

# Controlled Environment Horticulture



**Amy Droitcour, Nicole Hathaway, Garth Torvestad,  
Lydia Miner (West Monroe), Joe Sullivan (J2M Consulting),  
Nadia Sabeh (Dr. Greenhouse, Inc.), Michael Zartarian (Zartarian Engineering),  
Michael Gillespie (Gillie Consulting), Willy Stober, Hillary Weitze (Red Car Analytics)**

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Authors:	Amy Droitcour, Nicole Hathaway, Garth Torvestad, Lydia Miner (West Monroe), Joe Sullivan (J2M Consulting), Nadia Sabeh (Dr. Greenhouse, Inc.), Michael Zartarian (Zartarian Engineering), Michael Gillespie (Gillie Consulting), Willy Stober, Hillary Weitze (Red Car Analytics)
Project Support:	Gina Rodda (Gabel Energy), Martin Vu (RMS Energy Consulting), Brett Kelley (Kelley Energy Management), Jeff Kelley (Kelley Energy Management), Jon McHugh (McHugh Energy Consultants)
Prime Contractor:	West Monroe
Project Management:	California Statewide Utility Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric Company

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# Acronyms

Table 1 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a [glossary of terms](#).

**Table 1: List of Acronyms**

Acronym	Definition
<b>ACM</b>	Alternative Calculation Method
<b>AESAP</b>	Agriculture Energy Savings Action Plan
<b>AHJ</b>	Authorities Having Jurisdiction
<b>ANSI</b>	American National Standards Institute
<b>ASABE</b>	American Society of Agricultural and Biological Engineers
<b>ASHRAE</b>	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
<b>BCR</b>	Benefit-Cost Ratio
<b>Btu</b>	British Thermal Units
<b>Btuh/sqft</b>	British Thermal Units per Hour per square foot
<b>CALBO</b>	California Building Officials
<b>CALGreen</b>	California Green Building Standards Code
<b>Cal/OSHA</b>	California Division of Occupational Safety and Health
<b>CASE</b>	Codes and Standards Enhancement
<b>CAV</b>	Constant Air Volume
<b>CBECC</b>	California Building Energy Code Compliance Software
<b>CBO</b>	Community-Based Organization
<b>CEC</b>	California Energy Commission
<b>CEDARS</b>	California Energy Data and Reporting System
<b>CEH</b>	Controlled Environment Horticulture
<b>CEQA</b>	California Environmental Quality Act
<b>CFM</b>	Cubic Feet per Minute
<b>CFR</b>	Code of Federal Regulations
<b>CMR</b>	Code of Massachusetts Regulations
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>CO<sub>2</sub>e</b>	Carbon Dioxide Equivalent
<b>CPUC</b>	California Public Utilities Commission
<b>CZ</b>	Climate Zone
<b>DAC</b>	Disadvantaged Community
<b>DCC</b>	Department of Cannabis Control

<b>Acronym</b>	<b>Definition</b>
<b>DEER</b>	Database for Energy Efficient Resources
<b>DHI</b>	Diffuse Horizontal Irradiance
<b>DLC</b>	DesignLights Consortium
<b>DLI</b>	Daily Light Integral
<b>DOAS</b>	Dedicated Outdoor Air System
<b>DOE</b>	Department of Energy
<b>DOSH</b>	Division of Occupational Safety and Health
<b>DX</b>	Direct Expansion
<b>ECC</b>	Energy Code Compliance
<b>EER</b>	Energy Efficiency Ratio
<b>EPA</b>	Environmental Protection Agency
<b>ESJ</b>	Environmental and Social Justice
<b>EUI</b>	Energy Use Intensity
<b>EUL</b>	Estimated Useful Life
<b>F</b>	Fahrenheit
<b>ft<sup>2</sup></b>	Square Feet
<b>GHG</b>	Greenhouse Gas
<b>GWh</b>	Gigawatt-Hours
<b>GHI</b>	Global Horizontal Irradiance
<b>HID</b>	High Intensity Discharge
<b>HPS</b>	High Pressure Sodium
<b>HVAC</b>	Heating, Ventilation, and Air Conditioning
<b>HVAC/D</b>	Heating, Ventilation, Air Conditioning, and Dehumidification
<b>IEER</b>	Integrated Energy Efficiency Ratio
<b>IOU</b>	Investor-Owned Utility
<b>IPLV</b>	Integrated Part Load Value
<b>ISMRE</b>	Integrated Seasonal Moisture Removal Efficiency
<b>kBtu</b>	Thousand British Thermal Units
<b>kW</b>	Kilowatts
<b>kW/ft<sup>2</sup></b>	Kilowatts Per Square Foot
<b>kWh</b>	Kilowatt-Hours
<b>kWh/yr</b>	Kilowatt-Hours Per Year
<b>LED</b>	Light-Emitting Diode
<b>LPD</b>	Lighting Power Density
<b>LSC</b>	Long-term System Cost
<b>MRE</b>	Moisture Removal Efficiency

Acronym	Definition
<b>MW</b>	Megawatts
<b>nm</b>	Nanometers
<b>NRCA</b>	Nonresidential Certificates of Acceptance
<b>NRCC</b>	Nonresidential Certificate of Compliance
<b>NRCI</b>	Nonresidential Certificate of Installation
<b>NRCS</b>	Natural Resources Conservation Service
<b>PAR</b>	Photosynthetically Active Radiation
<b>PG&amp;E</b>	Pacific Gas and Electric
<b>PPE</b>	Photosynthetic Photon Efficacy
<b>PPFD</b>	Photosynthetic Photon Flux Density
<b>pFpm</b>	Parts per Million
<b>PV</b>	Present Value
<b>QPL</b>	Qualified Products List
<b>RH</b>	Relative Humidity
<b>RTU</b>	Rooftop Unit
<b>SHR</b>	Sensible Heat Ratio
<b>SME</b>	Subject Matter Expert
<b>SSPC</b>	Standing Standards Project Committee
<b>TMY</b>	Typical Meteorological Year
<b>UL</b>	Underwriters Laboratories
<b>UMLH</b>	Unmet Load Hours
<b>USDA</b>	United States Department of Agriculture
<b>VAV</b>	Variable Air Volume
<b>VPD</b>	Vapor Pressure Deficit
<b>VRF</b>	Variable Refrigerant Flow
<b>W</b>	Watts
<b>W/ft<sup>2</sup></b>	Watts Per Square Foot
<b>W/m<sup>2</sup></b>	Watts Per Square Meter
<b>μmol/J</b>	Micromoles Per Joule
<b>μmol/m<sup>2</sup>/s</b>	Micromoles Per Square Meter Per Second

# 1. Introduction

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*This is a draft report. The Statewide Codes and Standards Enhancement (CASE) Team encourages readers to provide comments on the proposed code changes and supporting analyses. The CEC will evaluate proposals that the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. More information about the rulemaking schedule and how to participate in the process can be found on CEC’s 2028 code cycle website. Suggested revisions will be considered when refining proposals and analyses. The final CASE Report will be submitted to the CEC in 2026.*

*For this report, the specific input on the following is requested:*

1. *Statewide construction forecast and existing facility stock by crop type and climate zone:*
  - a. *The Statewide CASE team is interested in data sources that provide up-to-date statewide facility stock disaggregated by crop type and building type (indoor and greenhouse). As they represent the majority of the products grown in California in CEH facilities, the data gathering effort is primarily focused on cannabis, leafy greens, vine crops (tomatoes, cucumbers, peppers), and ornamental. However, the Statewide CASE Team is interested in all plant types.*
2. *Confirmation & verification of modeling parameters for all crop types & stages (review values in report and indicate if you agree with assumptions or what assumptions you would change):*
  - a. *Canopy Area per Luminaire (ft<sup>2</sup>)*
  - b. *Photoperiod (hours per day)*
  - c. *Photosynthetic Photon Flux Density (PPFD) ( $\mu\text{Mol}/\text{m}^2/\text{s}$ )*
  - d. *Existing PPE ( $\mu\text{mol}/\text{J}$ ) levels in facilities 3 years or older*
  - e. *Existing or proposed PPE ( $\mu\text{mol}/\text{J}$ ) levels newer than 3 years or to be installed next year.*
  - f. *Mounting of PAR sensor Height Above Canopy (ft)*
  - g. *Mounting of horticultural lighting Height Above Canopy (ft)*
3. *Greenhouse envelope*
  - a. *Fraction of conditioned greenhouses with single layer glass glazing: \_\_\_\_%*
  - b. *Fraction of conditioned greenhouses with single layer plastic glazing \_\_\_\_%*
  - c. *Fraction of conditioned greenhouses with multi-layer layer plastic glazing \_\_\_\_%*

