercial and Industrial Work Area	High Bay	0.65	Detailed Task Work <sup>6</sup>	0.20
Manufacturing, Commercial and Industrial Work Area	Precision	0.85	Precision Specialized Work <sup>8</sup>	0.70
Museum Area	Exhibition/Display	0.60	Decorative/Display	0.45
Museum Area	Restoration Room	0.70	Detailed Task Work <sup>6</sup>	0.35
Office Area	> 250 square feet	0.60	Decorative/Display and Portable lighting for office areas <sup>5</sup>	0.20

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Office Area	≤ 250 square feet	0.65	Decorative/Display and Portable lighting for office areas <sup>5</sup>	0.20
Parking Garage Area	Parking Zone and Ramps	0.10	First ATM or Ticket Machine	100 W
Parking Garage Area	Parking Zone and Ramps	0.10	Additional ATM or Ticket Machine	50 W/each
Parking Garage Area	Daylight Adaptation Zones <sup>2</sup>	1.00	NA	NA
Pharmacy Area		1.00	Specialized Task Work <sup>8</sup>	0.35
Retail Sales Area	Grocery Sales	1.00	Decorative	0.35
Retail Sales Area	Grocery Sales	1.00	Wall Display MH ≤ 10'6"	6.6 W/ft
Retail Sales Area	Grocery Sales	1.00	Wall Display MH 10'7"- 14'	7.76 W/ft
Retail Sales Area	Grocery Sales	1.00	Wall Display MH > 14'	8.8 W/ft
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH ≤ 10'6"	0.60
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH 10'7"- 14'	0.70
Retail Sales Area	Grocery Sales	1.00	Floor Display and Task MH > 14'	0.80
Retail Sales Area	Grocery Sales	1.00	General Lighting in the enclosed space of ceiling height > 10'	0.10
Retail Sales Area	Retail Merchandise Sales	0.95	Decorative	0.35
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH ≤ 10'6"	9.5 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH 10'7"- 14'	11.2 W/ft
Retail Sales Area	Retail Merchandise Sales	0.95	Wall Display MH > 14'	12.7 W/ft

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH <= 10'6"	0.45
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH 10'7"- 14'	0.52
Retail Sales Area	Retail Merchandise Sales	0.95	Floor Display and Task MH > 14'	0.60
Retail Sales Area	Retail Merchandise Sales	0.95	Valuable Display Case	0.50
Retail Sales Area	Retail Merchandise Sales	0.95	General Lighting in the enclosed space of ceiling height > 10'	0.10
Retail Sales Area	Fitting Room	0.60	External Illuminated Mirror <sup>4</sup>	40 W/ea
Retail Sales Area	Fitting Room	0.60	Internal Illuminated Mirror <sup>4</sup>	120 W/ea
Religious Worship Area		0.95	Decorative/Display	0.25
Restrooms		0.65	Decorative/Display	0.35
Stairwell		0.60	Decorative/Display	0.35
Storage, Commercial/Industrial	Warehouse	0.40	NA	NA
Storage, Commercial/Industrial	Shipping and Handling	0.60	NA	NA
Sports Arena—Playing Area	Class I Facility <sup>12</sup>	2.25	NA	NA
Sports Arena—Playing Area	Class II Facility <sup>12</sup>	1.45	NA	NA
Sports Arena—Playing Area	Class III Facility <sup>12</sup>	1.10	NA	NA
Sports Arena—Playing Area	Class IV Facility <sup>12</sup>	0.75	NA	NA
Theater Area	Motion picture	0.50	Decorative/Display	0.25
Theater Area	Performance	0.80	Decorative/Display	0.25
Transportation Function	Baggage Area	0.40	NA	NA

Building Type/Use	Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft <sup>2</sup> )	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance <sup>3</sup> (W/ft <sup>2</sup> , unless noted otherwise)
Transportation Function	Ticketing Area	0.45	Decorative/Display	0.20
Videoconferencing Studio	NA	0.90	Videoconferencing <sup>13</sup>	1.00
All other	NA	0.40	NA	NA

# Appendix J: Luminaire Review

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## J.1 Troffers

### J.1.1 Guidelines and Targets fro 2025 LED Troffer Luminaire Efficacy Analysis

[Lighting Designer/Specifier Resources]

#### General

LED troffer luminaire specifications were sampled from manufacturers that are typical resources for lighting designers, architects, and electrical engineers that specify lighting products. The luminaires specifications, extracted from manufacture cut sheets, was recorded and collected, with efficacy performance documented in this report. The objective of the analysis is to determine the current efficacy of LED troffer luminaires available to the designer specifier market.

#### Specifics:

- Fluorescent maintained lumen output target for 2 X 2, 2 X 4, and Wall-Washer troffer luminaires.
- Fluorescent 2 X 2 troffers: Two T8U6 fluorescent lamps 2800 lumens each 3500K /80 CRI

#### Operational Performance:

5600 lumens lamps

Ballast factor .88 = 4928 initial lumens

luminaire efficiency of 70% = 3450 lumens @ 54 Luminaire watt = 64 lumens per watt

Fluorescent 2 X 4 troffers: Four T8-32 watt fluorescent lamps 2950 lumens each 3500K /80 CRI

#### Operational Performance:

11,800 lumens lamps—Ballast factor .88 = 10,384 initial lumens—luminaire efficiency of 70% = 7268 lumens @ 114 Luminaire watt = 64 lumens per watt

2 X 2 LED troffer LPW target: 3200 to 3600 lumens. Equivalent performance to 2 lamp 2 x 2 T8 fluorescent troffers.

2 X 4 LED troffer LPW target: 6800 to 7200 lumens. Equivalent performance to 4 lamp 2 x 4 T8 fluorescent troffers.

Twin Tube Fluorescent 2-foot & 4-foot Wall-Washer troffers: 1 lamp 40 W T5 twin tube and 1 lamp 50 W T5 twin tube (3150 lumens 40 W) (4000 lumens 50 W) / 2 lamp 40 W

T5 twin tube and 2 lamp 50 W T5 twin tube lamps (6300 lumens 80 W) (8000 lumens 100 W) 3500K /80 CRI

Operational performance:

2-foot 1 40 W lamp 3150 lamp lumens—Ballast factor .95 = 2993 initial lumens—luminaire efficiency of 70% = 2095 lumens @ 38 Luminaire watts = 55 lumens per watt

4-foot 2 40 W lamps 6300 lamp lumen—Ballast factor .95 = 5985 initial lumens—luminaire efficiency of 80% = @ 4788 lumens @ 76 Luminaire watts = 63 lumens per watt

2-foot 1 50 W lamp 4000 lamp lumens—Ballast factor 1.11 = 4440 initial lumens—luminaire efficiency of 80% = 3552 lumens @ 61 Luminaire watts = 58 lumens per watt

4-foot 2 50 W lamps 8000 lamp lumen—Ballast factor .95 = 8240 initial lumens—luminaire efficiency of 80% = @ 6592 lumens @ 111 Luminaire watts = 59 lumens per watt

T8 Fluorescent 2-foot and 4-foot Wall-Washer troffers: 1 lamp 17 W 2-ft lamp and 1 lamp 32 W 4-ft lamp T8 fluorescent 1400 lumens 17 W (2-foot lamp) and 2950 lumens 32(4-foot lamp) 3500K /80 CRI

Operational Performance

2-foot 1 lamp 1400 lamp lumens—Ballast factor .88 = 1232 initial lumens – luminaire efficiency of 85% =

1047 lumens @ 17 Luminaire watts = 62 lumens per watt

4-foot 1 lamp 2950 lamp lumens – Ballast factor .88 = 25962 initial lumens – luminaire efficiency of 85% =

2207 lumens @ 29 Luminaire watts = 76 lumens per watt

**LED WALL-WASHER TROFFER LUMEN OUTPUT TARGETS**

2 -foot Wall-Washer troffers LPW target: 1100 to 3600 lumens [equivalent performance to T8 and T5 fluorescent troffers]

4 -foot Wall-Washer troffers LPW target: 1200 to 6000 lumens [equivalent performance to T8 and T5 fluorescent troffers]

**Table 50: 2025 LED Luminaire Efficacy’s [Basket Troffers/Specifiers]**

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Notes, Comments and Remarks</b>
<b>A Basket Troffer Luminaires</b>	2X2	3500	80	Total of 8 luminaires sampled with watts from 30 W to 66 W and efficacy between 110 to 156 lumens per watt [Fixed output and multi tap luminaires were included in the sampling]
<b>A Basket Troffer Luminaires</b>	2X4	3500	80	Total of 8 luminaires sampled with watts from 30 W to 66 W and efficacy between 110 to 156 lumens per watt [Fixed output and Multi Tap luminaires were included in the sampling]
<b>B Basket Troffer Luminaires</b>	2X2	3500	80	Total of 4 luminaires sampled with watts from 28 W to 58 W and efficacy between 122 to 136 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B Basket Troffer Luminaires</b>	2X4	3500	80	Total of 4 luminaires sampled with watts from 28 W to 58 W and efficacy between 122 to 136 lumens per watt [Fixed output luminaires were only products in sampling]
<b>C Basket Troffer Luminaires</b>	2X2	3500	80	Total of 6 luminaires sampled with watts from 30 W to 66 W and efficacy between 110 to 156 lumens per watt [Fixed output and Multi Tap luminaires were included in the sampling]
<b>C Basket Troffer Luminaires</b>	2X4	3500	80	Total of 6 luminaires sampled with watts from 30 W to 66 W and efficacy between 110 to 156 lumens per watt [Fixed output and Multi Tap luminaires were included in the sampling]
<b>D Basket Troffer Luminaires</b>	2X2	3500	80	Total of 6 luminaires sampled with watts from 24 W to 55 W and efficacy between 107 to 149 lumens per watt [Fixed output luminaires were only products in sampling]
<b>D Basket Troffer Luminaires</b>	2X4	3500	80	Total of 6 luminaires sampled with watts from 24 W to 55 W and efficacy between 107 to 149 lumens per watt [Fixed output luminaires were only products in sampling]
<b>E Basket Troffer Luminaires</b>	2X2	3500	80	Total of 10 luminaires sampled with watts from 27 W to 68 W and efficacy between 101 to 143 lumens per watt [Fixed output luminaires were only products in sampling]
<b>E Basket Troffer Luminaires</b>	2X4	3500	80	Total of 10 luminaires sampled with watts from 27 W to 68 W and efficacy between 101 to 143 lumens per watt

				[Fixed output luminaires were only products in sampling]			
<b>F Basket Troffer Luminaires</b>	2X2	3500	80	Total of 8 luminaires sampled with watts from 24 W to 65 W and efficacy between 101 to 143 lumens per watt [Fixed output luminaires were only products]			
<b>F Basket Troffer Luminaires</b>	2X4	3500	80	Total of 8 luminaires sampled with watts from 24 W to 65 W and efficacy between 101 to 143 lumens per watt [Fixed output luminaires were only products]			
<b>G Basket Troffer Luminaires</b>	2X2	3500	80	Total of 16 luminaires sampled with watts from 30 W to 66 W and efficacy between 104 to 143 lumens per watt [Fixed output and Multi Tap luminaires were included in the sampling]			
<b>G Basket Troffer Luminaires</b>	2X4	3500	80	Total of 16 luminaires sampled with watts from 30 W to 66 W and efficacy between 104 to 143 lumens per watt [Fixed output and Multi Tap luminaires were included in the sampling]			
<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Watts</b>	<b>Lumens</b>	<b>LPW</b>	<b>Notes, Comments and Remarks</b>
<b>Average of All 2 X 2 Basket Luminaires</b>	2X2	3500	80	28	3560	126	Range of 2X2 Samples LPW 104 to 148
<b>Average of All 2 X 4 Basket Luminaires</b>	2X4	3500	80	53	6942	131	Range of 2X4 Samples LPW 101 to 162
<b>Average Efficacy of All 2 x 2 and 2 X 4 Basket Luminaires</b>	-	-	-	-	-	<b>130</b>	<b>Mix Includes Multi-Wattage and Tunable White Luminaires</b>

