TITLE 24, PART 6 | 2028 CODE CYCLE

Controlled Environment Horticulture: Lighting Efficacy

Codes and Standards Enhancement (CASE) Proposal

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Proposal Description

- Code Change Proposal
- Benefits
- Background Information

Proposed Code Change

Raise the minimum Photosynthetic Photon Efficacy (PPE) of horticultural light sources from **2.3 to 2.5 micromoles per joule** (µmol/J).

Who it applies to: No change from current rules — applies to new construction and alterations of indoor grow spaces and greenhouses with more than 40 kilowatts of lighting.

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

Benefits of the Proposed Change

Incremental Energy Savings

- More efficient fixtures deliver the same light using less electricity.

Minimal Incremental Cost Impact

- High-efficacy fixtures are already widely available and competitively priced.

Crop-Independent Lighting Efficiency

- Provides consistent performance across crops.

Grid Demand Reduction

- Lower energy use during peak lighting periods reduces pressure on California's electricity grid.

Reduced Cooling Loads

- Efficient lights produce less heat, reducing the need for HVAC or dehumidification.

Background Information: How Energy is Saved

- Photosynthetic Photon Efficacy (PPE) measures how efficiently horticultural light fixtures convert electricity into light usable for photosynthesis.

- By increasing the required PPE from **2.3 to 2.5 µmol/J**, the same light intensity can be achieved with **less electrical input**, reducing total energy use.

- More efficient fixtures produce **less waste heat**, lowering the **cooling load** on HVAC systems and further reducing facility energy use.

Background Information: Alignment with National Standards & Programs

The proposed 2.5 µmol/J PPE requirement aligns with several major standards and industry specifications:

International Energy Conservation Code (IECC)

- *IECC 2021, Section C405.4* – Requires horticultural luminaires to have a PPE of at least **2.5 µmol/J** for fixtures used for plant growth and maintenance.

DesignLights Consortium (DLC)

- The v4.0 Technical Requirements raise the minimum PPE threshold to **2.5 µmol/J** for QPL qualification, effective April 1, 2025.
- This spec is widely adopted by utility rebate programs across North America.

ASHRAE Standard 90.1 – Proposed Addendum for Controlled Environment Agriculture

- ASHRAE's July 2023 addendum proposal includes PPE requirements for horticultural lighting, aligned with a **2.5 µmol/J minimum**.
- Proposal intended for incorporation into ASHRAE 90.1, Section 9.4.4.

Background Information:
What's different from previous Energy Code updates?

- California's Title 24 has incrementally increased PPE requirements over time — from **1.7/1.9 µmol/J in 2022** to **2.3 µmol/J in 2025**. The proposed **2.5 µmol/J** level reflects **market maturity** and wider product availability.

- Unlike prior cycles, the proposed update is **already supported by national standards**, making this a low-risk, high-impact adjustment.

- This requirement will continue to apply to new construction and alterations of **greenhouses and indoor CEH facilities with over 40 kW of connected horticultural lighting**, ensuring consistency and limiting the burden on small-scale growers.

Marked-up Code Language

See Title24stakeholders.com for marked-up code language

Title 24, Part 1	Title 24, Part 6	Reference Appendices
▪ No changes	▪ Section 120.6(h)5.	▪ No changes

Market and Technical Considerations

- Current Conditions and Trends
- Potential Barriers and Solutions
- Technical feasibility

Current Market Conditions

LEDs in Horticulture

- LEDs account for **approximately 80% of global greenhouse lighting installations** and *65% of overall horticulture LED sales in the US.* (Note: PPE breakdown is not available).
- The 2025 Title 24 update already established **LED lighting as the baseline standard**, setting the stage for incremental improvements in light source efficacy.

DLC Qualified Products List (QPL)

- Version 4.0 of the DesignLights Consortium's Horticultural Technical Requirements (effective April 2025) **aligns with 2.5 µmol/J PPE**, encouraging manufacturer compliance.
- Only **~12%** of current DLC QPL fixtures (V3.0 or less) will be delisted.
- DLC-listed fixtures are eligible for **utility and incentive programs** such as PG&E's Agriculture Energy Savings Action Plan (≥ 2.86 µmol/J).

https://www.mordorintelligence.com/industry-reports/horticulture-lighting-market

https://www.mordorintelligence.com/industry-reports/grow-lights-market
https://designlights.org/our-work/horticultural-lighting/technical-requirements/hort-v4-0/ (Date visited: August 11, 2025)

https://agenergysavings.com/grow-lighting-rebates

Current Market Conditions: Why the Market Would Improve Even Without Code Change

Manufacturer Momentum

- Based on the current DLC QPL, there are **785 listed fixtures** that meet the 2.5 µmol/J PPE requirement and include test data.
- 50% of these fixtures—or **406 listed fixtures**—meet the requirements for PG&E's AESAP Program which offers their agricultural customers **$79/fixture** for new construction/added load or lighting replacement projects.