- d. *Other types of greenhouse construction?*
  - e. *Light transmissivity rates*
4. *Estimated percentage of greenhouses with supplemental lighting by crop type.*
  5. *Current adoption rate of 2.5  $\mu\text{mol}/\text{J}$  lighting across all facility sizes, with a focus on facilities  $\leq 40$  kW to assess whether the current exemption threshold remains appropriate.*
  6. *Expected life, long-term performance, and replacement interval of LEDs with PPE greater than or equal to 2.5  $\mu\text{mol}/\text{J}$*
  7. *Any specific horticultural needs or niche applications served by sub-2.5  $\mu\text{mol}/\text{J}$*
  8. *Prevalence of automatically dimmed (according to a schedule) LED lighting in greenhouses*
    - a. *By week of growth \_\_\_\_\_%*
    - b. *By time of day by ramping up or ramping down lighting at beginning or end of photoperiod (artificial sunrise or artificial sunset)? \_\_\_\_\_%*
    - c. *Another dimming schedule*
  9. *Prevalence LED lighting controlled with an on/off scheduling controller (timeclock) in greenhouses \_\_\_\_\_%*
    - a. *Fraction of these spaces with electric lighting PPFD adjusted each week via manual control \_\_\_\_\_%*
    - b. *Fraction of these spaces with electric lighting PPFD adjusted each day via manual control \_\_\_\_\_%*
  10. *Prevalence of greenhouses with LED lighting that is not automatically controlled at all (schedule and dimming level accomplished manually all the time).*
  11. *Prevalence of greenhouse LED supplemental lighting controlled in response to daylight availability according to the following methods:*
    - a. *No automatic control. Timming and dimming level adjusted manually. \_\_\_\_\_%*
    - b. *Not controlled according to daylight – lights turned on and off, but not dimmed, according to timeclock. \_\_\_\_\_% of greenhouses*
    - c. *Not controlled according to daylight – lights turned on and off and dimmed according to timeclock. \_\_\_\_\_% of greenhouses*
    - d. *Lights controlled on/off, but not dimmed, according to measured PPFD and time of day \_\_\_\_\_% of greenhouses*
    - e. *Lights controlled on/off and dimmed in response to measured PPFD during scheduled time of day. \_\_\_\_\_% of greenhouses*

- f. Lights controlled on/off and dimmed in response to integrated PAR during scheduled time of day (Daily Light Integral control). \_\_\_\_\_% of greenhouses*
12. *Space Conditioning System Data*
- a. Submetered electrical data for various system types*
  - b. Performance specifications and sequence of operation for integrated and decoupled HVAC/D systems*
  - c. Evapotranspiration rates, temperatures and desired vapor pressure deficit by cultivar during vegetative and flowering states in addition to the lighting parameters describe above.*
  - d. Performance curves for indoor agriculture combined cooling and dehumidification coils of sensible and latent cooling with respect to entering psychrometric conditions, and airflow rate for various water temperatures or refrigerant condensing temperatures*
  - e. Key attributes and differences between various integrated DX systems*
  - f. Cost considerations and economies of scale for chilled water systems*
  - g. Differences in replacement process (compressor vs. whole unit) for different equipment types*
  - h. Attributes, advantages, modeling approach for new/emerging dehumidification technologies*
  - i. Documented impact on yield/quality and energy savings from improved control, integrated vs. decoupled systems, other attributes.*
  - j. Effective Useful Life for various system types*

*Email comments and suggestions to [info@title24stakeholders.com](mailto:info@title24stakeholders.com) and [adroitcour@westmonroe.com](mailto:adroitcour@westmonroe.com). Comments will not be attributed to their authors unless these are publicly docketed or with permission of the contributor.*

## **1.1 Report Context**

This proposal describes specific energy efficiency code changes (referred to as “measures”) aimed at reducing wasteful, uneconomic, inefficient, or unnecessary energy consumption 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 California Green Building Standards Code (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 sponsored this effort as a group. Where the term, “Statewide CASE Team” is used in this report, it refers the authors of the CASE report and the Codes & Standards programs of the supporting California Investor-Owned Utilities.

### 1.2.1 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders, including controlled environment horticulture (CEH) growers, lighting manufacturers, controls manufacturers, heating, ventilation, and air conditioning (HVAC) manufacturers, dehumidifier manufacturers, designers, technicians, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during public stakeholder workshops that the Statewide CASE Team held on September 24, 2025<sup>1</sup> and December 12, 2025<sup>2</sup>.

Appendix E provides further details on the Statewide CASE Team’s stakeholder engagement.

<sup>1</sup> <https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/>

<sup>2</sup> <https://title24stakeholders.com/event/controlled-environment-horticulture-prototype-workshop/>

## 2. Lighting Efficacy

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### 2.1 Lighting Efficacy – Measure Description

#### 2.1.1 Proposed Code Change

The proposed code change would increase the mandatory photosynthetic photon efficacy (PPE) requirement for luminaires and lamps used for controlled environment horticulture (CEH) from 2.3 micromoles per joule ( $\mu\text{mol}/\text{J}$ ) to a luminaire photosynthetic photon efficacy (PPE) requirement of 2.5  $\mu\text{mol}/\text{J}$ . The updated requirement would align with the DesignLights Consortium (DLC) Horticultural Technical Requirements V4.0 for consistency with current industry performance criteria (DesignLights Consortium, 2025).

This proposal updates the definition of photosynthetic photon efficacy (PPE) to luminaire photosynthetic photon efficacy (PPE), so there is an even playing field for all products. The rating of all products will account for the optical efficiency of the luminaire and the thermal impacts of luminaire design. Otherwise, the remainder of the definition is aligned with the metric developed by the American Society of Agricultural and Biological Engineers (ASABE) for the ANSI/ASABE S640 standard (ANSI/ASABE, 2017). This definition will be inclusive of luminaires with replaceable, serviceable lamps.

The updated horticultural lighting efficacy requirement would apply to new construction, additions, and alterations of greenhouse and indoor CEH facilities with an aggregate horticultural lighting load of 40 kilowatts (kW) or greater. The minimum PPE threshold would apply to all crop types and system configurations meeting this load threshold. The proposal would revise the mandatory requirements in Section 120.6 (Covered Processes) of Title 24, Part 6. Since the lighting efficacy requirements are mandatory, if the California Energy Commission adopts a performance approach for space conditioning systems, the Standard Design horticultural lighting efficacy would be equal to the proposed horticultural lighting efficacy.

In addition, this measure clarifies and carries forward existing requirements already established in the 2025 Energy Code for the dimmability of horticultural lighting. Specifically, the proposed dimming functionality language is derived from the language previously contained in Section 120.6(h)5C, which requires luminaires to adhere to the multilevel lighting controls requirements in 130.1(b). The proposed language is intended to improve clarity and consistency in the interpretation and application of this existing requirement, ensuring that stakeholders clearly understand the expectations for compliant systems. This clarification does not expand the scope of regulated products or introduce new performance obligations beyond those already adopted in the 2025 Energy Code.

Table 2 summarizes the scope and applicability of the proposed change.

**Table 2: 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 type="checkbox"/> Prescriptive
<input checked="" type="checkbox"/> Nonresidential (not including Group R uses)	<input checked="" type="checkbox"/> Alterations	<input type="checkbox"/> Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	<ul style="list-style-type: none"> <li>Part 6, Section 100.1</li> <li>Part 6, Section 120.6</li> </ul>	NRCC-PRC NRCI-PRC	<ul style="list-style-type: none"> <li>N/A</li> </ul>

Third Party Verification)	Updates to Compliance Software
<input checked="" type="checkbox"/> No changes to third party verification	<input checked="" type="checkbox"/> No updates
<input type="checkbox"/> Update existing verification requirements	<input type="checkbox"/> Update existing feature
<input type="checkbox"/> Add new verification requirements	<input type="checkbox"/> Add new feature

### 2.1.2 Benefits of Proposed Change

California’s CEH sector is rapidly expanding to meet demand for locally grown, high-value crops produced all year. As these facilities rely heavily on electric lighting, improving fixture efficacy is one of the most effective strategies to reduce energy use. The proposed increase in the minimum PPE requirement from 2.3  $\mu\text{mol}/\text{J}$  to 2.5  $\mu\text{mol}/\text{J}$  ensures that new and retrofitted CEH lighting systems meet the current performance standard already commercially common.

By setting a higher efficacy threshold, the measure will deliver incremental, yet meaningful, energy savings with minimal cost impact because high-performance fixtures at or above 2.5  $\mu\text{mol}/\text{J}$  are already widely available. The new threshold represents an efficacy level approximately eight percent higher than the current standard, which equates to an anticipated annual statewide energy savings of 8.1 GWh for new constructions, additions and alterations.

The proposal also enhances alignment with the DLC Horticultural Technical Requirements V4.0, ensuring that Title 24 continues to reflect current (DesignLights

Consortium, 2025). This step builds on the 2025 iteration of the Energy Code, advancing a multi-cycle strategy to improve CEH efficiency, reduce emissions, and maintain California's leadership in sustainable agriculture technology.

### **2.1.3 Background Information**

CEH refers to the practice of growing plants in enclosed or partially enclosed facilities, such as greenhouses or indoor growing spaces, where environmental conditions can be precisely managed. These facilities use mechanical and electrical systems to regulate light, temperature, humidity, airflow, water, nutrients, and carbon dioxide, thus enabling year-round production of a wide range of high-value crops. Because these systems operate continuously and at high energy intensity, CEH facilities have some of the highest energy use per square foot of any building type, ranging from about 800 kBtu/ft<sup>2</sup>/yr for indoor cannabis (Mills, 2012; New Frontier Data, 2018; Sabeh, Miner, & Perman, 2022), about 700 kBtu/ft<sup>2</sup>/yr for vertical farms (Resource Innovation Institute, 2023) to about 400-450 kBtu/ft<sup>2</sup>/yr for greenhouse cannabis (New Frontier Data, 2018; Sabeh, Miner, & Perman, 2022) and about 250 kBtu/ft<sup>2</sup>/yr for other greenhouse crops (Resource Innovation Institute, 2023). For comparison, California office building energy use intensity is about 50 kBtu/ft<sup>2</sup>/yr (California Energy Commission, 2024) and California data center energy use intensity ranges from 340 kBtu/ft<sup>2</sup>/yr (25<sup>th</sup> percentile) to 1127 kBtu/ft<sup>2</sup>/yr (75<sup>th</sup> percentile) (U.S. Environmental Protection Agency, 2026).