**Table 51: 2025 LED Luminaire Efficacy's [Direct/Indirect Troffers/Specifiers]**

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Notes, Comments and Remarks</b>
<b>A Direct/Indirect Troffers</b>	2X2	3500	80	Total of 4 luminaires sampled with watts from 40 W to 76 W and efficacy between 87 to 109 lumens per watt [Fixed output luminaires were only products in sampling]
<b>A Direct/Indirect Troffers</b>	2X4	3500	80	Total of 4 luminaires sampled with watts from 40 W to 76 W and efficacy between 87 to 109 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B Direct/Indirect Troffers</b>	2X2	3500	90	Total of 2 luminaires sampled with watts of 23 W and 38 W with efficacy of 133 and 137 lumens per watt (only 90 CRI product available) [Fixed output luminaires were only products in sampling]
<b>B Direct/Indirect Troffers</b>	2X4	3500	90	Total of 2 luminaires sampled with watts of 23 W and 38 W with efficacy of 133 and 137 lumens per watt (only 90 CRI product available) [Fixed output luminaires were only products in sampling]
<b>C Direct/Indirect Troffers</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 34 W and 57 W with efficacy of 60 and 70 lumens per watt (both samplings missed the lumen output targets) [Fixed output luminaires were only products in sampling]
<b>C Direct/Indirect Troffers</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 34 W and 57 W with efficacy of 60 and 70 lumens per watt (both samplings missed the lumen output targets) [Fixed output luminaires were only products in sampling]
<b>D Direct/Indirect Troffers</b>	2X2	3500	80	Total of 6 luminaires sampled with watts 34 W to 62 W with efficacy between 80 to 128 lumens per watt (two 2X4 samplings missed lumen output targets)
<b>D Direct/Indirect Troffers</b>	2X4	3500	80	Total of 6 luminaires sampled with watts 34 W to 62 W with efficacy between 80 to 128 lumens per watt (two 2X4 samplings missed lumen output targets)
<b>E Direct/Indirect Troffers</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 30 W and 50 W with efficacy of 100 lumens per watt (the 2X4 sampling missed the lumen output target)
<b>E Direct/Indirect Troffers</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 30 W and 50 W with efficacy of 100 lumens per watt (the 2X4 sampling missed the lumen output target)
<b>F Direct/Indirect Troffers</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 23 W and 62 W with efficacy of 133 and 137 lumens per watt (the 2X2 sampling missed the lumen output target)
<b>F Direct/Indirect Troffers</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 23 W and 62 W with efficacy of 133 and 137 lumens per watt (the 2X2 sampling missed the lumen output target)

Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
Ave. All 2 X 2 Direct/Indirect Luminaires	2X2	3500	80	32	3170	99	Range of 2X2 Samples LPW 60 to 137
Ave. All 2 X 4 Direct/Indirect Luminaires	2X4	3500	80	58	5956	103	Range of 2X4 Samples LPW 70 to 133
Average Efficacy of All 2 x 2 and 2 X 4 Direct/Indirect Luminaires	-	-	-	-	-	<b>101</b>	<b>Majority range 100 LPW + - 20 LPW</b>

**Table 52: 2025 LED Luminaire Efficacy’s [Lensed Troffers/Specifiers]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks
<b>A</b>	2X2	3500	80	Total of 4 luminaires sampled with watts from 39 W to 59 W and efficacy between 108 to 126 lumens per watt [Fixed output luminaires were only products in sampling]
<b>A</b>	2X4	3500	80	Total of 4 luminaires sampled with watts from 39 W to 59 W and efficacy between 108 to 126 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 43 W and 74 W and efficacy of 86 and 97 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 43 W and 74 W and efficacy of 86 and 97 lumens per watt [Fixed output luminaires were only products in sampling]
<b>C</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 31 W and 39 W and efficacy of 105 and 125 lumens per watt [Fixed output luminaires were only products in sampling]
<b>C</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 31 W and 39 W and efficacy of 105 and 125 lumens per watt

				[Fixed output luminaires were only products in sampling]			
D	2X2	3500	80	Total of 2 luminaires sampled with watts of 30 W and 56 W with efficacy of 101 and 129 lumens per watt [Fixed output luminaires were only products in sampling]			
D	2X4	3500	80	Total of 2 luminaires sampled with watts of 30 W and 56 W with efficacy of 101 and 129 lumens per watt [Fixed output luminaires were only products in sampling]			
E	2X2	3500	80	Total of 4 luminaires sampled with watts from 34 W to 61 W and efficacy between 124 to 131 lumens per watt [Fixed output luminaires were only products in sampling]			
E	2X4	3500	80	Total of 4 luminaires sampled with watts from 34 W to 61 W and efficacy between 124 to 131 lumens per watt [Fixed output luminaires were only products in sampling]			
Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
Ave. All 2 X 2 Lensed Luminaires	2X2	3500	80	34	3977	118	Range of 2X2 Samples LPW 86 to 131
Ave. All 2 X 4 Lensed Luminaires	2X4	3500	80	55	6558	120	Range of 2X4 Samples LPW 97 to 130
<b>Ave. Efficacy of All 2 x 2 and 2 X 4 Lensed Luminaires</b>						119	Majority range 110 LPW + - 15 LPW

**Table 53: 2025 LED Luminaire Efficacy's [LED Panel Troffer/Specifiers]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks
A	2X2	3500	80	Total of 4 luminaires sampled with watts from 25 W to 52 W and efficacy between 127 to 136 lumens per watt [Fixed output luminaires were only products in sampling]
A	2X4	3500	80	Total of 4 luminaires sampled with watts from 25 W to 52 W and efficacy between 127 to 136 lumens per watt [Fixed output luminaires were only products in sampling]
B	2X2	3500	80	Total of 2 luminaires sampled with watts of 33 W and 58 W with efficacy of 110 and 127 lumens per watt

				[Fixed output luminaires were only products in sampling]			
<b>B</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 33 W and 58 W with efficacy of 110 and 127 lumens per watt [Fixed output luminaires were only products in sampling]			
<b>C</b>	2X2	3500	80	1 luminaire sampled with 28 watts and 127 lumens per watt efficacy			
<b>D</b>	2X2	3500	80	Total of 10 luminaires sampled with watts from 23 W to 57 W and efficacy between 115 to 145 lumens per watt [8 samplings were multi-tap and 2 samplings fixed output luminaires]			
<b>D</b>	2X4	3500	80	Total of 10 luminaires sampled with watts from 23 W to 57 W and efficacy between 115 to 145 lumens per watt [8 samplings were multi-tap and 2 samplings fixed output luminaires]			
<b>E</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 30 W and 60 W with efficacy of 101 and 115 lumens per watt [Fixed output luminaires were only products in sampling]			
<b>E</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 30 W and 60 W with efficacy of 101 and 115 lumens per watt [Fixed output luminaires were only products in sampling]			
<b>F</b>	2X2	3500	80	Total of 2 luminaires sampled with watts of 29 W and 48 W with efficacy of 111 and 116 lumens per watt [both luminaires sampled were multi-tap watts and CCT products]			
<b>F</b>	2X4	3500	80	Total of 2 luminaires sampled with watts of 29 W and 48 W with efficacy of 111 and 116 lumens per watt [both luminaires sampled were multi-tap watts and CCT products]			
<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Watts</b>	<b>Lumens</b>	<b>LPW</b>	<b>Notes, Comments and Remarks</b>
<b>Ave. All 2 X LED Panel Luminaires</b>	2X2	3500	80	28	3456	123	Range of 2X2 Samples LPW 110 to 145
<b>Ave. All 2 X 4 LED Panel Luminaires</b>	2X4	3500	80	52	5481	124	Range of 2X4 Samples LPW 101 to 138
<b>Ave. Efficacy of All 2 x 2 and 2 X 4 LED Panel Luminaires</b>						124	Majority range 125 LPW + - 10 LPW

**Table 54: 2025 LED Luminaire Efficacy’s @3500K, 80 CRI [LED Parabolic Troffer/Specifiers]**

Manufacturer	Model #	Size	Watts	Lumens	Efficacy	Notes, Comments and Remarks
A Parabolic Troffer	2ALL233L	2X2	28	3338	118	Only one of seven manufacturers, typical resources for designers, architect’s engineers offered this product
A Parabolic Troffer	2ALL472L	2X4	61	7271	119	Only one of seven manufacturers, typical resources for designers, architect’s engineers offered this product
<b>Average Efficacy of 2 x 2 and 2 X 4 Parabolic Luminaires</b>					119	Similar performance to average of lensed troffers

**Table 55: 2025 LED Luminaire Efficacy’s [3500 K 80 CRI T8 Type B LED Retrofit Lamps]**

Manufacturers Sampled	Size	Notes, Comments and Remarks
A	2X2-2U6	Total of 2 luminaires sampled with watts of 31 W and 54 W and efficacy of 126 and 129 lumens per watt   [Fixed output lamps were only products in sampling]
A	2X4-4T8	Total of 2 luminaires sampled with watts of 31 W and 54 W and efficacy of 126 and 129 lumens per watt   [Fixed output lamps were only products in sampling]
B	2X2-2U6	Total of 2 luminaires sampled with watts of 26 W and 56 W and efficacy of 125 and 138 lumens per watt   [Fixed output lamps were only products in sampling]
B	2X4-4T8	Total of 2 luminaires sampled with watts of 26 W and 56 W and efficacy of 125 and 138 lumens per watt   [Fixed output lamps were only products in sampling]
C	2X2-2U6	Total of 2 luminaires sampled with watts of 30 W and 45 W and efficacy of 125 and 133 lumens per watt   [Multi Tap lamps were used in the sampling]
C	2X4-4T8	Total of 2 luminaires sampled with watts of 30 W and 45 W and efficacy of 125 and 133 lumens per watt   [Multi Tap lamps were used in the sampling]
D	2X2-2U6	Total of 2 luminaires sampled with watts of 26 W and 58 W and efficacy of 124 and 154 lumens per watt   [Fixed output lamps were only products in sampling]
D	2X4-4T8	Total of 2 luminaires sampled with watts of 26 W and 58 W and efficacy of 124 and 154 lumens per watt   [Fixed output lamps were only products in sampling]
E	2X2-2U6	Total of 2 luminaires sampled with watts of 30 W and 48 W and efficacy of 143 and 146 lumens per watt   [Multi Tap lamps were used in the sampling]