Price Competitiveness

- Anticipate that growers replacing fixtures will naturally select higher-efficiency models due to cost-effectiveness and incentive alignment.
- Anticipate that as higher-efficiency fixtures become the norm, economies of scale will bring down prices, narrowing any remaining cost gap — even without a code mandate

https://qpl.designlights.org/qpl/horticulture (Visited: August 11, 2025)

https://agenergysavings.com/grow-lighting-rebates

Market Barriers and Solutions

Market Barriers	Potential Solutions
1. Limited availability of high PPE fixtures with a broad light spectrum.	1. Stakeholder outreach to identify purchasing preferences related to plant performance and red-light ratio at or above 2.5 µmol/J PPE.

Data Barriers and Solutions

Market Barriers

1. Insufficient data on number of greenhouses by crop type that use supplemental lighting
2. Dimming is standard practice to manage plant stress/crop traits and achieve varying Photosynthetic Photon Flux Density (PPFD) targets through the growth cycle (cannabis veg and flower, lettuce, etc.)

   Current model assumes static PPFD.

Potential Solutions

1. Collect data
   - Interviews with greenhouse manufacturers, industry associations, and growers.
   - Analyze available data sources - USDA Hort. Census, CDFA Farm Surveys, Industry Reports, county agriculture reports, etc.
2. Conduct stakeholder outreach to document real-world dimming strategies. Adjust energy and cost models to simulate realistic dimming strategies.

Current Market Share (Estimated)

Market share: percentage of buildings that already use the proposed technology or design practice (at or above the proposed stringency level)

New Construction and Additions	**60-65%** ▪ LED: 70% ▪ ≥2.5 PPE: 88%	
Alterations	**60-65%** ▪ LED: 70% ▪ ≥2.5 PPE: 88%	

Source: CASE Team Assumption based on LED penetration of horticulture applications study from 2024 Cannabis Business Times survey

Poll

In your experience, how common is CEH lighting with ≥2.5 PPE today?

a. Very rare (<10%)
b. Somewhat rare (10–25%)
c. About half (26–50%)
d. Common (51–75%)
e. Very common (>75%)

Poll

What is the biggest barrier to adopting ≥2.5 PPE light fixtures?

Which of the following is the primary challenge preventing your facility—or others you know—from selecting LED fixtures rated at 2.5 µmol/J or higher?

a. Already installed LED with less than 2.5 µmol/J
b. Fixture cost
c. Spectrum quality concerns
d. Limited product availability that meets crop-specific needs
e. Lack of awareness/education
f. Infrastructure limitations
g. Other

Technical Considerations

LED baseline remains unchanged, but PPE requirement improves to 2.5 µmol/J.

- High-efficacy LEDs can provide **flexible spectral quality**, supporting a range of crops and production goals.
- While increases in PPE can sacrifice spectrum quality, 2.5 µmol/J level still allows for flexibility in spectrum for diverse crops.
- However, 2.5 µmol/J does **not guarantee spectrum quality**—and growers must still select spectrum-conscious fixtures for their goals.
- Important: PPE measures Photosynthetically Active Radiation (PAR) efficiency (400–700 nm) and does **not capture far-red (FR)** or **UV contributions**. Far red light (700–750 nm) can be important for some crops.

Technical Barrers and Solutions

Technical Barriers	Potential Solutions
1. High PPE often means using a higher ratio of red LEDs—which is cost-effective—but may reduce full-spectrum output, potentially harming crop quality.	1. Collect photometric and spectral data on fixtures above and below 2.5 µmol/J PPE. Identify acceptable spectrum trade-offs or need for spectrum guidelines.