To manage energy use in this expanding sector, California introduced energy efficiency requirements for CEH facilities in 2022, marking the first time these specialized building types were addressed in Title 24, Part 6 (Energy Solutions, 2021). The 2025 iteration of the Energy Code strengthened these requirements by setting a minimum PPE of 2.3  $\mu\text{mol}/\text{J}$  for horticultural lighting systems in greenhouses and indoor grow facilities with lighting loads greater than 40 kW. This standard ensures that CEH lighting systems deliver a higher output of plant-usable light per unit of electricity consumed (Energy Solutions, 2023).

High-efficacy lighting systems, most commonly LED fixtures, consume significantly less energy than legacy lighting such as high-pressure sodium lamps. LEDs also emit less heat, reducing cooling demands and improving environmental control within the growing spaces. Because lighting often represents the largest single source of electrical load in CEH facilities, these improvements help lower energy bills for growers, reduce grid demand during peak hours, and prepare facilities for demand management and grid flexibility programs. With LED and other solid state lighting systems as the technology default, additional savings accrue from the ease of full range dimming as compared to legacy HID (high intensity discharge) sources which were difficult to dim to less than 60% of full power. Section 3 of this report describes a code change proposal for dimming controls, which leverage this capability.

The proposed update to a 2.5  $\mu\text{mol}/\text{J}$  requirement builds upon these earlier efforts and reflects ongoing advancements in lighting technology and market availability. Fixtures meeting or exceeding this threshold can now be widely found at competitive prices, supported by utility incentive programs and recognized in industry standards such as the DLC Horticultural Technical Requirements V4.0 (Agriculture Energy Savings Action Plan, 2025; DesignLights Consortium, 2025)). Aligning California's code with these benchmarks supports the state's long-term strategy for energy efficiency, decarbonization, and reliable grid performance. Findings from ASHRAE 90.1 and feedback from CEH industry stakeholders and lighting manufacturers also inform this proposal.

For details on current regulatory and market practices, see Sections 2.1.4, 2.3.1, and 2.3.2 of this report.

## **2.1.4 Modifications to Energy Code Documents**

This section provides descriptions of how the proposed code change will affect each relevant Energy Code document. See Section 2.6 of this report for detailed revisions to code language.

### **2.1.4.1 Energy Code Change Summary**

**SECTION 100.1 – DEFINITIONS:** The proposed regulations replace the existing definition for Photosynthetic Photon Efficacy (PPE) with a definition for Luminaire Photosynthetic Photon Efficacy. The new definition will specify which wavelengths emitted by a luminaire are included in the PPE calculation. This proposed change enables simplification of the code language in 120.6(h)5 by having a single luminaire PPE requirement rather than separate requirements for integrated luminaires and for luminaires with removable lamps.

#### **SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES**

**Subsection 120.6(h)5:** The proposed regulations update the minimum lamp or luminaire PPE from 2.3  $\mu\text{mol}/\text{J}$  to a luminaire PPE of 2.5  $\mu\text{mol}/\text{J}$  for greenhouses and indoor growing spaces. This requirement cost-effectively increases the stringency of the Energy Code, thereby reducing the energy use of controlled environment horticulture buildings, which in turn improves the state's economic and environmental health. The proposed regulations delete existing language that is extraneous and simplify the Luminaire PPE requirements.

### **2.1.4.2 Reference Appendices Change Summary**

This proposal does not include any changes to the Energy Code Reference Appendices. Horticultural lighting efficacy is not addressed in the Reference Appendices and is not subject to acceptance testing.

### 2.1.4.3 Compliance Manuals Change Summary

Section 10.12.2 of the Nonresidential and Multifamily Compliance Manual, which outlines mandatory requirements for CEH facilities, would be updated to reflect the changes to the mandatory code.

### 2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

This proposal does not include any changes to the Alternative Calculation Method (ACM) Reference Manuals. Horticultural lighting is not currently included in the ACM Reference Manuals. Since the lighting efficacy requirements are mandatory, if the California Energy Commission adopts a performance approach for CEH space conditioning systems, the Standard Design horticultural lighting efficacy would be equal to the proposed horticultural lighting efficacy.

### 2.1.4.5 Compliance Forms Change Summary

This proposal does not require updates to the existing Process System Certificate of Installation (NRCI-PRC-E) form. The Process Systems Certificate of Compliance (NRCC-PRC-E) form will require minor updates to include the revised threshold for PPE.

## 2.1.5 Measure Context

### 2.1.5.1 Comparable Model Codes or Standards

The proposed PPE requirement of 2.5  $\mu\text{mol}/\text{J}$  is consistent with the following state, national, and industry standards currently guiding horticultural lighting practices:

- **ASHRAE/ANSI/IES Standard 90.1:** Addendum bz to Standard 90.1 Section 9.4.4 sets a minimum luminaire PPE requirement of 2.5  $\mu\text{mol}/\text{J}$  for horticultural lighting. (ASHRAE, 2025)
- **DesignLights Consortium Version 4.0:** Sets a PPE threshold of 2.5  $\mu\text{mol}/\text{J}$  for qualified luminaires, forming the basis for many utility rebate and incentive programs across North America. (DesignLights Consortium, 2025)
- **Washington State Energy Code:** The Washington State Building Code is considering an update to a minimum PPE requirement of 2.5  $\mu\text{mol}/\text{J}$  as part of a proposed modification to Section C405.3 for horticultural luminaires used in plant growth and maintenance. (Washington, 2025)

The proposal references the ANSI/ASABE S640 standard, *Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)*, as the industry-accepted test procedure for measuring PPE within the PAR range of 400 to 700 nm (American Society of Agricultural and Biological Engineers, 2022). This reference

ensures that performance data used to demonstrate compliance is based on a consistent and verifiable testing method recognized nationally.

In addition, the proposed PPE requirement shares notable alignment with standards already adopted in Massachusetts and Illinois for licensed cannabis cultivation. In Illinois, the *Cannabis Regulation and Tax Act* requires that lighting power densities not exceed 36 watts per square foot (W/ft<sup>2</sup>) or that all installed fixtures must be listed on the current DLC Horticultural Qualified Products List (QPL), which at the time of this report required a minimum PPE of 2.5 µmol/J (Illinois Compiled Statutes, 2023). In Massachusetts, the regulation under *935 CMR 500.120* establishes two compliance pathways for horticultural lighting in cannabis facilities: (1) a lighting power density limit of 36 W/ft<sup>2</sup> (and up to 50 W/ft<sup>2</sup> for certain tiers), or (2) use of lighting listed on the current DLC Horticultural QPL with PPE at least 15 percent above the current DLC QPL minimum (Massachusetts Code of Regulations, 2023).

### **2.1.5.2 Interactions with Other Regulations**

No federal, state, or local regulatory requirements that conflict with or duplicate the proposed change were identified. This change is limited in scope and does not introduce new equipment mandates or testing procedures and remains consistent with existing safety listing requirements such as UL 8800 for horticultural lighting equipment. Under current California Bureau/Department of Cannabis Control cultivation regulations, artificial lighting is permitted only for supporting plant growth and must comply with general licensing and electricity reporting requirements, but there are no specific state cannabis rules directly prescribing PPE thresholds for horticultural lighting in cultivation licenses at this time.

## **2.2 Lighting Efficacy – Compliance and Enforcement**

### **2.2.1 Compliance Considerations**

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. The proposal would change the threshold of an existing code requirement and limits the additional burden to those responsible for ensuring compliance with the building code to staying apprised of the updates to the new luminaire PPE value, and that PPE is measured on a luminaire basis. In the rare event that compliance is accomplished with a luminaire with removable lamps, all the market actors would need to know that the luminaire Photosynthetic Photon Flux would need to be tested in accordance with ASABE 640 with the lamps installed and this value is divided by the luminaire input Watts to yield luminaire PPE.

**Designers.** Designers would need to be aware that the horticultural lighting efficacy requirement in Section 120.6(h)5 has been increased so they can specify compliant horticultural lighting fixtures.

**Authorities Having Jurisdiction (AHJ) Plan Checkers.** During the permit application phase, AHJ plan checkers would need to review the submitted NRCC-PRC-E form and design documents to confirm that the design includes lighting fixtures meeting the updated requirement.

**Installation contractors.** Installation contractors would be required to install compliant horticultural lighting fixtures, consistent with current practice. When the installation contractor fills in the Certificate of Installation form, they would need to include information on the lighting fixture efficacy, as currently required.

**AHJ Building Inspectors.** The AHJ building inspector would need to verify the installation of compliant lighting fixtures.

The proposed measure does not require field verification or diagnostic testing. Statewide CASE Team review finds that the edited requirement would not conflict with any existing definitions in other parts of Title 24.

The proposed regulations modify the existing definition for PPE to be Luminaire Photosynthetic Photon Efficacy. The new definition will specify which wavelengths emitted by a luminaire are included in the PPE calculation. This proposed change reduces complexity in the code language in 120.6(h)5.