<b>E</b>	2X4-4T8	Total of 2 luminaires sampled with watts of 30 W and 48 W and efficacy of 143 and 146 lumens per watt   [Multi Tap lamps were used in the sampling]			
<b>F</b>	2X2-2U6	Total of 2 luminaires sampled with watts of 31 W and 42 W and efficacy of 116 and 155 lumens per watt   [Multi Tap and Fixed Output lamps were used in the sampling]			
<b>F</b>	2X4-4T8	Total of 2 luminaires sampled with watts of 31 W and 42 W and efficacy of 116 and 155 lumens per watt   [Multi Tap and Fixed Output lamps were used in the sampling]			
<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>Lumens</b>	<b>LPW</b>	<b>Notes, Comments and Remarks</b>
<b>Average All T8U6 Retrofit T8 B Lamps</b>	2X2-2U6	29	3917	135	Luminaire efficiency losses not included
<b>Average All T8-4Ft. Retrofit T8 B Lamps</b>	2X4-4T8	51	6950	136	Luminaire efficiency losses not included
<b>Average Efficacy of All 2X2-2U6 and 2X4-4T8 T8 Type B Retrofits</b>				136	Assume similar performance with T8 Type C retrofits

**Table 56: 2025 LED Luminaire Efficacy's [LED Wall-Washer Troffer/Specifiers]**

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Notes, Comments and Remarks</b>
<b>A</b>	2ft-WW	3500	80	Total of 4 luminaires sampled with watts from 20 W to 50 W and efficacy between 92 to 103 lumens per watt [Fixed output luminaires were only products in sampling]
<b>A</b>	4ft-WW	3500	80	Total of 4 luminaires sampled with watts from 20 W to 50 W and efficacy between 92 to 103 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B</b>	2ft-WW	3500	80	Total of 6 luminaires sampled with watts from 22 W to 44 W and efficacy between 86 to 137 lumens per watt [Fixed output luminaires were only products in sampling]
<b>B</b>	4ft-WW	3500	80	Total of 6 luminaires sampled with watts from 22 W to 44 W and efficacy between 86 to 137 lumens per watt [Fixed output luminaires were only products in sampling]
<b>C</b>	2ft-WW	3500	80	Total of 2 luminaires sampled with watts of 37 W and 49 W and efficacy of 77 lumens per watt   [Fixed output lamps were only products in sampling]

C	4ft-WW	3500	80	Total of 2 luminaires sampled with watts of 37 W and 49 W and efficacy of 77 lumens per watt   [Fixed output lamps were only products in sampling]			
D	3ft-WW	3500	80	Total of 4 luminaires sampled with watts from 14 W to 41 W and efficacy between 84 to 90 lumens per watt [Fixed output luminaires were only products in sampling]			
D	4ft-WW	3500	80	Total of 4 luminaires sampled with watts from 14 W to 41 W and efficacy between 84 to 90 lumens per watt [Fixed output luminaires were only products in sampling]			
E	2ft-WW	3500	80	Total of 2 luminaires sampled with watts of 32 W and 53 W and efficacy of 54 and 67 lumens per watt [Fixed output lamps were only products in sampling]			
E	4ft-WW	3500	80	Total of 2 luminaires sampled with watts of 32 W and 53 W and efficacy of 54 and 67 lumens per watt [Fixed output lamps were only products in sampling]			
F	2ft-WW	3500	80	Total of 4 luminaires sampled with watts from 15 W to 60 W and efficacy of 103 lumens per watt [Fixed output luminaires were only products in sampling]			
F	4ft-WW	3500	80	Total of 4 luminaires sampled with watts from 15 W to 60 W and efficacy of 103 lumens per watt [Fixed output luminaires were only products in sampling]			
Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
Ave. All 2-foot LED Wall-Washer Troffers	2X2	3500	80	24 W	2151	91	Range 2ft WW Samples LPW 77 to 137
Ave. All 4-foot LED Wall-Washer Troffers	2X4	3500	80	43	4109	95	Range 4ft WW Samples LPW 77 to 137
Ave. Efficacy of All 2-foot & 4-foot LED Wall-Washer Troffer Samplings	-	-	-	-	-	<b>93</b>	<b>Majority range 95 LPW + - 10 LPW</b>

## J.1.2 Guidelines and Targets for 2025 LED

### TROFFER LUMINAIRE EFFICACY ANALYSIS

[Contractor and Design Build/Distributor Resources]

#### General:

LED troffer luminaire specifications were sampled from key manufacturers that are typical resources for Contractors and Design Build/Distributors that specify lighting products. The luminaires specifications, extracted from manufacture cut sheets were recorded collected and their performance with respect to efficacy documented in this report. The objective of the analysis is to determine the current efficacy of LED troffer luminaires available to the designer specifier market.

#### Specifics:

Fluorescent maintained lumen output target for 2 X 2, 2 X 4, and Wall-Washer troffer luminaires

- **Fluorescent 2 X 2 troffers:** Two T8U6 fluorescent lamps 2800 lumens each 3500K /80 CRI  
Operational Performance:  
5600 lumens lamps – Ballast factor .88 = 4928 initial lumens – luminaire efficiency of 70% = **3450 lumens**  
@ 54 Luminaire watt = **64 lumens per watt**
- **Fluorescent 2 X 4 troffers:** Four T8-32 watt fluorescent lamps 2950 lumens each 3500K /80 CRI  
Operational Performance:  
11,800 lumens lamps – Ballast factor .88 = 10,384 initial lumens – luminaire efficiency of 70% = **7268 lumens**  
@ 114 Luminaire watt = **64 lumens per watt**

#### LED TROFFER LUMEN OUTPUT TARGETS

- **2 X 2 LED troffer LPW target:** 3200 to 3600 lumens [equivalent performance to 2 lamp 2 x 2 T8 fluorescent troffers]
- **2 X 4 LED troffer LPW target:** 6800 to 7200 lumens [equivalent performance to 4 lamp 2 x 4 T8 fluorescent troffers]

- **Twin Tube Fluorescent 2-foot & 4-foot Wall-Washer troffers:** 1 lamp 40 W T5 twin tube & 1 lamp 50 W T5 twin tube (3150 lumens 40 W) (4000 lumens 50 W) / 2 lamp 40 W T5 twin tube and 2 lamp 50 W T5 twin tube lamps (6300 lumens 80 W) (8000 lumens 100 W) 3500K /80 CRI
- **Operational performance:**  
 2-foot 1 40 W lamp 3150 lamp lumens – Ballast factor .95 = 2993 initial lumens – luminaire efficiency of 70% = 2095 lumens @ 38 Luminaire watts = 55 lumens per watt  
 4-foot 2 40 W lamps 6300 lamp lumen – Ballast factor .95 = 5985 initial lumens – luminaire efficiency of 80% = @ 4788 lumens @ 76 Luminaire watts = 63 lumens per watt  
 2-foot 1 50 W lamp 4000 lamp lumens – Ballast factor 1.11 = 4440 initial lumens – luminaire efficiency of 80% = 3552 lumens @ 61 Luminaire watts = 58 lumens per watt  
 4-foot 2 50 W lamps 8000 lamp lumen – Ballast factor .95 = 8240 initial lumens – luminaire efficiency of 80% = @ 6592 lumens @ 111 Luminaire watts = 59 lumens per watt
- **T8 Fluorescent 2-foot & 4-foot Wall-Washer troffers:** 1 lamp 17 W 2-ft lamp and 1 lamp 32 W 4-ft lamp T8 fluorescent 1400 lumens 17 W (2-foot lamp) and 2950 lumens 32(4-foot lamp) 3500K /80 CRI
- **Operational Performance**  
 2-foot 1 lamp 1400 lamp lumens – Ballast factor .88 = 1232 initial lumens – luminaire efficiency of 85% = **1047 lumens @ 17 Luminaire watts = 62 lumens per watt**  
 4-foot 1 lamp 2950 lamp lumens – Ballast factor .88 = 2596 initial lumens – luminaire efficiency of 85% = **2207 lumens @ 29 Luminaire watts = 76 lumens per watt**

## LED WALL-WASHER TROFFER LUMEN OUTPUT TARGETS

- **2 -foot Wall-Washer troffers LPW target:** 1100 to 3600 lumens [equivalent performance to T8 and T5 fluorescent troffers]
- **4 -foot Wall-Washer troffers LPW target:** 1200 to 6000 lumens [equivalent performance to T8 and T5 fluorescent troffers]

**Table 57: 2025 LED Luminaire Efficacy's [Basket Troffers/Design-Build]**

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Notes, Comments and Remarks</b>
<b>A</b>	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 25 W to 40 W and efficacy between 107 to 148 lumens per watt   [Retro-fit kit fixed output luminaires were only products in sample]
<b>A</b>	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 25 W to 40 W and efficacy between 107 to 148 lumens per watt [Retro-fit kit fixed output luminaires were only products in sample]
<b>B</b>	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 24 W to 45 W and efficacy between 128 to 134 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>B</b>	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 24 W to 45 W and efficacy between 128 to 134 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>C</b>	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 20 W to 53 W and efficacy between 137 to 152 lumens per watt [Fixed output luminaires were only products in sample]
<b>C</b>	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 20 W to 53 W and efficacy between 137 to 152 lumens per watt [Fixed output luminaires were only products in sample]
<b>D</b>	2 X 2	3500	80	Total of 5 luminaires sampled with watts from 20 W to 45 W and efficacy between 125 to 150 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>D</b>	2 X 4	3500	80	Total of 5 luminaires sampled with watts from 20 W to 45 W and efficacy between 125 to 150 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>E</b>	2 X 2	3500	80	Total of 6 luminaires sampled with watts from 25 W to 55 W and efficacy between 110 to 137 lumens per watt [4 luminaires fixed output and 2 luminaires multi-tap output/CRI]
<b>E</b>	2 X 4	3500	80	Total of 6 luminaires sampled with watts from 25 W to 55 W and efficacy between 110 to 137 lumens per watt

				[4 luminaires fixed output and 2 luminaires multi-tap output/CRI]
<b>F</b>	2 X 2	3500	80	Total of 6 luminaires sampled with watts from 28 W to 49 W and efficacy between 115 to 130 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>F</b>	2 X 4	3500	80	Total of 6 luminaires sampled with watts from 28 W to 49 W and efficacy between 115 to 130 lumens per watt [all luminaires were multi-tap output/CRI sample]
<b>G</b>	2 X 2	3500	80	Total of 2 luminaires sampled with watts of 29 W and 48 W and efficacy of 126 and 1131 lumens per watt [Fixed output luminaires were only products in sample]
<b>G</b>	2 X 4	3500	80	Total of 2 luminaires sampled with watts of 29 W and 48 W and efficacy of 126 and 1131 lumens per watt [Fixed output luminaires were only products in sample]

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Watts</b>	<b>Lumens</b>	<b>LPW</b>	<b>Notes, Comments and Remarks</b>
<b>Average of All 2 X 2 Basket Luminaires</b>	2X2	3500	80	26	3399	131	Range of 2X2 Samples LPW 107 to 150
<b>Average of All 2 X 4 Basket Luminaires</b>	2X4	3500	80	43	5438	130	Range of 2X4 Samples LPW 111 to 152
<b>Average Efficacy of All 2 x 2 and 2 X 4 Basket Luminaire Samplings</b>						131	Mix Includes 62% Multi-Tap Samplings & 66% of 2 X 4 fixtures less than target lumens