Poll

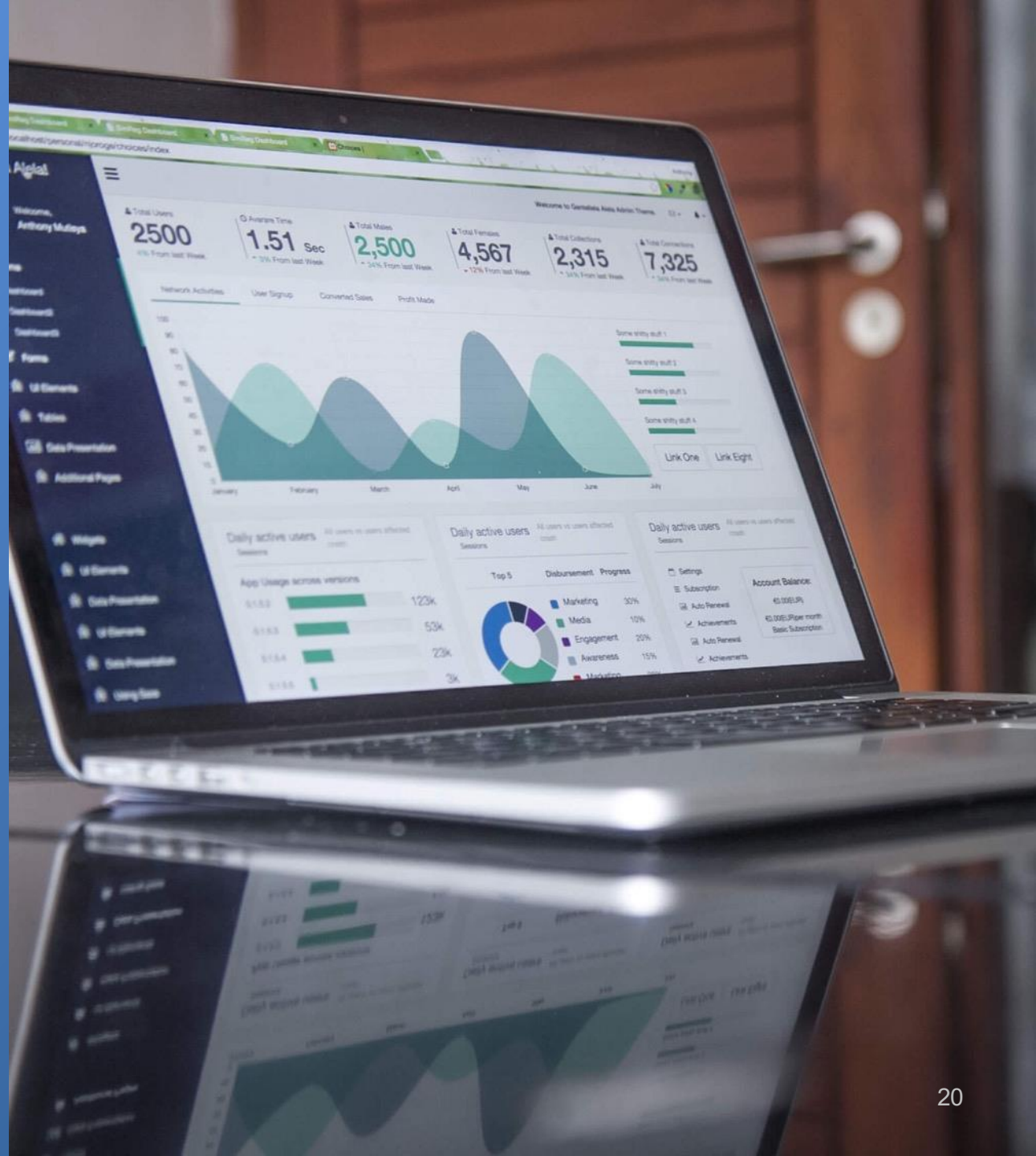
What is the typical PPFD (Photosynthetic Photon Flux Density) you maintain in your cannabis flowering rooms?

a) Below 400 µmol/m²/s
b) 400–600 µmol/m²/s
c) 601–800 µmol/m²/s
d) 801–1000 µmol/m²/s
e) 1001–1200 µmol/m²/s
f) Above 1200 µmol/m²/s

Per Unit Energy and Cost Impacts

Methodology and Assumptions

- Energy Savings
- Energy Cost Savings
- Incremental Costs



Energy and Cost Savings Methodology

Based on T24 2025 Methodology

- Our calculations follow the established **Title 24 CEH lighting model**, using Excel-based hourly energy simulation.
- Maintain consistent PPFD, photoperiod, crop-specific design parameters—only PPE changes incrementally from 2.3 to 2.5 µmol/J.
- All other factors—mounting height, maintenance, controls, layout—are held constant.