### **2.2.2 Impact on Market Actors**

Table 3 summarizes the 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 3: Impacts on Market Actors and Suggested Training and Education Opportunities**

Market Actor	Impact(s)	Suggested Outreach and Education
<b>Builders<sup>a</sup></b>	Be aware of new requirements and increased costs.	Marginal impact on needed ongoing training to stay current with changes to code.
<b>Design Professionals<sup>b</sup></b>	Be aware of the updated horticultural lighting efficacy requirement and specify horticultural lighting fixtures meeting the updated requirement.	Marginal impact on needed ongoing training to stay current with changes to code.  Update resources such as the <a href="#">Energy Code Ace Fact Sheet on Controlled Environment Horticulture</a> .
<b>Construction Team<sup>c</sup></b>	Install horticultural lighting fixtures meeting the updated requirement. No change to current installation practice.	Marginal impact on needed ongoing training to stay current with changes to code.
<b>Building Departments<sup>d</sup></b>	Plan checker and building inspector currently confirm that the design and installation include lighting fixtures meeting the PPE requirement. This code change would just change the value.  When a luminaire with removable lamps is used, be aware that the luminaire Photosynthetic Photon Flux needs to be tested in accordance with ASABE 640.	Additional outreach and education are needed to ensure building departments are aware of CEH code requirements. Smaller AHJs and those with a higher density of CEH facilities may require more outreach.
<b>Verification Testers<sup>e</sup></b>	No verification testing required.	N/A
<b>Building Owners, Managers, and Occupants</b>	Higher upfront cost and reduced energy bills.	Update Energy Code Ace Fact Sheet on Controlled Environment Horticulture and similar resources offered by other programs.  Additional outreach likely unnecessary.
<b>Manufacturers and Distributors</b>	Need to be aware of which products can no longer be sold in California. Sales of higher PPE fixtures will increase; sales of lower PPE fixtures will decrease.	Changed PPE can be included with outreach on T-24 and T-20 regulatory updates.

- a. Builders include builders and developers
- b. Design professionals include architects, interior designers, engineers (including mechanical, electrical, plumbing, and structural engineers), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
- c. Construction team includes general contractors, 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 sustainability department staff.
- e. Verification 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. The analysis in the methodology report is not specific to the code change presented in this report. 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 likely affect commercial builders; however, it would likely 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 specific subsectors within the industry.

Under the proposed code change, builders must install lighting fixtures meeting the updated horticultural efficacy requirements. No other changes to current practice are anticipated. Table 4 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

**Table 4: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)**

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
<b>Nonresidential Electrical Contractors</b>	3,245	72,794	\$7.8
<b>Other Nonresidential Equipment Contractors</b>	580	9,749	\$1.1
<b>All Other Nonresidential Trade Contractors</b>	948	17,084	\$1.7

- a. Source: (State of California, n.d.)
- b. \*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>

**Manufacturers.** Major manufacturers already offer horticultural luminaires that meet or exceed the proposed 2.5  $\mu\text{mol}/\text{J}$  PPE requirement. The proposed standard is therefore not expected to create compliance challenges but will reinforce California's leadership in high-efficiency horticultural lighting and support continued growth in local clean technology and manufacturing sectors.

For additional information on market impacts and employment considerations, refer to Section 2.3.4.

### **2.2.3 Compliance Software Updates**

Statewide CASE Teams expects no compliance software updates to be required for this measure proposal. Since the lighting efficacy requirements are mandatory, if the California Energy Commission adopts a performance approach for CEH space conditioning systems, the standard design horticultural lighting efficacy would be equal to the proposed horticultural lighting efficacy.

### **2.2.4 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.

Statewide CASE Team expects no additional costs to the state or local governments associated with the enforcement of the proposed measure. The current enforcement framework already accounts for a PPE requirement of 2.3  $\mu\text{mol}/\text{J}$ , and the proposed measure increases this to 2.5  $\mu\text{mol}/\text{J}$ . This incremental adjustment does not require the development of new programs or significant changes to existing enforcement protocols.

Assuming the existing training infrastructure is maintained, this should be sufficient to support the minor change in enforcement. Similarly, given that workforce training is maintained, because the proposed measure does not change installation practices beyond those already covered under current guidelines, new trainings are not required. The Statewide CASE Team recommends supporting updates to existing training to account for the change.

Given that there is turn-over in all sectors of the design, construction and enforcement industries, ongoing training is needed to maintain the high performance of these industries. As such, the state will not incur any additional costs associated with this proposal outside of updating materials describing the new criteria for compliance assurance, enforcement, or training.

## 2.3 Horticultural Lighting Efficacy – Market and Economic Analysis

### 2.3.1 Market Structure and Availability

#### 2.3.1.1 Current Market Structure and Availability

LED technology now dominates horticultural lighting, representing roughly 80 percent of global greenhouse installations and 65 percent of U.S. horticulture LED sales (Mordor Intelligence Research & Advisory, 2025). California’s 2025 Title 24 code already establishes LEDs as the baseline, reflecting their role as the prevailing standard for CEH new construction and alterations statewide.

Major manufacturers, including Acuity (Verjure), California Lightworks, Gavita, Signify (Philips and Fluence), and ThinkGrow, currently offer fixtures meeting or exceeding the proposed 2.5  $\mu\text{mol}/\text{J}$  PPE requirement. As of August 2025, the DesignLights Consortium Qualifying Products List (DLC QPL) includes 785 fixtures meeting the proposed efficacy threshold, with 406 of those fixtures qualifying for PG&E’s Agriculture Energy Savings Action Plan (AESAP) incentive of \$79 per fixture (DesignLights Consortium, 2025; Agriculture Energy Savings Action Plan, 2025). Multiple vendors offer products ensuring competitive supply and flexibility for growers. High-efficacy fixtures are already common, and as adoption expands, economies of scale are expected to reduce costs further.

A December 2025 review of the 1403 luminaires listed in version 4 of the DesignLights Consortium horticultural lighting database with non-zero values for reported minimum input wattage found that 97% of the luminaires are dimmable from 10% to 100% of power.

The proposal aligns with emerging trends toward energy-efficient, low-heat lighting systems that lower both lighting and cooling loads while promoting innovation in fixture design. Based on feedback from the stakeholder meeting, industry already thoroughly understands and widely implements this design strategy, indicating that manufacturers, suppliers, and installers are prepared to comply by the effective date (Hathaway, Controlled Environment Horticulture: Lighting Efficacy September 24 Stakeholder Meeting Slides, 2025).

For broader market impacts and workforce training needs, see Section 2.2.2.

#### 2.3.1.2 Market Challenges and Solutions

During proposal development, the Statewide CASE Team engaged with lighting manufacturers, researchers, and agricultural consultants to identify barriers and design practical solutions. Stakeholder feedback was gathered through targeted interviews,

market surveys, and coordination with industry programs to ensure both technical feasibility and market readiness.

Most manufacturers and large-scale cultivators indicated that fixtures meeting or exceeding 2.5  $\mu\text{mol}/\text{J}$  are widely available and already being adopted in new facilities. However, one consultant reported limited availability of fixtures achieving 2.5  $\mu\text{mol}/\text{J}$  PPE that also maintained a balanced light spectrum, including blue, green, and far-red.

Fixtures with higher red-light ratios are cost-effective and contribute to increased PPE, but may reduce full-spectrum output, potentially impacting crop quality. Prior to publication of the Final CASE Report, the Statewide CASE Team plans to collect spectral data on fixtures both above and below the 2.5  $\mu\text{mol}/\text{J}$  PPE threshold to evaluate acceptable spectrum trade-offs and determine the need for spectrum guidelines. The Statewide CASE Team will also speak with additional stakeholders to determine whether some crops require lighting spectra that cannot be achieved with fixtures at or above 2.5  $\mu\text{mol}/\text{J}$  PPE. If that issue is identified as a true market limitation, the Statewide CASE Team will consider a code exception for proprietary spectral requirements justified by crop-specific needs.

## 2.3.2 Design and Construction Practices

### 2.3.2.1 *Current Design and Construction Practices*

LEDs are the compliance baseline for the 2025 Energy Code because they are the only technology capable of reliably meeting the current 2.3  $\mu\text{mol}/\text{J}$  minimum PPE requirement that was established in the 2025 Title 24, Part 6 Energy Code. The proposed measure does not change this or any other existing requirements for indoor grow spaces and greenhouses with lighting loads greater than 40 kW. The Statewide CASE Team estimates that 70% of the total CEH square footage in California is subject to the proposed code.

Current best practices focus on selecting luminaires that maximize PPE while maintaining desired spectral characteristics. The proposed update to a PPE requirement of 2.5  $\mu\text{mol}/\text{J}$  represents about an eight percent increase in efficiency compared with the current standard. This proposed improvement would move the industry to use higher-performing fixtures without affecting building layout, electrical service capacity, aesthetics, or occupant comfort.

Design approaches remain consistent with current practice, including the following:

- **Fixture layout and spacing** are optimized to achieve uniform light distribution while minimizing shadowing and overlap.
- **Spectral output** is tuned to crop-specific needs, balancing intensity and color ratios for targeted growth outcomes.

- **Controls integration** (e.g., dimming or photo sensors) continues to be a key strategy for aligning light delivery with plant requirements and available daylight.

In short, the measure reinforces established best practices rather than introducing new design challenges or construction requirements.

### **2.3.2.2 Health and Safety Considerations**

The proposed code change does not introduce any new health or safety risks and does not modify existing federal, state, or local safety regulations, including those enforced by the California Division of Occupational Safety and Health (DOSH). All current safety requirements related to electrical systems, lighting installations, and greenhouse operations remain in effect. Since the proposal only updates the minimum PPE requirement for horticultural luminaires, no changes are expected to structural, seismic, fire safety, or indoor environmental quality provisions.