**Table 58: 2025 LED Luminaire Efficacy's [Direct/Indirect Troffers/Design-Build]**

<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Notes, Comments and Remarks</b>			
<b>A</b>	2 X 2	3500	80	Total of 6 luminaires sampled with watts from 25 W to 50 W and efficacy between 107 to 122 lumens per watt [Fixed output luminaires were only products in sampling]			
<b>A</b>	2 X 4	3500	80	Total of 6 luminaires sampled with watts from 25 W to 50 W and efficacy between 107 to 122 lumens per watt [Fixed output luminaires were only products in sampling]			
<b>Manufacturers Sampled</b>	<b>Size</b>	<b>CCT</b>	<b>CRI</b>	<b>Watts</b>	<b>Lumens</b>	<b>LPW</b>	<b>Notes, Comments and Remarks</b>
<b>Average 2 X 2 Direct/Indirect Luminaires</b>	2 X 2	3500	80	31	3438	111	Range of 2X2 Samples LPW 107 to 122
<b>Average 2 X 4 Direct/Indirect Luminaires</b>	2 X 4	3500	80	48	5644	118	Range of 2X4 Samples LPW 115 to 121
<b>Average Efficacy of All 2 x 2 and 2 X 4 Direct/Indirect Luminaire Samplings</b>						114	Mix of various outputs from one mfr. Luminaire

**Table 59: 2025 LED Luminaire Efficacy's [Lensed Troffers/Design-Build]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks			
<b>A</b>	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 25 W to 47 W and efficacy between 133 to 139 lumens per watt [Fixed output luminaires were only products in sample]			
<b>A</b>	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 25 W to 47 W and efficacy between 133 to 139 lumens per watt   [Fixed output luminaires were only products in sample]			
<b>B</b>	2 X 2	3500	80	Total of 2 luminaires sampled with watts of 33 W and 61 W and efficacy of 103 and 124 lumens per watt   [Fixed output luminaires were only products in sample]			
<b>B</b>	2 X 4	3500	80	Total of 2 luminaires sampled with watts of 33 W and 61 W and efficacy of 103 and 124 lumens per watt   [Fixed output luminaires were only products in sample]			
Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
<b>Average 2 X 2 Lensed Luminaires</b>	2 X 2	3500	80	28	3291	118	Range of 2X2 Samples LPW 103 to 131
<b>Average 2 X 4 Lensed Luminaires</b>	2 X 4	3500	80	53	6605	125	Range of 2X4 Samples LPW 124 to 139
<b>Average Efficacy of All 2 x 2 and 2 X 4 Lensed Luminaire Samplings</b>						122	Tunable white and 90 CRI available on some samples

**Table 60: 2025 LED Luminaire Efficacy's [LED Panel Troffer/Design-Build]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks			
<b>A</b>	2 X 2	3500	80	Total of 2 luminaires sampled with watts of 30 W and 38 W with efficacy of 110 and 127 lumens per watt (2X4 luminaire below lumen output target) [Fixed output luminaires were only products in sample]			
<b>A</b>	2 X 4	3500	80	Total of 2 luminaires sampled with watts of 30 W and 38 W with efficacy of 110 and 127 lumens per watt (2X4 luminaire below lumen output target) [Fixed output luminaires were only products in sample]			

B	2 X 2	3500	80	Total of 2 luminaires sampled with watts of 30 W and 45 W with efficacy of 115 and 118 lumens per watt (2X4 luminaire below lumen output target) [all luminaires were multi-tap output/CRI sample]
B	2 X 4	3500	80	Total of 2 luminaires sampled with watts of 30 W and 45 W with efficacy of 115 and 118 lumens per watt (2X4 luminaire below lumen output target) [all luminaires were multi-tap output/CRI sample]
C	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 30 W to 60 W and efficacy between 125 to 140 lumens per watt (one of the 2X4 luminaire below lumen output target) [Fixed output luminaires were only products in sample]
C	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 30 W to 60 W and efficacy between 125 to 140 lumens per watt (one of the 2X4 luminaire below lumen output target) [Fixed output luminaires were only products in sample]
D	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 30 W to 50 W and efficacy between 113 to 125 lumens per watt [all luminaires were multi-tap output/CRI sample]
D	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 30 W to 50 W and efficacy between 113 to 125 lumens per watt [all luminaires were multi-tap output/CRI sample]
E	2 X 2	3500	80	Total of 10 luminaires sampled with watts from 25 W to 50 W and efficacy between 109 to 138 lumens per watt (2 of 10 samples 90CRI only, no 80CRI) [all luminaires were multi-tap output/CRI sample]
E	2 X 4	3500	80	Total of 10 luminaires sampled with watts from 25 W to 50 W and efficacy between 109 to 138 lumens per watt (2 of 10 samples 90CRI only, no 80CRI) [all luminaires were multi-tap output/CRI sample]
F	2 X 2	4000	80	Total of 6 luminaires sampled with watts from 28 W to 49 W and efficacy between 115 to 130 lumens per watt [all luminaires were multi-tap output/CRI sample]
F	2 X 4	4000	80	Total of 2 luminaires sampled with watts of 26 W and 52 W with efficacy of 137 lumens per watt (4000 K only, no 3500 K offered) [Fixed output luminaires were only products in sample]

Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
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<b>Average 2 X 2 LED Panel Luminaires</b>	2 X 2	3500	80	30	3640	121	Range of 2 X 2 Samples LPW 109 to 140 (one 90 CRI product in mix 115 lpw.)
<b>Average 2 X 4 LED Panel Luminaires</b>	2 X 4	3500	80	51	6027	119	Range of 2 X 4 Samples LPW 109 to 141 (one 90 CRI product in mix 115 lpw.)
<b>Average Efficacy of All 2 x 2 and 2 X 4 LED Panel Luminaire Samplings</b>						120	One sampling at 90 CRI and one sampling multi-tap CCT with fixed wattage output

**Table 61: 2025 LED Luminaire Efficacy's [LED Wall-Washer Troffer/Design-Build]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks			
<b>A LED Wall-Washer Troffer Luminaires</b>	2-FT	3500	80	Total of 8 luminaires sampled with watts from 16 W to 52 W and efficacy between <b>68*</b> to 144 lumens per watt ( <b>68 lumens anomaly/suspect specification error</b> ) [Fixed output luminaires were only products in sampling]			
<b>A LED Wall-Washer Troffer Luminaires</b>	4-FT	3500	80	Total of 8 luminaires sampled with watts from 16 W to 52 W and efficacy between <b>68*</b> to 144 lumens per watt ( <b>68 lumens anomaly/suspect specification error</b> ) [Fixed output luminaires were only products in sampling]			
Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
<b>Average 2-FT Wall-Washer Luminaires</b>	2-FT	3500	80	20	2080	104	Range of 2-ft wall-washer Samples LPW 87 to 143
<b>Average 4-FT Wall-Washer Luminaires</b>	4-FT	3500	80	36	3714	102	Range of 4-ft wall-washer Samples LPW 68 to 144 ( <b>68 lms. – spec error?</b> )
<b>Average Efficacy of All 2FT and 4FT LED Wall-Washers (sampling one Mfr. Only)</b>						103	Sampling from only manufacturers with wide range of efficacy's and possible one specification error

**Table 62: 2025 LED Luminaire Efficacy's [LED Parabolic Troffer/Design-Build]**

Manufacturers Sampled	Size	CCT	CRI	Notes, Comments and Remarks			
A	2 X 2	3500	80	Total of 4 luminaires sampled with watts from 25 W to 51 W and efficacy between 120 to 132 lumens per watt [Fixed output luminaires were only products in sample]			
A	2 X 4	3500	80	Total of 4 luminaires sampled with watts from 25 W to 51 W and efficacy between 120 to 132 lumens per watt [Fixed output luminaires were only products in sample]			
B	2 X 2	4000	80	Total of 2 luminaires sampled with watts of 34 W and 50 W and efficacy of 92 and 122 lumens per watt (no 3500 K offered only 4000 K / 5000 K) [Fixed output lamps were only product in sample]			
B	2 X 4	4000	80	Total of 2 luminaires sampled with watts of 34 W and 50 W and efficacy of 92 and 122 lumens per watt (no 3500 K offered only 4000 K / 5000 K) [Fixed output lamps were only product in sample]			
Manufacturers Sampled	Size	CCT	CRI	Watts	Lumens	LPW	Notes, Comments and Remarks
<b>Average 2-FT Parabolic Louver Luminaires</b>	2 X 2	3500/ 4000	80	28	3056	109	Range of 2 X 2 Samples LPW 92 to 122 (one 80 CRI @ 4000K product in mix)
<b>Average 4-FT Parabolic Louver Luminaires</b>	2 X 4	3500/ 4000	80	49	6225	126	Range of 2 X 4 Samples LPW 122 to 132 (one 80 CRI @ 4000K product in mix)
<b>Average Efficacy of All 2 X 2 and 2 X 4 LED Parabolic Troffers (sampling two Mfr. Only)</b>						120	Sample from only two manufacturers with limited options (only 4000 K and white louvers on one manufacturer's product)

## J.2 Slots

### Baseline for Evaluation

**Fluorescent legacy T5 and T5/HO lamps [3500 K/80 CRI]**

- 4-ft T5 lamp 2900 lumens X .9 lumen depreciation x 1.0 ballast factor = 2610 lamp lumens @ 30 W (*ballast input power*)
- 4-ft T5/HO lamp 5000 lumens X .9 lumen depreciation x 1.0 ballast factor = 4500 lamp lumens @ 60 W (*ballast input power*)

#### **Fluorescent legacy Recessed T5 & T5/HO 4-foot Laminates**

- **T5 2-inch X 4-foot slot luminaire** 2610 lumens X .40 luminaire efficiency = 1044 lumens @ 30 W (*35 lumens per watt*)
- **T5 4-inch X 4-foot slot luminaire** 2610 lumens X .50 luminaire efficiency = 1395 lumens @ 30 W (*43 lumens per watt*)
- **T5 6-inch X 4-foot slot luminaire** 2610 lumens X .70 luminaire efficiency = 1827 lumens @ 30 W (*61 lumens per watt*)
- **T5/HO 2-inch X 4-foot slot luminaire** 4500 lumens X .40 luminaire efficiency = 1800 lumens @ 60 W (*30 lumens per watt*)
- **T5/HO 4-inch X 4-foot slot luminaire** 4500 lumens X .50 luminaire efficiency = 2250 lumens @ 60 W (*38 lumens per watt*)
- **T5/HO 6-inch X 4-foot slot luminaire** 4500 lumens X .70 luminaire efficiency = 3150 lumens @ 60 W (*53 lumens per watt*)
- **T5/HO 6-inch X 4-foot slot 2-lamp luminaire** 9000 lumens X .60 luminaire efficiency = 5400 lumens @ 121 W (*45 lumens per watt*)

#### **Lumen Output Target for LED Recessed Slot Light Luminaires [3500 K/80 CRI]**

- **T5 & T5/HO 2-inch X 4-foot Recessed LED slot luminaire Target:** 1044 to 1800 lumens
- **T5 & T5/HO 4-inch X 4-foot Recessed LED Slot luminaire Target:** 1395 to 2250 lumens
- **T5/HO 6-foot X 4-foot Recessed 2-lamp LED Slot luminaire Target:** 5000 to 6000 lumens