Lighting Use = Wattage per square foot × Photoperiod × Area

- *Wattage* derived from canopy PPFD × photoperiod length.
- *Area per luminaire* varies based on crop type and facility type (indoor vs greenhouse).

$$\text{Efficiency Gain} = \frac{2.5 - 2.3}{2.3} \approx 8.7\%$$

Energy and Cost Savings Methodology

$$Annual\ Energy\ Use\ (GWh) = \frac{PPFD}{PPE\ x\ 10.764} \times \frac{1}{1000} \times FLH \times Area\ (ft^2) \div 1{,}000{,}000$$

Where,

- PPFD = µmol/m^2/s
- PPE = µmol/J
- 10.764 = m^2 to ft^2
- FLH = Full Load Hours per Year
- Area = ft^2
- 1000 = W to kW
- 1,000,000 = kWh to GWh

Energy Modeling Assumptions

- Simulating using the following prototypical buildings and climate zones

Prototypical Buildings

Building Types Included

- **Indoor** grow facilities
- **Greenhouses** with supplemental lighting

Crops Modeled

- **Cannabis**
- **Tomatoes** (vine crops)
- **Greens** (e.g., herbs, microgreens)

Climate Zones

- Climate zones 1-16

Energy Modeling Assumptions

Prototype: Indoor & Greenhouse

Photosynthetic Photon Flux Density (µMol/m²/s)

Building Type	Cannabis Flower	Cannabis Vegetative	Cannabis Clone	Leafy Greens	Tomatoes
Indoor	1,000	600	200	200	350
Greenhouse	600	400	200	200	350

Lighting System Design Parameters

	Cannabis Flower	Cannabis Vegetative	Cannabis Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft²)	20	24	10	58	56
Photoperiod (hours per day)	12	18	24	18	12
Mounting Height Above Canopy	24”	24”	24”	24”	24”

Standard Design

1. 2.3 PPE (µMol/J)
2. Title 24 2025

Proposed Design

1. 2.5 PPE (µMol/J)
2. All other assumptions are identical to Standard Design / Baseline

Incremental Cost Framework

Prototype(s): Greenhouse and Indoor Horticulture

Baseline

First Cost

1. Lighting Costs by plant type
2. Installation

30-Year Maintenance Costs

1. Equipment Replacement
2. Regular Maintenance (Lens cleaning)

Proposed

First Cost

1. Lighting Costs by plant type
2. Installation

30-Year Maintenance Costs

1. Equipment Replacement
2. Regular Maintenance (Lens cleaning)

Approach for Gathering Costs

Direct Outreach to Industry Stakeholders

- Targeted calls and surveys to collect real-world installation and equipment costs from **Growers & Facility Owners.**
- Interviews with **Lighting Manufacturers & Distributors** focused on fixture prices, high-PPE options, and emerging market trends.
- Data sharing, especially for facilities installing both HVAC and lighting upgrades, with **HVAC & Controls Vendors**.

Industry Association Engagement

- Partner with groups like **GLASE, RII, ALA, and horticulture equipment associations** to access aggregated pricing data.
- Leverage existing contacts and vendor networks for broader insight.

Approach for Gathering Costs

Surveys + Data Collection

Conduct structured surveys of contractors, integrators, and distributors to gather:

- Fixture costs (standard vs. >2.5 µmol/J)
- Installation labor rates (new vs. retrofit)
- Commissioning and calibration fees

Integrated Outreach

- Combine lighting cost research with HVAC measure outreach whenever possible to increase efficiency and reach.
- Joint survey instruments to streamline stakeholder engagement.

Supplemental Baselines

- Use RSMeans or online cost databases as a preliminary benchmark, only if primary data falls short.

Compliance Verification

- Key Aspects of Compliance Verification
- Barriers and Solutions

Key Aspects of Compliance Verification

No Third-Party Verification Required

- The current proposal maintains the existing Title 24 approach with no third-party verification of PPE. There is no new mandate for independent verification of PPE performance.

No Commissioning Requirement Introduced

- Lighting systems under this measure are **not subject to commissioning** or functional performance checks beyond standard inspection.

No Change to Current Compliance Process

- There are **no alterations to the current Title 24 compliance framework or energy modeling requirements** for horticultural lighting.

Compliance Barriers and Solutions

Compliance Verification Barriers	Potential Solutions
1. Lack of clarity for building officials on how to identify and verify compliance of horticultural lighting fixtures—especially the PPE threshold.	1. Educating building officials and inspectors, developing educational materials.

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More information on
CEC's 2028 proceeding website.

We want to hear from you!

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