Stakeholders did not raise any health or safety concerns during engagement activities, and the Statewide CASE Team anticipates no adverse impacts for building occupants, operators, or maintenance personnel.

### **2.3.2.3 Design and Construction Challenges and Solutions**

The proposed updates do not introduce new design or installation methods or create conflicts with existing electrical or mechanical codes. Regular fixture maintenance, such as cleaning optical surfaces and verifying dimming calibration, remains sufficient to maintain performance. See Table 3 in Section 2.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

## **2.3.3 Energy Equity and Environmental Justice**

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities,<sup>3</sup> including impacts related to race, class, and gender via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Specific impacts identified to date include the following:

<sup>3</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 socio-economic 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).

- **Cost and Affordability:** While preliminary market assessment findings indicate the incremental cost between the proposed and baseline technologies is small, early stakeholder feedback indicates that initial equipment and installation costs may disproportionately affect small or independent CEH operators serving local markets, particularly in rural or low-income regions.
- **Health and Safety:** Improved lighting efficacy standards may reduce waste heat and improve indoor air quality and worker comfort, providing long-term health and safety benefits.

**Economic Participation:** Over time, energy savings can improve the financial viability of operations, creating more sustainable employment opportunities in ESJ communities engaged in agriculture and indoor production.

Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Any stakeholders with input on how this proposal may impact ESJ communities or who would like to offer their perspective should reach out to Lydia Miner ([lminer@westmonroe.com](mailto:lminer@westmonroe.com)).

### 2.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

### 2.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report

## 2.4 Horticultural Lighting Efficacy - Cost Effectiveness

### 2.4.1 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. The CEC develops and publishes LSC hourly conversion factors for the 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.

## 2.4.2 Energy and Energy Cost Savings Results

The Statewide CASE Team completed an energy savings analysis using prototypical indoor and greenhouse facilities representative of CEH operations across California. To model energy savings, the Statewide CASE Team used custom spreadsheet-based simulation tools tailored to CEH applications. The analysis did not use the California Building Energy Code Compliance Software (CBECC) software because it does not currently support space types or systems unique to CEH buildings and operations.

Prototypes were adapted from those used in the 2025 CEH CASE Report and reflect industry-standard geometry, crop mix, and operational characteristics (Energy Solutions, 2023). The Statewide CASE Team simulated cannabis, tomatoes, and leafy greens as representative crops in both indoor and greenhouse prototypes. Microgreens and herbs are represented by leafy greens, and vine crops and flowering crops are represented by tomatoes due to similar light and temperature requirements. Table 5 summarizes the prototype buildings used to evaluate energy, demand, cost, and environmental impacts.

**Table 5: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis**

Prototype	Crop Type
Indoor (Warehouse)	Cannabis (83% flowering, 15% vegetative, 2% clone breakdown by canopy area)
Indoor (Warehouse)	Leafy greens
Indoor (Warehouse)	Tomatoes
Greenhouse	Cannabis (65% flowering, 33% vegetative, 2% clone breakdown by canopy area)
Greenhouse	Leafy greens
Greenhouse	Tomatoes

The analysis simulated energy use for each prototype on an hourly basis to capture lighting power, as well as cooling and interactive effects for indoor prototypes. In greenhouses, variations in daylight throughout the year impacted the amount of light used and were analyzed by climate zone. Interactive cooling energy impacts were

modeled for indoor CEH facilities, where reduced lighting heat output from LEDs decreased the cooling loads. Greenhouse simulations assumed venting as the primary cooling mechanism excluded interactive effects. The proposed model was identical to the baseline model except for lighting efficacy changes reflecting the proposed code update.

This analysis uses the assumptions from the 2025 CEH CASE Report unless otherwise noted (Energy Solutions, 2023). Table 6 highlights key assumptions for indoor growing and Table 7 does the same for greenhouse growing. The assumptions will be updated as new inputs are provided via ongoing stakeholder outreach to industry groups, academic researchers, luminaire manufacturers, agricultural lighting consultants, and CEH owners/operators. Stakeholders will be asked to review the proposed savings methodology, key assumptions, and analytical framework.

**Table 6: Indoor CEH Lighting Assumptions**

<b>Parameter</b>	<b>Cannabis - Flower</b>	<b>Cannabis - Vegetative</b>	<b>Cannabis - Clone</b>	<b>Leafy Greens</b>	<b>Tomatoes</b>
<b>Canopy Area per Luminaire (ft<sup>2</sup>)</b>	20	24	10	58	56
<b>Photoperiod (hours/day)</b>	12	18	24	18	12
<b>PPFD (μmol/m<sup>2</sup>/s)</b>	1,000	600	200	200	350
<b>Baseline PPE (μmol/J)</b>	2.3	2.3	2.3	2.3	2.3
<b>Proposed PPE (μmol/J)</b>	2.5	2.5	2.5	2.5	2.5

**Table 7: Greenhouse CEH Lighting Assumptions**

<b>Parameter</b>	<b>Cannabis - Flower</b>	<b>Cannabis - Vegetative</b>	<b>Cannabis - Clone</b>	<b>Leafy Greens</b>	<b>Tomatoes</b>
<b>Canopy Area per Luminaire (ft<sup>2</sup>)</b>	20	24	10	58	56
<b>Photoperiod (hours/day)</b>	12	18	24	18	12
<b>PPFD (μMol/m<sup>2</sup>/s)</b>	600	400	200	200	350
<b>Baseline PPE (μmol/J)</b>	2.3	2.3	2.3	2.3	2.3
<b>Proposed PPE (μmol/J)</b>	2.5	2.5	2.5	2.5	2.5

The Statewide CASE Team identified a technical challenge in accurately modeling lighting control practices in horticultural environments. Facilities commonly utilize dimming to manage plant stress and optimize crop traits by adjusting photosynthetic photon flux density (PPFD) throughout growth cycles, such as during vegetative and flowering stages for cannabis or for leafy greens like lettuce. However, the current energy model assumes static PPFD levels. To resolve this discrepancy, the Statewide CASE Team plans to document real-world dimming strategies through stakeholder outreach and adjust energy and cost models to simulate realistic dimming strategies and maximum PPFD levels for the Final CASE Report.

For each crop and prototype type, analysis calculated lighting energy use based on canopy area per luminaire, photoperiod, required PPFD, and PPE (either baseline or proposed). Baseline PPE values reflect the minimum efficiency required by the 2025 Energy Code, while proposed PPE values reflect the proposed 2028 Energy Code updates presented in this report. More details on the methodology for calculating energy savings from the proposed code change are in Appendix A.

Energy savings and peak demand reductions per unit are presented in Table 8 through Table 12. Per-unit savings for the first year are expected to range from 0.23 to 16.26 kilowatt-hours per year (kWh/yr) per canopy square foot (ft<sup>2</sup>), depending upon climate zone, facility type, and crop type, and no natural gas savings are expected. Demand reductions are expected to range between 0.00005kW and 0.001 kW/ft<sup>2</sup>, depending on climate zone, facility type, and crop type. The per-unit energy savings do not vary between new construction and additions/alterations.

Energy and energy cost savings results will be updated after the model is updated with new assumptions to incorporate stakeholder feedback, as described above.

The savings from this measure are expected to persist over the 30-year analysis period, assuming equipment is maintained and replaced at equivalent efficacy levels. See Section 2.4.4.1 for more information on expected useful life and replacement frequency.

**Table 8: First Year Electricity Savings (kWh) Per Canopy Square Foot by Climate Zone (CZ) – Lighting Efficacy**

<b>Prototype</b>	<b>CZ 1</b>	<b>CZ 2</b>	<b>CZ 3</b>	<b>CZ 4</b>	<b>CZ 5</b>	<b>CZ 6</b>	<b>CZ 7</b>	<b>CZ 8</b>	<b>CZ 9</b>	<b>CZ 10</b>	<b>CZ 11</b>	<b>CZ 12</b>	<b>CZ 13</b>	<b>CZ 14</b>	<b>CZ 15</b>	<b>CZ 16</b>
<b>Indoor (Warehouse) Cannabis</b>	15.41	15.62	15.57	15.75	15.62	15.71	15.75	15.86	15.86	15.91	15.81	15.74	15.88	15.87	16.26	15.43
<b>Indoor (Warehouse) Leafy Greens</b>	4.75	4.80	4.80	4.84	4.80	4.84	4.85	4.88	4.88	4.89	4.86	4.84	4.89	4.87	5.00	4.75
<b>Indoor (Warehouse) Tomatoes</b>	5.55	5.63	5.61	5.68	5.63	5.66	5.67	5.72	5.72	5.73	5.70	5.67	5.72	5.72	5.86	5.56
<b>Greenhouse Cannabis</b>	3.52	2.80	2.65	2.17	2.15	2.06	2.12	2.10	2.03	1.99	2.89	2.64	2.32	1.86	1.81	2.83
<b>Greenhouse Leafy Greens</b>	0.97	0.72	0.66	0.42	0.37	0.30	0.28	0.31	0.31	0.30	0.81	0.66	0.52	0.25	0.23	0.74
<b>Greenhouse Tomatoes</b>	1.31	0.99	0.92	0.63	0.58	0.49	0.47	0.50	0.50	0.48	1.08	0.92	0.74	0.41	0.38	1.01