**Table 63: 2025 LED Recessed Light Slot Luminaire Efficacy & Lumen Maintenance Recap**

Manufacturer	Model Output	Size (inch)	CCT	CRI	Notes, Comments, and Remarks
A	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 7 luminaires sampled with watts from 11.6 W to 41.2 W and efficacy between 100 to 126 lumens per watt Lumen maintenance documented at L70 @40,000 K [All samplings were fixed output luminaire]
B	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	90	Total of 9 luminaires sampled with watts from 14 W to 52 W and efficacy between 87 to 123 lumens per watt (only 90 CRI available) Lumen maintenance not documented [All samplings were fixed output luminaire]
C	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 2 luminaires sampled with watts at 18 W and 26 W with efficacy of 111 and 115 lumens per watt (6-inch slot offered) Lumen maintenance documented at L70 @ 60,000 K [All samplings were fixed output luminaire]
D	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 7 luminaires sampled with watts from 11.7 W to 45 W and efficacy between 110 to 129 lumens per watt Lumen maintenance documented at L90 @ 61,000 K [All samplings were fixed output luminaire]
E	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	90	Total of 7 luminaires sampled with watts from 11.2 W to 45 W and efficacy between 108 to 128 lumens per watt (only 90 CRI available) Lumen maintenance documented at L90 @ 60,000 K [All samplings were fixed output luminaire]
F	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 7 luminaires sampled with watts from 16 W to 40 W and efficacy between 89 to 108 lumens per watt Lumen maintenance documented at L80 @ 65,000 K [All samplings were fixed output luminaire]
G	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 4 luminaires sampled with watts from 10 W to 22.4 W and efficacy between 121 to 134 lumens per watt (6-inch slot offered) Lumen maintenance documented at L80 @ 60,000 K

					[All samplings were fixed output luminaire]
H	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 4 luminaires sampled with watts from 18.4 W to 34.8 W and efficacy between 89 to 106 lumens per watt (6-inch slot offered) Lumen maintenance documented at L80 @ 60,000 K [All samplings were fixed output luminaire]
I	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 5 luminaires sampled with watts from 15.2 W to 42 W and efficacy between 106 to 126 lumens per watt Lumen maintenance documented at L90 @ 60,000 K [All samplings were fixed output luminaire]
J	Low Output High Output Very High Output	2-inch 4-inch 6-inch	3500	80	Total of 3 luminaires sampled with watts from 13.6 W to 64.7 W and efficacy between 106 to 114 lumens per watt (4 -inch & 6-inch slot offered) Lumen maintenance documented at L90 @ 60,000 K [All samplings were fixed output luminaire]

**Table 64: Recap of Recessed Light Slot Luminaire Efficacy and Lumen Maintenance**

LED Type Recessed Slot Luminaire	Size (in)	CCT	CRI	Watts	Lumen	Efficacy (Lms./W)	Lumen Maintenance	Remarks/Comments
Low Output LED Light Slot ( <i>T5 equivalent</i> )	2-inch	3500	80	11.2	1127	96	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 400 K lumen maintenance
High Output LED Light Slot ( <i>T5/HO equivalent</i> )	2-inch	3500	80	19.5	2117	110	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 400 K lumen maintenance
Low Output LED Light Slot ( <i>T5 equivalent</i> )	4-inch	3500	80	11.7	1384	105	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 400 K lumen maintenance
High Output LED Light Slot ( <i>T5/HO equivalent</i> )	4-inch	3500	80	21.0	2441	117	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 400 K lumen maintenance
Low Output LED Light Slot ( <i>T5 equivalent</i> )	6-inch	3500	80	19.9	2105	112	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 385 K lumen maintenance
High Output LED Light Slot ( <i>T5/HO equivalent</i> )	6-inch	3500	80	29.5	3212	109	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 385 K lumen maintenance
Very High Output LED Light Slot ( <i>2 lamp T5/HO equivalent</i> )	6-inch	3500	80	47.5	5213	109	.70 to .90 @ 60 K typical range	All offer 90 CRI option Several projects .70 200 K to 385 K lumen maintenance
<b>Average All 2-4-6-inch LED Light Slot Luminaires</b>	-	-	-	<b>22.9</b>	<b>2514</b>	<b>108</b>	<b>No lumen maintenance constancy</b>	<b>20% @ of products sampled could not hit lumen targets</b>

**Table 65: Efficacy Loss Factor for 90+ CRI, Dim-To-Warm, Tunable White and RGB White**

Manufacturer	80 to 90 CRI	%	Dim to Warm	%	Tunable White	%	RGB White	%	Comments and Remarks
A	.86	14	NA	NA	NA	NA	NA	NA	Product only offers 90 CRI adder
B	Baseline	0	Offered	NA	Offered	NA	Offered	NA	Product has 90 CRI as baseline <i>(Other technologies offered / Efficacy loss not stated)</i>
C	Offered	NA	Offered	NA	Offered	NA	Offered	NA	Product offers 90 CRI plus other technologies however no efficacy losses stated
D	.89	11	NA	NA	.69 to .76	24-31	NA	NA	Product offers 90 CRI and Tunable White with efficacy loss factors as shown
E	Baseline	0	Offered	NA	Offered	NA	NA	NA	Product has 90 CRI as baseline <i>(Other technologies offered / Efficacy loss not stated)</i>
F	Offered	NA	NA	NA	NA	NA	NA	NA	Product offers 90 CRI no efficacy loss stated
G	.83	17	NA	NA	NA	NA	NA	NA	Product offers 90 CRI no other technologies
H	.88	12	NA	NA	.72 to .76	24-28	NA	NA	Product offers 90 CRI and Tunable White with efficacy loss factors as shown
I	.85	15	Offered	NA	.59 to .72	28-41	Offered	NA	Product offers 90 CRI and tunable white with efficacy loss factors as shown. Also dim to warm & RGB white but without loss factor shown
J	.83	17	NA	NA	NA	NA	NA	NA	Product only offers 90 CRI adder
<b>Average of All Samples</b>	<b>0.86</b>	<b>14</b>	<b>NA</b>	<b>NA</b>	<b>0.71</b>	<b>29</b>	<b>NA</b>	<b>NA</b>	<b>NOTE: 2 of 10 manufacturers sampled offer 90 CRI as baseline / Light Control 90 CRI product has 119 lumens per watt av. efficacy</b>

## J.3 Linear Pendants

### LINEAR PENDANTS

The following describes characteristics of linear 90 CRI 3500K LED pendants indirect/direct as typically used in offices and classrooms. Information collected focusses on luminaire efficacy, lumen maintenance and possibly efficacy adjustments for 90 CRI products.

The pendant luminaires evaluated were indirect/direct type usually having a 70 percent up-light with 30 percent downlight distribution. These linear LED pendants were applied to design options where less glare is desired. Spaces with heavier use of computer monitor screens in the work task or other spaces that employ a layer of task (focused) illumination may prefer the pendant general lighting system than troffers or downlights.

This system is most effective if the ceiling reflectivity is a minimum of 75 percent (reflectivity of standard white acoustic tile or most off-white paints). However, there are numerous high reflectance white acoustic tiles and white paints that will deliver 85 percent to 88 percent reflectance. Provided these products are appropriate for use with the architects or interior designers project design scheme, they are the preferred ceiling materials for linear pendant up/down light lighting systems.

As to photometric distribution, the recommended up-light component should be a symmetric batwing design as this will provide the most even soft glow on the ceiling. Downlight components are usually a general symmetric distribution though some manufacturers offer batwing or asymmetric optics

#### Baseline for Evaluation

#### **Fluorescent legacy T5 and T5/HO lamps [3500 K/80 CRI]**

- 4-ft T5 lamp 2900 lumens X .9 lumen depreciation x 1.0 ballast factor = 2610 lamp lumens @ 30 W (*ballast input power*)
- 4-ft T5/HO lamp 5000 lumens X .9 lumen depreciation x 1.0 ballast factor = 4500 lamp lumens @ 60 W (*ballast input power*)

#### **Fluorescent legacy Linear Pendant Up/Down Light T5 & T5/HO 4-foot Luminaire Section**

- **4-foot Low Output Up/Down Light Pendant**

[2-T5 lamps = 5200 lumens X .75 luminaire efficiency = 3900 lumens at 60 W (*65 lumens per watt*)]

- **4-foot High Output Up/Down Light Pendant**

[2-T5HO lamps = 9000 lumens X .75 luminaire efficiency = 6700 lumens at 120 W (*56 lumens per watt*)]

### **Lumen Output Target for LED Recessed Slot Light Luminaires [3500 K/80 CRI]**

**\*NOTE:** One manufacturer's product only available in **90 CRI**

- **4-foot Section Low Output Up/Down Light Linear Pendant Luminaire**

[Lumen Output Target: 3100 to 3900 lumens with 70 percent up light and 30 percent downlight ideal distribution]

- **4-foot Section High Output Up/Down Light Linear Pendant Luminaire**

[Lumen Output Target: 6200 to 7200 lumens with 70 percent up light and 30 percent downlight ideal distribution]

**Table 66: 2025 LED Linear Pendant Up/Down Light Luminaire Efficacy and Lumen Maintenance (CCT = 3500 K)**

Manufacturer	Output (lm)	CRI	Watts	Total Lumens	Up Light %	Down Light %	Efficacy (lm/W)	Lumen Maintenance	90 CRI Factor*
A	Low	90	48	3,840	50	50	80	Not Indicated	1.00
A	High	90	96	7,210	50	50	75	Not Indicated	1.00
A	Low	90	28	3,488	57	43	125	Not Indicated	1.00
A	High	90	52	6,248	62	38	120	Not Indicated	1.00
B	Low	80	22.8	3,721	74	26	129	L90 @100,000	0.76
B	High	80	53.6	7,188	68	32	134	L90 @100,000	0.76
C	Low	80	22.8	3,162	70	30	138	L80 @ 72,000	NA
C	High	80	46.3	6,142	68	32	136	L80 @ 72,000	NA
C	Low	80	28.4	3,416	75	25	120	L80 @ 72,000	NA
C	High	80	56.7	6,458	75	25	114	L80 @ 72,000	NA
D	Low	80	32.3	3,680	70	30	114	L80 @ 60,000	NS
D	High	80	60.3	6,880	70	30	114	L80 @ 60,000	NS
D	Low	80	29.6	3,916	70	30	132	L80 @ 60,000	0.86
D	High	80	57.8	7,056	70	30	122	L80 @ 60,000	0.86
E	Low	80	28	3,600	50	50	128	L90 @100.00	0.90
E	Low	80	38.8	4,600	60	40	113	L90 @100.000	0.90
E	High	80	49.2	6,400	50	50	130	L90 @100.000	0.90
E	High	80	60	7,200	60	40	120	L90 @100.000	0.90
E	Low	80	30.4	3,900	53	47	128	L90 @100.000	0.85
E	High	80	44.8	6,240	53	47	139	L90 @100.000	0.85
F	High	80	52.6	6,468	67	33	123	L85 @ 58,000	0.82
F	High	80	58.4	6,700	52	48	115	L85 @ 58,000	0.84

\* Where 90 CRI factor = 1, 90 CRI is standard. Where 90 CRI factor = NA, no indication of 90 CRI available. Where 90 CRI factor = NS, 90 CRI available but adjustment factor not stated

Table 67: Summary of 2025 LED Linear Indirect/Direct Pendant Luminaire Performance (CCT = 3500 K, 80 CRI)

High vs Low Output Luminaires	Watts	Total Lumens	Up Light/Downlight ratio range	Efficacy (lm/W)	Range Lumen Maint	Remarks/Comments
Average of <b>Low Output</b> luminaires	30.9	3,723	50/50 to 70/30 up/down ratio	121	L85 @ 58,000 hrs to L90 @ 100,000 hr	Six manufacturers. One provides 90 CRI only. One provides 80 CRI only. Four provide multiple CRI. 90 CRI factor between 0.75 and 0.91
Average of <b>High Output</b> Light luminaires	57.3	6,883	50/50 to 70/30 up/down ratio	117	L85 @ 58,000 hrs to L90 @ 100,000 hr	Six manufacturers. One provides 90 CRI only. One provides 80 CRI only. Four provide multiple CRI. 90 CRI factor between 0.75 and 0.92
Average all luminaires	45.3	5,368	See above	118	See above	See above. A couple of manufacturers did not have a high or low output version of a given luminaire model

## J.4 Downlights

### Downlight recaps

Results of 80 CRI LED specifier down light luminaires indicate that 4-inch and 6-inch down lights average between 90 lumens to 100 lumens per watt. However, 2-inch down lights at 75 lumens per watt are 22 percent less efficacious. The range of efficacy loss 90 CRI specifier down lights averaged all sizes (2", 4", and 6") and light outputs (high, medium and low) were only 7 percent less efficacious on average than the 80 CRI products. When segmented by downlight diameter and light output the range of average efficacy loss ranged from 15 percent and 3 percent.

Results of 80 CRI LED premium down light luminaires were similar with 4-inch and 6-inch down lights averaging between 90 lumens to 112 lumens per watt. However, premium 2-inch down lights are as much as 32 percent less efficacious as 4-inch and 6-inch 80 CRI down lights. On average across all downlight diameter and outputs, the 90CRI products were 14 percent less efficacious. When segmented by downlight diameter and light output the range of average efficacy loss ranged from 11 percent to 18 percent as published in manufacturers specifications cut-sheets.

**Table 68: Luminaire Efficacy Recap Information for Specifier Downlights; AVE 2-inch Downlights**

<b>Manufacturer</b>	<b>Low Output 80 CRI</b>	<b>Low Output 90 CRI</b>	<b>Low Output 95/98 CRI</b>	<b>Medium Output 80 CRI</b>	<b>Medium Output 90 CRI</b>	<b>Medium Output 95/98 CRI</b>	<b>High Output 80 CRI</b>	<b>High Output 90 CRI</b>	<b>High Output 95/98 CRI</b>
<b>A</b>	100	75	NA	NA	NA	NA	NA	NA	NA
<b>B</b>	NA	63	NA	NA	NA	NA	NA	NA	NA
<b>C</b>	60	NA	NA	NA	NA	NA	NA	NA	NA
<b>D</b>	78	56	NA	NA	NA	NA	NA	NA	NA
<b>E</b>	72	NA	NA	NA	NA	NA	NA	NA	NA
<b>F</b>	78	62	NA	NA	NA	NA	NA	NA	NA
<b>AVERAGE</b>	<b>78</b>	<b>64</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
<b>CRI Adjustment Factor</b>	<b>1.0</b>	<b>0.82</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>

**Table 69: Luminaire Efficacy Recap Information for Specifier Downlights; AVE 4-inch Downlights**

<b>Manufacturer</b>	<b>Low Output 80 CRI</b>	<b>Low Output 90 CRI</b>	<b>Low Output 95/98 CRI</b>	<b>Medium Output 80 CRI</b>	<b>Medium Output 90 CRI</b>	<b>Medium Output 95/98 CRI</b>	<b>High Output 80 CRI</b>	<b>High Output 90 CRI</b>	<b>High Output 95/98 CRI</b>
<b>A</b>	100	75	NA	100	75	NA	NA	NA	NA
<b>B</b>	NA	108	NA	NA	102	NA	NA	NA	NA
<b>C</b>	100	85	NA	102	89	NA	100	83	NA
<b>D</b>	126	106	NA	115	98	NA	111	94	NA
<b>E</b>	NA	104	NA	NA	104	NA	NA	NA	NA
<b>F</b>	65	NA	NA	74	NA	NA	NA	NA	NA
<b>AVERAGE</b>	98	96	NA	98	94	NA	NA	NA	NA
<b>CRI Adjustment Factor</b>	1.0	0.98	NA	1.0	0.96	NA	NA	NA	NA

**Table 70: Luminaire Efficacy Recap Information for Specifier Downlights; AVE 6-inch Downlights**

<b>Manufacturer</b>	<b>Low Output 80 CRI</b>	<b>Low Output 90 CRI</b>	<b>Low Output 95/98 CRI</b>	<b>Medium Output 80 CRI</b>	<b>Medium Output 90 CRI</b>	<b>Medium Output 95/98 CRI</b>	<b>High Output 80 CRI</b>	<b>High Output 90 CRI</b>	<b>High Output 95/98 CRI</b>
<b>A</b>	100	NA	NA	100	NA	NA	NA	NA	NA
<b>B</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>C</b>	84	NA	NA	89	NA	NA	88	NA	NA
<b>D</b>	105	NA	NA	107	NA	NA	109	NA	NA
<b>E</b>	82	NA	NA	93	NA	NA	100	NA	NA
<b>F</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>G</b>	105	NA	NA	106	NA	NA	103	NA	NA
<b>AVERAGE</b>	95	92	NA	99	91	NA	100	93	NA
<b>CRI Adjustment Factor</b>	1.0	0.97	NA	1.0	0.92	NA	1.0	0.93	NA

**Table 71: Luminaire Efficacy Recap Information for Specifier Downlights; Average for all**

Average	80 CRI	90 CRI	95/98 CRI
<b>AVE 2-inch Downlight, Low Output</b>	78	64	NA
<b>AVE 4-inch Downlight, Low Output</b>	98	96	NA
<b>AVE 4-inch Downlight, Medium Output</b>	98	94	NA
<b>AVE 6-inch Downlight, Low Output</b>	95	92	NA
<b>AVE 6-inch Downlight, Medium Output</b>	99	91	NA
<b>AVE 6-inch Downlight, High Output</b>	100	93	NA
<b>Average Efficiency for all</b>	95	88	NA
<b>Adjustment Factors</b>	Baseline at 1.0	Adjustment Factor of 0.93	NA

**Table 72: Luminaire Efficacy Recap Information for Premium Downlights; AVE 2-inch Downlights**

Manufacturer	Low Output 80 CRI	Low Output 90 CRI	Low Output 95/98 CRI	Medium Output 80 CRI	Medium Output 90 CRI	Medium Output 95/98 CRI	High Output 80 CRI	High Output 90 CRI	High Output 95/98 CRI
<b>A</b>	NA	75	NA	NA	NA	NA	NA	NA	NA
<b>B</b>	85	70	61	85	NA	NA	NA	NA	NA
<b>C</b>	53	47	NA	NA	NA	NA	NA	NA	NA
<b>D</b>	75	65	NA	NA	NA	NA	NA	NA	NA
<b>E</b>	77	60	NA	NA	NA	NA	NA	NA	NA
<b>F</b>	85	74	NA	NA	NA	NA	NA	NA	NA
<b>AVERAGE</b>	75	65	61	85	NA	NA	NA	NA	NA
<b>CRI Adjustment Factor</b>	1.0	0.87	0.81	1.0	NA	NA	NA	NA	NA

**Table 73: Luminaire Efficacy Recap Information for Premium Downlights; AVE 4-inch Downlights**

<b>Manufacturer</b>	<b>Low Output 80 CRI</b>	<b>Low Output 90 CRI</b>	<b>Low Output 95/98 CRI</b>	<b>Medium Output 80 CRI</b>	<b>Medium Output 90 CRI</b>	<b>Medium Output 95/98 CRI</b>	<b>High Output 80 CRI</b>	<b>High Output 90 CRI</b>	<b>High Output 95/98 CRI</b>
<b>A</b>	NA	94	NA	NA	89	NA	NA	NA	NA
<b>B</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>C</b>	80	68	59	79	67	NA	NA	NA	NA
<b>D</b>	99	84	70	91	77	72	NA	NA	NA
<b>E</b>	NA	65	NA	NA	62	NA	NA	NA	NA
<b>F</b>	93	73	NA	81	NA	NA	NA	NA	NA
<b>G</b>	113	95	88	110	93	82	NA	NA	NA
<b>AVERAGE</b>	96	80	72	90	78	77	NA	NA	NA
<b>CRI Adjustment Factor</b>	1.0	0.83	0.75	1.0	0.87	0.86	NA	NA	NA

**Table 74: Luminaire Efficacy Recap Information for Premium Downlights; AVE 6-inch Downlights**

Manufacturer	Low Output 80 CRI	Low Output 90 CRI	Low Output 95/98 CRI	Medium Output 80 CRI	Medium Output 90 CRI	Medium Output 95/98 CRI	High Output 80 CRI	High Output 90 CRI	High Output 95/98 CRI
<b>A</b>	NA	102	NA	NA	100	NA	NA	97	NA
<b>B</b>	88	73	64	86	72	61	NA	NA	NA
<b>C</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>D</b>	102	86	70	94	84	72	103	84	73
<b>E</b>	125	102	NA	130	107	NA	120	97	NA
<b>F</b>	NA	NA	NA	NA	NA	NA	NA	NA	NA
<b>G</b>	82	70	NA	98	NA	NA	NA	NA	NA
<b>AVERAGE</b>	99	87	67	102	91	67	112	93	73
<b>CRI Adjustment Factor</b>	1.0	0.88	0.68	1.0	0.89	0.66	1.0	0.83	0.65

**Table 75: Luminaire Efficacy Recap Information for Premium Downlights; Average for all Premium Downlights**

Average	80 CRI	90 CRI	95/98 CRI
<b>AVE 2-inch Downlight, Low Output</b>	75	65	61
<b>AVE 4-inch Downlight, Low Output</b>	96	80	72
<b>AVE 6-inch Downlight, Low Output</b>	99	87	67
<b>Average Efficiency for All</b>	90	77	67
<b>Adjustment Factors</b>	Baseline at 1.0	Adjustment Factor of 0.86	Adjustment Factor of 0.74

## J.5 Track and Accent Lighting

### Recap of track accent light performance

Results of 80 CRI dedicated LED track head accent lights luminaires averaged between 89 lumens to 98 lumens per watt. The 90 CRI track head accent lights in the samples reviewed were about 10 percent less efficacious than the 80 CRI lights. However, manufacturers' published cut-sheets show 90 CRI as being about 14 to 18 percent less efficacious than 80 CRI. Two of the manufacturers offered premium 95-97 CRI color rendering products. One of the 95-97 CRI track head accent lights in the sample was more efficacious than their 90 CRI product. The other manufacturer doesn't offer 80 CRI and their 95-97 CRI was 6 percent less efficacious than their 90 CRI products.