**Table 9: First Year Peak Demand Reduction (kW) Per Canopy Square Foot by CZ – Lighting Efficacy**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Indoor (Warehouse) Cannabis	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Indoor (Warehouse) Leafy Greens	0.00047	0.00047	0.00047	0.00048	0.00047	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00049	0.00047
Indoor (Warehouse) Tomatoes	0.00040	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00041	0.00042	0.00040
Greenhouse Cannabis	0.00038	0.00034	0.00032	0.00031	0.00030	0.00030	0.00030	0.00030	0.00030	0.00029	0.00037	0.00033	0.00033	0.00030	0.00028	0.00035
Greenhouse Leafy Greens	0.00014	0.00010	0.00009	0.00007	0.000061	0.000057	0.000047	0.000057	0.00006	0.00005	0.00012	0.00010	0.00009	0.000058	0.000045	0.00011
Greenhouse Tomatoes	0.00015	0.00011	0.00010	0.00009	0.00008	0.00008	0.000068	0.00007	0.00007	0.00007	0.00013	0.00011	0.00011	0.00007	0.00007	0.00012

**Table 10: First Year Natural Gas Savings (kBtu) Per Canopy Square Foot by CZ – Lighting Efficacy**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
<b>Indoor (Warehouse) Cannabis</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
<b>Indoor (Warehouse) Leafy Greens</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
<b>Indoor (Warehouse) Tomatoes</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
<b>Greenhouse Cannabis</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
<b>Greenhouse Leafy Greens</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
<b>Greenhouse Tomatoes</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A									

**Table 11: First Year Source Energy Savings (kBtu) Per Canopy Square Foot by CZ– Lighting Efficacy**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
<b>Indoor (Warehouse) Cannabis</b>	14.29	14.35	14.40	14.41	14.41	14.53	14.57	14.58	14.56	14.57	14.46	14.43	14.53	14.43	14.75	14.22
<b>Indoor (Warehouse) Leafy Greens</b>	14.29	14.35	14.40	14.41	14.41	14.53	14.57	14.58	14.56	14.57	14.46	14.43	14.53	14.43	14.75	14.22
<b>Indoor (Warehouse) Tomatoes</b>	4.67	4.69	4.70	4.71	4.71	4.74	4.76	4.76	4.75	4.76	4.72	4.71	4.74	4.71	4.81	4.64
<b>Greenhouse Cannabis</b>	5.50	4.92	4.78	4.26	4.15	4.00	3.94	4.02	4.00	4.03	5.01	4.74	4.56	3.93	3.87	4.72
<b>Greenhouse Leafy Greens</b>	2.27	1.86	1.73	1.25	1.10	0.98	0.86	0.98	0.98	1.01	2.00	1.73	1.58	0.91	0.85	1.69
<b>Greenhouse Tomatoes</b>	2.11	1.83	1.75	1.38	1.28	1.18	1.08	1.18	1.17	1.20	1.90	1.73	1.64	1.11	1.07	1.67

**Table 12: Total 30-Year LSC Savings (2029 Present Value \$) Per Canopy Square Foot by CZ – Lighting Efficacy**

<b>Prototype</b>	<b>CZ 1</b>	<b>CZ 2</b>	<b>CZ 3</b>	<b>CZ 4</b>	<b>CZ 5</b>	<b>CZ 6</b>	<b>CZ 7</b>	<b>CZ 8</b>	<b>CZ 9</b>	<b>CZ 10</b>	<b>CZ 11</b>	<b>CZ 12</b>	<b>CZ 13</b>	<b>CZ 14</b>	<b>CZ 15</b>	<b>CZ 16</b>
<b>Indoor (Warehouse) Cannabis</b>	\$111.50	\$111.77	\$111.58	\$111.74	\$112.24	\$112.24	\$111.36	\$110.68	\$113.55	\$111.29	\$111.34	\$112.57	\$111.89	\$109.09	\$116.09	\$108.64
<b>Indoor (Warehouse) Leafy Greens</b>	\$39.28	\$39.70	\$39.61	\$40.01	\$39.70	\$39.97	\$40.04	\$40.86	\$40.91	\$40.97	\$40.28	\$40.06	\$40.50	\$40.66	\$41.19	\$39.91
<b>Indoor (Warehouse) Tomatoes</b>	\$39.15	\$39.18	\$39.11	\$39.10	\$39.38	\$38.95	\$38.93	\$38.49	\$39.70	\$38.72	\$38.88	\$39.44	\$39.07	\$37.86	\$40.70	\$37.82
<b>Greenhouse Cannabis</b>	\$29.20	\$23.66	\$23.04	\$18.44	\$18.20	\$17.80	\$17.67	\$17.04	\$16.58	\$16.47	\$23.41	\$21.45	\$19.38	\$15.62	\$15.65	\$21.91
<b>Greenhouse Leafy Greens</b>	\$9.11	\$6.95	\$6.67	\$4.04	\$3.50	\$3.07	\$2.67	\$2.89	\$2.89	\$2.83	\$7.27	\$5.99	\$4.91	\$2.45	\$2.28	\$6.23
<b>Greenhouse Tomatoes</b>	\$11.08	\$8.53	\$8.14	\$5.51	\$5.02	\$4.46	\$4.11	\$4.24	\$4.23	\$4.15	\$8.74	\$7.54	\$6.33	\$3.70	\$3.55	\$7.80

### 2.4.3 Incremental First Cost

The baseline for this analysis reflects lighting systems meeting the 2025 Title 24, Part 6 CEH lighting efficacy requirements of 2.3  $\mu\text{mol}/\text{J}$ . The proposed measure increases the minimum PPE requirement to 2.5  $\mu\text{mol}/\text{J}$ , applicable to both new construction and alterations of greenhouse and indoor grow facilities with a horticultural lighting load of at least 40 kW.

In practice, alteration projects may realize larger total savings when they replace legacy high-pressure sodium systems with LED lighting. However, this analysis isolates only the incremental savings associated with increasing the efficacy requirement from 2.3  $\mu\text{mol}/\text{J}$  to 2.5  $\mu\text{mol}/\text{J}$ . Savings attributable to the prior transition from HPS systems to the 2.3  $\mu\text{mol}/\text{J}$  baseline were established in previous code cycle analyses and are therefore not included here.

First cost estimates were collected from online vendors from November 2025 through December 2025. All costs will reflect pricing available during that time. Incremental first cost is defined as the difference between the proposed and baseline systems and includes:

- **Baseline Equipment costs:** Fixture cost at 2.3  $\mu\text{mol}/\text{J}$  PPE rating (\$/fixture)
- **Proposed Equipment costs:** Fixture cost at 2.5  $\mu\text{mol}/\text{J}$  PPE rating (\$/fixture)

The analysis evaluates incremental first costs by prototype, as fixture wattage varies by crop type and incremental costs vary by wattage class. The Statewide CASE Team analyzed cost data for 37 horticultural LED fixtures across power the following power ranges:

- 200–330 W (cannabis clones)
- 345–465 W (leafy greens)
- 600–1050 W (cannabis veg/flower and tomatoes)

Fixture costs were normalized to dollars per 1,000  $\mu\text{mol}/\text{s}$ . First cost per canopy square foot was computed as target PPFD multiplied by the normalized cost. The Statewide CASE Team does not anticipate differences in installation time per fixture or maintenance costs between baseline and proposed equipment. The Statewide CASE Team does not anticipate first cost differences between new construction and alterations.

For indoor cannabis, costs were weighted based on the canopy area assumption of 83 percent flower, 15 percent vegetative, and 2 percent clone. For greenhouse cannabis, costs were weighted based on the canopy area assumption of 65 percent flower, 33 percent vegetative, and 2 percent clone.

The Statewide CASE Team will refine these assumptions based on ongoing stakeholder feedback and market data for the Final CASE Report, where incremental first costs will be derived from LED horticultural luminaires meeting the proposed 2.5  $\mu\text{mol}/\text{J}$  PPE threshold compared with baseline luminaires meeting the existing 2.3  $\mu\text{mol}/\text{J}$  PPE requirement. Current assumptions of equipment first costs and incremental costs per square foot of canopy are presented in Table 13.

**Table 13: Equipment First Cost Per Canopy Square Foot– Lighting Efficacy**

Building Type	Crop Type	Measure Case Equipment First Cost (Dollar per Canopy Square Foot)	Incremental Equipment First Cost (Dollar per Canopy Square Foot)
Indoor (Warehouse)	Cannabis	\$38.92	\$1.23
	Leafy Greens	\$11.27	\$0.00
	Tomatoes	\$14.72	\$0.47
Greenhouse	Cannabis	\$22.17	\$0.70
	Leafy Greens	\$11.27	\$0.00
	Tomatoes	\$14.72	\$0.47

#### 2.4.4 Incremental Maintenance and Replacement Costs

The proposed lighting efficacy measure for CEH facilities is expected to have long-term persistence of energy savings due to the durability and low-maintenance nature of modern LED luminaires.

Based on manufacturer reported rated life data to the DLC as of December 2025, the Statewide CASE Team assumed that LED luminaires achieving 2.5  $\mu\text{mol}/\text{J}$  PPE used in CEH applications have a rated life of 58,945 hours, while those achieving a 2.3  $\mu\text{mol}/\text{J}$  PPE have a rated life of 55,826 hours. This increase in rated life at higher PPE levels is likely attributable to newer, more efficient LED architectures and improved thermal management, which reduce operating stress and improved lifetime (U.S. Department of Energy). The actual estimated useful life (EUL) in years varies by crop type due to differences in annual lighting run hours associated with crop photoperiod and production cycles. The Statewide CASE Team assumed that the facilities are operational 95 percent of the year and non-operational for the remaining five percent of the year to allow for periodic downtime associated with crop turnover, sanitation and cleaning, and maintenance of environmental and mechanical systems. This assumption is-round production system enabled by continuous environmental control consistent with published descriptions Table 14.