Legacy 120V PAR38 track heads with PAR38 LED lamps were also evaluated. The PAR38 80 CRI lamps averaged 94 lumens per watt. While 90 CRI lamp samples were about three to four percent less efficacious. Of the 11 manufacturers evaluated, only six still offer 80 CRI lamps

**Table 76: Luminaire Efficacy Recap Information for LED Accent Light Track Heads**

Manufacturer	Low Output 80 CRI	Low Output 90 CRI	Low Output 95/98 CRI	Medium Output 80 CRI	Medium Output 90 CRI	Medium Output 95/98 CRI	High Output 80 CRI	High Output 90 CRI	High Output 95/98 CRI
<b>A</b>	94	75	94	91	74	121	107	92	NA
<b>B</b>	99	84	NA	94	77	NA	86	70	NA
<b>C</b>	NA	NA	NA	NA	75	NA	NA	85	NA
<b>D</b>	NA	92	NA	NA	86	NA	NA	79	NA
<b>E</b>	104	92	NA	98	87	NA	80	70	NA
<b>F</b>	113	NA	NA	NA	102	NA	NA	103	NA
<b>G</b>	NA	90	NA	83	NA	NA	82	86	NA
<b>H</b>	NA	82	77	NA	80	75	NA	94	88
<b>I</b>	88	77	NA	105	90	NA	89	81	NA
<b>J</b>	91	93	NA	75	61	NA	92	75	NA
<b>AVERAGE</b>	<b>98</b>	<b>86</b>	<b>86</b>	<b>91</b>	<b>81</b>	<b>98</b>	<b>89</b>	<b>84</b>	<b>88</b>
<b>CRI Adjustment Factor</b>	<b>1.0</b>	<b>0.88</b>	<b>0.88</b>	<b>1.0</b>	<b>0.89</b>	<b>1.08</b>	<b>1.0</b>	<b>0.94</b>	<b>0.99</b>

**Table 77: Luminaire Efficacy Recap Information for Premium Downlights; Average for all Premium Downlights**

Average	80 CRI	90 CRI	95/98 CRI
<b>AVE Low Output Heads</b>	98	86	86
<b>AVE Medium Output Heads</b>	91	81	98
<b>AVE High Output Heads</b>	89	84	88
<b>Average Efficacy for All</b>	93	84	91
<b>Adjustment Factors</b>	Baseline at 1.0	Adjustment Factor of 0.9	Adjustment Factor of 0.98

**Table 78: Luminaire Efficacy Recap Information for Accent Light Legacy PAR38 Track Heads**

Manufacturer	Low Output 80 CRI	Low Output 90 CRI	Low Output 95/98 CRI	Medium Output 80 CRI	Medium Output 90 CRI	Medium Output 95/98 CRI	High Output 80 CRI	High Output 90 CRI	High Output 95/98 CRI
<b>A</b>	NA	86	NA	88	89	NA	91	NA	NA
<b>B</b>	NA	88	NA	112	97	NA	97	NA	NA
<b>C</b>	NA	90	NA	NA	86	NA	NA	93	NA
<b>D</b>	83	75	NA	NA	84	NA	115	NA	NA
<b>E</b>	81	75	NA	100	NA	NA	115	NA	NA
<b>F</b>	NA	100	NA	93	96	NA	104	NA	NA
<b>G</b>	81	89	NA	NA	100	NA	NA	NA	NA
<b>H</b>	92	86	NA	NA	89	NA	NA	92	NA
<b>I</b>	NA	79	NA	94	NA	NA	92	NA	NA
<b>J</b>	NA	88	NA	NA	88	NA	NA	NA	NA
<b>K</b>	81	71	NA	81	72	NA	100	110	NA
<b>AVERAGE</b>	84	84	NA	95	89	NA	102	98	NA
<b>CRI Adjustment Factor</b>	1.0	1.0	NA	1.0	0.94	NA	1.0	0.96	NA

**Table 79: Luminaire Efficacy Recap Information for Premium Downlights; Average for all PAR38 LED Lamps**

Average	80 CRI	90 CRI	95/98 CRI
<b>AVE Low Output Heads</b>	84	84	NA
<b>AVE Medium Output Heads</b>	95	94	NA
<b>AVE High Output Heads</b>	102	96	NA
<b>Average Efficacy</b>	94	91	NA
<b>Adjustment Factors</b>	Baseline at 1.0	Adjustment Factor of 0.97	NA

## J.6 Decorative Lighting

For decorative lighting (chandeliers, pendants and sconces), we will examine our 2022 models that include both dedicated LED and screw in lamp legacy luminaires lamped with LED bulbs. These models will be updated using current LED technology.

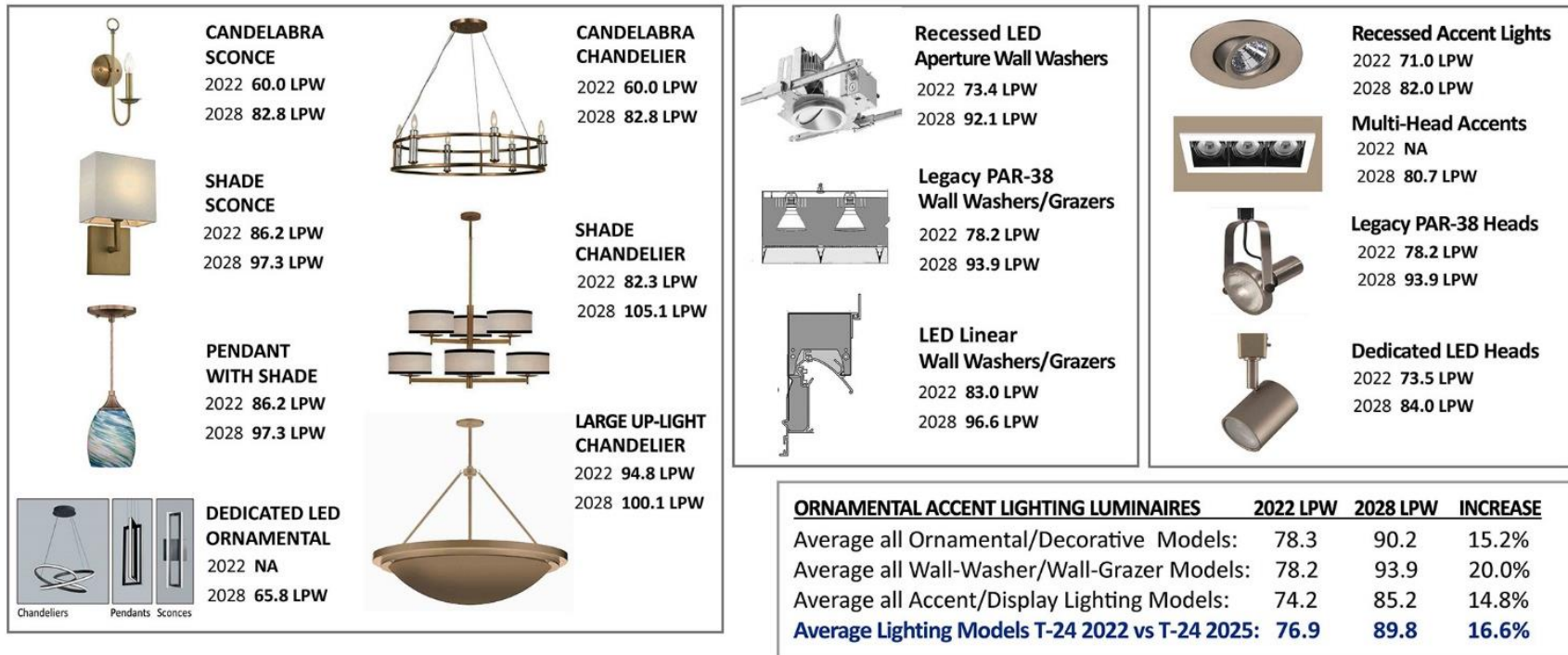


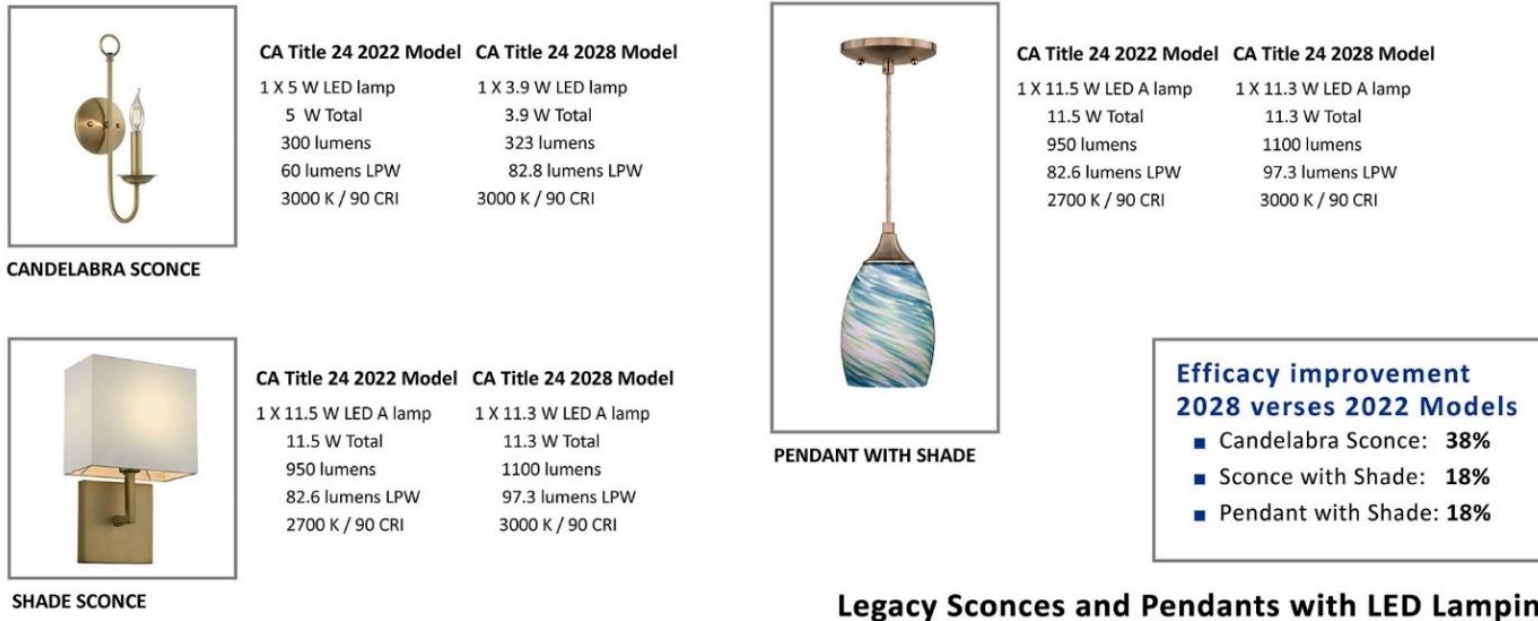
Figure 18: Ornamental and accent lighting recap LED 2022 versus 2028 models.

Models initially created for analysis of decorative/ornamental lighting during development of the 2022 Title 24 code cycle were updated with current LED technologies. The original models included legacy incandescent luminaires re-lamped with early generation LED bulbs and early generation dedicated LED luminaires. The updated decorative/ornamental lighting luminaires provided the team with a tool to evaluate efficacy improvements of both LED bulbs used in legacy luminaires as well as more current LED luminaires developed since the 2022 code cycle. Our findings documented an average overall 16.6 percent improvement in efficacy over that of models created for Title 22-2022 code development.

A more detailed review of the team’s analysis and findings of the various type of decorative/ornamental luminaires are as follows:

- Legacy incandescent sconces and pendants lamped with LED retrofit bulbs.
- Legacy incandescent chandeliers lamped with LED retrofit bulbs.

- Dedicated LED ornamental/decorative luminaires versus legacy incandescent LED retrofits.
- LED wall-washers and wall-grazers, both legacy products as well as dedicated LED luminaires.
- LED accent lights recessed and track mounted both legacy products and dedicated LED.



### Legacy Sconces and Pendants with LED Lamping

Figure 19: Legacy sconces and pendants with LED lamping.

### Legacy Incandescent Sconces and Pendants Lamped with LED Retrofit Bulbs

Efficacy improvements of legacy incandescent sconces and pendants with LED lamps ranged from 18 percent to 38 percent for current LED lamp technology versus lamps used in the 2022 models. This high range in efficacy improvements is because exposed candle (bare lamp) legacy sconces employ candelabra base lamps which had significantly higher efficacy improvements over candelabra LED lamps used in the 2022 models. Led retrofit lamps in the

sconces with shades and pendants use LED A lamps which were more efficacious in 2022 and therefore exhibited less efficacy improvement in the 2028 models.