**Table 14: Estimated Useful Life by Crop Type**

Parameter	Cannabis – Flower	Cannabis – Vegetative	Cannabis – Clone	Leafy Greens	Tomatoes
<b>Photoperiod (hours/day)</b>	12	18	24	18	12
<b>Annual Operating Hours</b>	4,161	6,242	8,322	6,242	4,161
<b>EUL (years) Baseline</b>	Indoor = 12 Greenhouse = 11			8	13
<b>EUL (years) Measure Case</b>	Indoor = 12 Greenhouse = 12			9	14

Cannabis cultivation typically includes three distinct growth phases—flowering, vegetative, and cloning—each with its own photoperiod. Weighted by the share of annual production time in each phase (83 percent flower, 15 percent vegetative, and 2 percent clone), cannabis operations average roughly 4,556 annual lighting hours, resulting in an EUL of about 12 years. For greenhouse cultivation, weighted by the share of annual production time in each phase (65 percent flower, 33 percent vegetative, and 2 percent clone), cannabis operations average approximately 4,931 annual lighting hours. Other CEH crops also differ by photoperiod intensity and production duration: leafy greens operate under longer daily lighting hours resulting in an EUL of eight to nine years, while tomatoes typically use shorter photoperiods aligned with natural daylight cycles resulting in an EUL of 13 to 14 years. See Table 14 for crop specific details. Note that there are no lamp replacements associated with horticultural LED luminaires. In previous code cycles, when non-LED fixtures were the baseline, annual lamp replacements were included in the incremental maintenance costs.

The Statewide CASE Team plans to collect additional input from stakeholders on fixture EUL for the Final Report. The residual value of the LED horticulture fixture is zero at the end of the 30-year period analysis.

Routine maintenance for LED luminaires includes periodic cleaning of optical lenses and heat sinks, typically performed every six to twelve months, consistent with standard facility maintenance schedules. The routine maintenance requirements and costs remain unchanged between the baseline and proposed cases and thus there is no incremental maintenance cost.

Energy savings from this measure are expected to persist throughout the analysis period, provided that luminaires are properly maintained and replaced with equipment meeting or exceeding the minimum efficacy requirements. Because LED performance

degrades slowly over time, light output and efficacy are expected to remain stable throughout their service life.

Incremental maintenance and replacement cost assumptions will be vetted through stakeholder engagement with lighting manufacturers, agricultural energy consultants, and CEH facility operators.

## 2.4.5 Cost Effectiveness

The cost-effectiveness analysis evaluates incremental first costs, maintenance costs, and replacement costs relative to the current 2025 Title 24, Part 6 baseline of a 2.3  $\mu\text{mol}/\text{J}$  PPE for both luminaires and lamps and quantifies the present value (PV) of benefits over a 30-year analysis period using a three percent real discount rate. All values are expressed in 2029 present value dollars (2029 PV \$) to align with the expected code implementation year.

Incremental maintenance costs were estimated using fixture lifetime and replacement assumptions described in the Incremental Maintenance and Replacement Costs section. The analysis assumes that the luminaires maintain rated performance for 55,826 hours in the baseline case (PPE < 2.5) and 58,945 hours in the measure case (PPE  $\geq$  2.5). Based on these lifetimes, the resulting EULs are 12 years for cannabis; eight years (baseline) and nine years (measure) for leafy greens; and 13 years (baseline) and 14 years (measure) for tomatoes.

As an example, indoor cannabis has a 12-year EUL. This means that over the 30 year period of analysis, there are two replacements at 13 years and 25 years, so in addition to the initial incremental cost of \$1.23/canopy square foot, and additional discounted incremental costs of \$1.23/canopy square foot  $\times (1/1.03)^{13}$  for the 10<sup>th</sup> year replacement and \$1.23/canopy square foot  $\times (1/1.03)^{25}$  for the 20<sup>th</sup> year replacement equaling a total incremental cost with a net present value of \$2.66.

Energy and cost savings were modeled using prototype greenhouse and indoor grow facilities that represent typical CEH applications, as described in Section 2.4.2. Each prototype incorporates representative operating schedules, lighting densities, and control strategies. Savings were calculated as the difference in site energy use and annualized energy cost between the baseline and proposed efficacy levels, applied across all California climate zones.

Current market research indicates that LED manufacturers producing luminaires for leafy green applications do not offer products with PPE below 2.5  $\mu\text{mol}/\text{J}$ . Because compliant products represent standard market practice and no lower-efficacy baseline products are available, there is no incremental cost associated with the proposed requirement. As a result, the benefit-cost ratio is mathematically undefined (i.e., infinite), reflecting that the measure delivers energy benefits without additional cost.

Results of the per-unit cost-effectiveness analyses are presented in Table 15 and Table 16 for new construction/additions and alterations, respectively. Results of the per-unit cost-effectiveness analysis for each climate zone and each building prototype are presented in Appendix A.

**Table 15: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Climate Zones 1-16**

<b>Prototype</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit- Cost Ratio</b>
<b>Indoor (Warehouse) Cannabis</b>	\$111.81	\$2.66	42
<b>Indoor (Warehouse) Leafy Greens</b>	\$40.12	\$0.00	Not Applicable
<b>Indoor (Warehouse) Tomatoes</b>	\$39.11	\$0.50	77
<b>Greenhouse Cannabis</b>	\$20.55	\$0.77	27
<b>Greenhouse Leafy Greens</b>	\$5.17	\$0.00	Not Applicable
<b>Greenhouse Tomatoes</b>	\$6.64	\$0.50	13

**Table 16: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot - Alterations - Climate Zones 1-16**

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-Cost Ratio
Indoor (Warehouse) Cannabis	\$111.84	\$2.66	42
Indoor (Warehouse) Leafy Greens	\$40.16	\$0.00	Not Applicable
Indoor (Warehouse) Tomatoes	\$39.12	\$0.50	77
Greenhouse Cannabis	\$19.24	\$0.77	25
Greenhouse Leafy Greens	\$4.34	\$0.00	Not Applicable
Greenhouse Tomatoes	\$5.79	\$0.50	11

## 2.5 Horticultural Lighting Efficacy - Statewide Impacts

### 2.5.1 Statewide Energy and Energy Cost Savings

Statewide savings for both new construction and alterations were estimated using a bottom-up approach consistent with the 2028 CASE Methodology Report. The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts provided by the CEC. These forecasts estimate new construction and additions anticipated to occur in 2029, the first year the 2028 Title 24, Part 6 requirements take effect, as well as the total existing building stock forecasted in 2029, which was used to approximate savings from building alterations. See the 2028 CASE Methodology Report for 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 based on construction rates and what fraction of newly installed horticultural lighting that is less efficacious than a PPE of 2.5  $\mu\text{mol}/\text{J}$ .

Table 17 presents statewide energy and LSC savings for new construction by prototype with values summed across all climate zones.

Table 18 presents statewide energy and LSC savings for new construction by climate zone, with values summed across all prototypes. Table 19 presents statewide energy and LSC savings for alterations by prototype with values summed across all climate

zones. Table 20 presents statewide energy and LSC savings for alterations by climate zone, with values summed across all prototypes. In Appendix C, the detailed statewide energy savings (GWh/yr) and statewide lifecycle energy savings (Present Valued Dollars) are segmented by climate zone. Total first year savings are shown in Table 21 by new construction vs. alterations and in Table 22 by prototype.

Table 17: Statewide Energy and LSC Impacts – New Construction and Additions – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
Indoor (Warehouse) Cannabis	0.114	1.79	136.35	N/A	1.65	\$12.75
Indoor (Warehouse) Leafy Greens	0.006	0.03	2.99	N/A	0.042	\$0.25
Indoor (Warehouse) Tomatoes	0.004	0.02	1.53	N/A	0.018	\$0.15
Greenhouse Cannabis	0.114	0.28	37.10	N/A	0.52	\$2.35
Greenhouse Leafy Greens	0.114	0.06	9.45	N/A	0.17	\$0.59
Greenhouse Tomatoes	0.152	0.12	14.80	N/A	0.24	\$1.01
<b>Total</b>	<b>0.505</b>	<b>2.31</b>	<b>202.22</b>	<b>N/A</b>	<b>2.63</b>	<b>\$17.10</b>

**Table 18: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) and Greenhouse – Cannabis, Leafy Greens, and Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0225	0.112	9.78	N/A	0.129	\$0.85
2	0.0188	0.089	7.73	N/A	0.102	\$0.67
3	0.0777	0.361	31.03	N/A	0.417	\$2.73
4	0.0097	0.043	3.81	N/A	0.049	\$0.32
5	0.0491	0.215	18.92	N/A	0.243	\$1.60
6	0.0626	0.271	23.90	N/A	0.306	\$2.00
7	0.0004	0.002	0.13	N/A	0.002	\$0.01
8	0.0057	0.025	2.18	N/A	0.028	\$0.18
9	0.0063	0.028	2.42	N/A	0.031	\$0.20
10	0.0675	0.294	25.67	N/A	0.332	\$2.13
11	0.0735	0.356	31.53	N/A	0.408	\$2.61
12	0.0742	0.347	30.27	N/A	0.398	\$2.57
13	0.0219	0.100	8.97	N/A	0.116	\$0.73
14	0.0026	0.011	1.00	N/A	0.013	\$0.08
15	0.0116	0.051	4.41	N/A	0.056	\$0.37
16	0.0011	0.005	0.47	N/A	0.006	\$0.04
<b>Total</b>	<b>0.5052</b>	<b>2.308</b>	<b>202.22</b>	<b>N/A</b>	<b>2.634</b>	<b>\$17.10</b>