CANDELABRA CHANDELIER

CA Title 24 2022 Model	CA Title 24 2028 Model
6 X 5 W LED lamps	6 X 3.9 W LED lamp
30 W Total	23.4 W Total
1800 lumens	1938 lumens
60 lumens LPW	82.8 lumens LPW
2700 K / 90 CRI	3000 K / 90 CRI



SHADE CHANDELIER

CA Title 24 2022 Model	CA Title 24 2028 Model
6 X 17 W LED A lamps	6 X 14.9 W LED A lamp
102 W Total	89.4 W Total
9600 lumens	9396 lumens
82.3 lumens LPW	105.1 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI



LARGE UP-LIGHT CHANDELIER

CA Title 24 2022 Model	CA Title 24 2028 Model
8 X 17 W LED PL lamps	8 X 16.1 W LED lamp
136 W Total	128.8 W Total
12300 lumens	15304 lumens
94.8 lumens LPW	118.8 lumens LPW
3000 K / 90 CRI	3000 K / 80 CRI **

\*\* 90 CRI PL LED lamps were not found — using a 0.80 to 0.85 adjustment factor 90 CRI product efficacy = 95 LPW to 100.1 LPW

**NOTE:** Legacy large chandeliers can be retrofitted with 90 CRI A lamps to provide high color rendering illumination

Efficacy improvement 2028 versus 2022 Models	
■ Candelabra Chandelier:	<b>38%</b>
■ Chandelier with Shade:	<b>18%</b>
■ Large Up-Light Chandelier:	<b>38%</b>

Figure 20: Legacy chandeliers with LED lamping.

### Legacy Incandescent Chandeliers Lamped with LED Retrofit Bulbs

Legacy chandeliers LED lamps efficacy improvements also ranged from 18 percent to 38 percent for current lamps versus those used in the 2022 models. The high range in lamp efficacy improvements is that exposed candle (bare lamp) legacy chandeliers candelabra base lamps had higher efficacy improvements over legacy chandeliers with shades. These luminaires typically use LED A lamps which were more efficacious in 2022 and therefore saw a smaller improvement versus the candelabra LED lamps. The large chandeliers' 2028 models 38 percent efficacy improvement because the 2022 model used a 90 CRI lamp that is no longer available the 2028 model now uses 80 CRI lamps.

33% average efficacy loss for LED Ornamental Luminaires delivered lumens versus system lumens

### Legacy Luminaires Re-Lamped with LED Bulbs



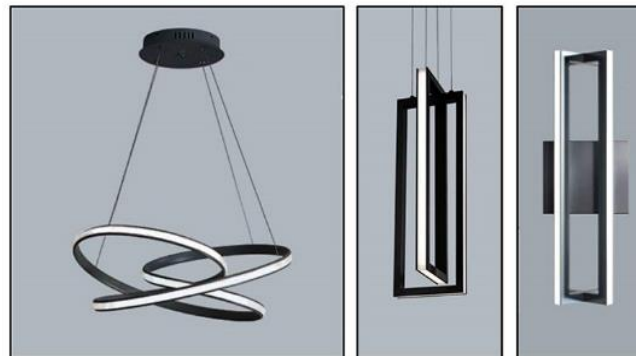
Chandeliers      Pendants      Sconces

#### EFFICACY RANGE OF LED LAMPS

71.1 to 137.5 lumens per watt @ 80 CRI and 90 CRI Sampling

NOTE: Efficacy losses from shades, lenses, filters or structure not include in legacy luminaire re-lamping with LED lamps

### LED Luminaires with LED Light Engines



Chandeliers      Pendants      Sconces

#### EFFICACY RANGE OF LED LUMINAIRES

30.7 to 106.7 lumens per watt @ 80 CRI and 90 CRI Sampling

NOTE: Efficacy losses can be significant from shades, lenses, filters or structure depending on luminaire design and form

**CA Title 24 2028 Models**  
 LEGACY LUMINAIRES  
 9.7 W lamping (average)  
 958 lumens (average)  
 98.8 lumens LPW  
 2700 K & 3000 K / 80 CRI & 90 CRI

**CA Title 24 2028 Models**  
 DEDICATED LED LUMINAIRES  
 38.4 W luminaire (average)  
 2529 lumens (average)  
 65.8 lumens LPW  
 2700 K & 3000 K / 80 CRI & 90 CRI  
  
 1/3 Efficacy Loss  
 Delivered Lumens  
 Versus  
 System Lumens  
 88 LPW +- (System Lumens)

Figure 21: Ornamental lighting LED retrofit lamping versus dedicated LED luminaires.

## Dedicated LED Ornamental / Decorative Luminaires Versus Legacy LED Retrofit Luminaires

In comparing efficacy of legacy incandescent luminaires re-lamped with LED bulbs versus dedicated LED ornamental/decorative luminaire, there were many instances where the dedicated LED luminaire was less efficacious than the retrofits. At first glance this finding appears to be counter intuitive, however on closer examination the dedicated LED luminaire less efficacious performance can be understood.

Dedicated LED ornamental/decorative luminaires are available with a wide range of design offerings (many unique to LED technology). Their purpose is to provide the designer with a wide range of options to support and enhance the ambiance of the space in which the luminaires are placed. While legacy incandescent ornamental/decorative luminaires also serve to support and enhance the ambiance of the space they are more lamp dependent than dedicated LED designs. As a result, an efficacy improvement from 15 to 18 lumens per watt incandescent bulb ornamental/decorative luminaire re-lamped with a 97 to 105 lumens per watt LED bulb results in linear improvement in luminaire efficiency.

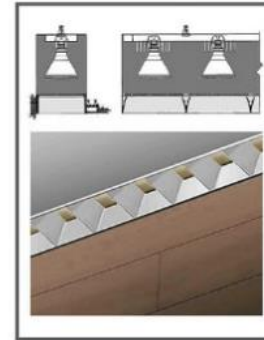
However, many of the LED ornamental/decorative luminaire designs that are unique but achievable because of LED technology, result in delivered lumens which are often 1/3 to 1/2 the efficacy of source lumen efficacy. A prime example of these luminaire designs is the LED ribbon lighting chandelier, pendant and sconce shown in images of luminaires with LED light engines. The ribbon is typically a very narrow 1/2 -inch to 1-1/2-inch (and sometimes less wide) light slot which contributes to some of the source lumen losses as well as translucent material to mask the LED ribbon light source which adds an additional loss to delivered lumens.

There is less concern with the efficacy of ornamental/decorative chandeliers sconces and pendants as they are primarily meant to enhance the ambiance of the space and not provide functional illumination. The lighting power density assigned to these luminaires is to ensure that the luminaires provide the necessary visual ambiance only, not general, task or display illumination.



### Recessed LED Aperture Wall Washers

CA Title 24 2022 Model	CA Title 24 2028 Model
4-inch/6-inch aperture	4-inch/6-inch aperture
31 W (average)	33 W (average)
2269 lumens (average)	3040 lumens (average)
73.4 lumens LPW	92.1 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI

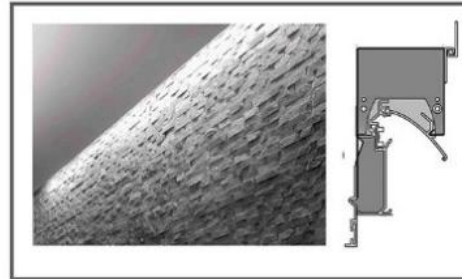


### Legacy PAR-38 Wall Washers/Grazers

CA Title 24 2022 Model	CA Title 24 2028 Model
18 W & 26 W	18 W & 26 W
LED PAR 38 lamps	LED PAR 38 lamps
22 W lamp (average)	23 W lamp (average)
1720 lumens (average)	2160 lumens (average)
78.2 lumens LPW	93.9 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI

### Efficacy improvement 2028 versus 2022 Models

- Recessed LED Aperture Wall Washers : **25%**
- Legacy PAR-38 Wall Washers/Grazers: **20%**
- Desiccated LED Wall Washers/Grazers: **16%**



### LED Linear Wall Washers/Grazers

CA Title 24 2022 Model	CA Title 24 2028 Model
LED Linear Wall Washers/Grazers	LED Linear Wall Washers/Grazers
18 W 4-foot Section	17.5 W 4-foot Section
1500 lumens 4-foot Section	1690 lumens 4-foot Section
83 lumens LPW	96.6 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI

Figure 22: LED wall-washers and wall-grazers, 2022 versus 2028 models.

## LED Wall-washer and Wall-grazers / Legacy Products and Dedicated LED Luminaires

Wall-washers/wall-grazers can serve dual functions. If illuminating merchandise or a task they are usually classified as accent or display lighting. However, when illuminating works of art or architectural features such as ornate walls surfaces, they are defined as decorative lighting. Current LED efficacy improvements versus that used for the 2022 models are 16 percent to 25 percent. The 25 percent gain, for aperture wall-washers, contributed to the general improvement in LED efficacy as well as a diminishing efficacy gap between 80 CRI and 90 CRI LED chipsets. The smaller 16 percent gain for LED linear wall-washer/wall-grazer luminaires is reflector losses which are unchanged from the 2022 models.



### Recessed Adjustable Accent Lights

CA Title 24 2022 Model	CA Title 24 2028 Model
4-inch & 6-inch Aperture	4-inch & 6-inch Aperture
24.4 W luminaire (average)	24.7 W luminaire (average)
1732 lumens	2026 lumens (average)
71 lumens LPW	82 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI



### 3-lamp Low/High Output Multi-Head Accent Lights

CA Title 24 2022 Model	CA Title 24 2028 Model
No 2022 Model Sampling for this Luminaire Type	59 W luminaire (average)
	4764 lumens (average)
	80.7 lumens LPW
	3000 K / 90 CRI

### Efficacy improvement 2028 versus 2022 Models

- Recessed Adjustable Accent Lights: **15%**
- Recessed Multi-Head Accent Lights: **No 2022 Model**
- Legacy PAR-38 Tack Mount Accent Lights: **20%**
- Dedicated LED Tack Mount Accent Lights: **14%**



### Legacy PAR-38 Heads

CA Title 24 2022 Model	CA Title 24 2028 Model
18 W & 26 W	18 W & 26 W
LED PAR 38 lamps	LED PAR 38 lamps
22 W lamp (average)	23 W lamp (average)
1720 lumens (average)	2160 lumens (average)
78.2 lumens LPW	93.9 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI



### Dedicated LED Heads

CA Title 24 2022 Model	CA Title 24 2028 Model
13 W & 22 W	13 W & 22 W
LED Dedicated Heads	LED Dedicated Heads
19 W luminaire (average)	17 W luminaire (average)
1395 lumens (average)	1428 lumens (average)
73.5 lumens LPW	84.0 lumens LPW
3000 K / 90 CRI	3000 K / 90 CRI

### TRACK MOUNTED ACCENT LIGHTS

Figure 23: Recessed and track mount LED accent lights, 2022 versus 2028 models.

## LED Accent Lights Recessed and Track Mounted / Legacy Products and Dedicated

Display and accent light luminaire can also serve dual functions. If illuminating merchandise or a task they are usually classified as they are usually classified as accent or display lighting. However, when illuminating works of art or architectural features such as ornate walls surfaces, they are defined as decorative lighting. These luminaires had 14 percent to 20 percent efficacy gain over the efficacy of the LED's used in the 2022 models. This data was used to assist the Statewide CASE Team in determining the proposed lighting power density (LPD) target for accent/display and decorative lighting for the 2028 code cycle.