Table 19: Statewide Energy and LSC Impacts – Alterations – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
Indoor (Warehouse) Cannabis	0.286	4.51	342.54	N/A	4.15	\$32.02
Indoor (Warehouse) Leafy Greens	0.022	0.10	10.34	N/A	0.147	\$0.87
Indoor (Warehouse) Tomatoes	0.008	0.05	3.26	N/A	0.038	\$0.31
Greenhouse Cannabis	0.263	0.60	83.03	N/A	1.14	\$5.06
Greenhouse Leafy Greens	0.395	0.18	29.38	N/A	0.52	\$1.71
Greenhouse Tomatoes	0.324	0.22	29.39	N/A	0.46	\$1.87
<b>Total</b>	<b>1.298</b>	<b>5.66</b>	<b>497.94</b>	<b>N/A</b>	<b>6.46</b>	<b>\$41.85</b>

**Table 20: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) and Greenhouse – Cannabis, Leafy Greens, and Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.02	0.11	9.56	N/A	0.13	\$0.83
2	0.01	0.07	5.91	N/A	0.08	\$0.51
3	0.08	0.38	32.89	N/A	0.44	\$2.90
4	0.03	0.15	13.23	N/A	0.17	\$1.10
5	0.20	0.87	76.39	N/A	0.98	\$6.47
6	0.27	1.12	98.84	N/A	1.27	\$8.30
7	0.03	0.15	12.68	N/A	0.16	\$1.07
8	0.02	0.10	8.89	N/A	0.11	\$0.74
9	0.05	0.22	19.15	N/A	0.25	\$1.61
10	0.12	0.49	42.99	N/A	0.56	\$3.58
11	0.08	0.38	33.89	N/A	0.44	\$2.81
12	0.15	0.67	58.18	N/A	0.77	\$4.94
13	0.17	0.77	69.06	N/A	0.89	\$5.64
14	0.02	0.06	5.57	N/A	0.07	\$0.45
15	0.02	0.09	7.63	N/A	0.10	\$0.65
16	0.01	0.03	3.06	N/A	0.04	\$0.25
<b>Total</b>	<b>1.30</b>	<b>5.66</b>	<b>497.94</b>	<b>N/A</b>	<b>6.46</b>	<b>\$41.85</b>

**Table 21: Total First-Year Energy Savings**

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
<b>New Construction &amp; Additions</b>	2.31	0.20	N/A	2.63	\$17.10
<b>Alterations</b>	5.66	0.50	N/A	6.46	\$41.85
<b>Total</b>	<b>7.97</b>	<b>0.70</b>	<b>N/A</b>	<b>9.09</b>	<b>\$58.95</b>

**Table 22: Total First-Year Energy Savings By Crop Type**

Crop Type	Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
<b>Cannabis</b>	New Construction & Additions	2.07	0.17	N/A	2.17	\$15.10
	Alterations	5.11	0.43	N/A	5.29	\$37.08
<b>Greens</b>	New Construction & Additions	0.09	0.01	N/A	0.21	\$0.84
	Alterations	0.29	0.04	N/A	0.67	\$2.58
<b>Tomatoes</b>	New Construction & Additions	0.140	0.02	N/A	0.25	\$1.16
	Alterations	0.263	0.03	N/A	0.50	\$2.19
<b>All</b>	<b>Total</b>	<b>7.97</b>	<b>0.70</b>	<b>N/A</b>	<b>9.09</b>	<b>\$58.95</b>

## 2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 23 presents the estimated first-year reduction in greenhouse gas (GHG) emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 481 metric tons of carbon dioxide equivalent (CO<sub>2</sub>e) emissions. These reductions, along with their associated monetary value, were calculated using hourly 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.

**Table 23: First-Year Statewide GHG Emissions Impacts**

Facility Type	Crop Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO <sub>2</sub> e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO <sub>2</sub> e)	Total Reduced GHG Emissions (Metric Ton CO <sub>2</sub> e)	Total Monetary Value of Reduced GHG Emissions (\$)
Indoor (Warehouse)	Cannabis	307	N/A	307	\$37,770
	Leafy Greens	10	N/A	10	\$1,234
	Tomatoes	3	N/A	3	\$362
Greenhouse	Cannabis	88	N/A	88	\$10,817
	Leafy Greens	36	N/A	36	\$4,489
	Tomatoes	37	N/A	37	\$4,555
<b>TOTAL</b>	<b>All</b>	<b>481</b>	<b>N/A</b>	<b>481</b>	<b>\$59,227</b>

## 2.5.3 Statewide Water Use Impacts

The proposed code change will not cause water use impacts.

## 2.5.4 Statewide Material Impacts

Since the proposal increases the minimum PPE requirement from 2.3 μmol/J to 2.5 μmol/J and does not involve a change in lamp type or introduce new equipment or testing requirements, the Statewide CASE Team found no additional material analysis necessary.

## 2.5.5 Environmental Impacts

Increasing the required lighting efficacy for horticultural lighting will reduce the total amount of energy that CEH facilities consume, resulting in direct environmental benefits, including reduced GHG emissions due to the reduced need to generate

electricity. The Statewide CASE Team has not identified any indirect environmental benefits or any direct or indirect adverse environmental impacts. The Statewide CASE Team also did not identify any other reasonable alternatives that would achieve the same goal of reducing the energy consumption of CEH lighting.

### **2.5.6 Other Non-Energy Impacts**

In addition to energy-related benefits, the proposed code change is expected to result in several non-energy impacts that may be relevant to the California Environmental Quality Act (CEQA) analysis. Improved lighting efficacy standards may reduce waste heat, contributing to better worker comfort and long-term health and safety outcomes in CEH facilities. Additionally, improvements in indoor environmental quality may positively influence worker productivity and comfort.

Lower energy demand may enhance grid reliability and resilience, particularly in underserved or rural areas.

While initial equipment and installation costs may disproportionately affect small or independent CEH operators serving local markets, especially in low-income regions, long-term energy savings can improve operational sustainability and economic participation. These savings may support more stable employment opportunities and increase financial viability in ESJ communities engaged in agriculture and indoor production.

No additional impacts beyond those identified have been found that would require further consideration under CEQA at this time, though the Statewide CASE Team acknowledges that the list of impacts may evolve with continued stakeholder engagement.

## **2.6 Horticultural Lighting Efficacy - Proposed Code Language**

### **2.6.1 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 should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

### **2.6.2 Administrative Code (Title 24, Part 1)**

There are no proposed changes to Title 24, Part 1.

### **2.6.3 Energy Code (Title 24, Part 6)**

100.1 Definitions

**LUMINAIRE PHOTOSYNTHETIC PHOTON EFFICACY (PPE)** is photosynthetic photon flux emitted by a luminaire between 400 and 700 nm divided by input electric power in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640. Luminaire is inclusive of both integrated and luminaires with removable, serviceable lamps.

120.6 (h) Mandatory requirements for Controlled Environment Horticulture (CEH) spaces.

...

**120.6(h)5. Horticultural lighting.** ~~In a building with CEH spaces or a greenhouse with more than~~ Where more than 40 kW of aggregate horticultural lighting load is installed to serve indoor growing spaces or greenhouse spaces, the electric lighting system used for plant growth and plant maintenance shall meet the following requirements:

**A. Luminaire PPE and Dimmability.** Horticultural lighting shall have a luminaire photosynthetic photon efficacy (PPE) of at least 2.5  $\mu\text{mol}/\text{J}$  when tested at the manufacturer-designed state with the highest power consumption. Horticultural lighting shall be capable of continuous dimming between 100% and 10% of full power in response to a line voltage, low voltage, or wireless signal.

~~A. The horticultural lighting systems shall have a photosynthetic photon efficacy (PPE) rated in accordance with ANSI/ASABE S640 for wavelengths from 400 to 700 nanometers and meet one of the following requirements:~~

~~i. Integrated, non-serviceable luminaires shall have a rated PPE of at least 2.3 micromoles per joule; or~~

~~ii. Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 2.3 micromoles per joule.~~

There are no changes proposed to Title 24 Part 6, section 141.1(c). The section is shown for reference.

**141.1(c) Controlled Environment Horticulture Spaces.**

...

3. Indoor Growing and Greenhouses, Horticultural Lighting. When alterations to horticultural lighting systems increase lighting wattage or include adding, replacing, or altering 10 percent or more of the horticultural luminaires serving an enclosed space, the newly installed, replaced, or altered lighting shall meet the requirements of Section 120.6(h)5.

EXCEPTION to Section 141.1(c)3: Any alteration limited to adding lighting controls or replacing lamps, ballasts, or drivers.

#### **2.6.4 Reference Appendices**

Review does not find necessary any changes to the Reference Appendices.

#### **2.6.5 Compliance Manuals**

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

#### **2.6.6 ACM Reference Manual**

Review does not find necessary any changes to the ACM Reference Manual.

#### **2.6.7 Compliance Forms**

As described in Section 2.1.4.5, a minor update is required to the NRCC-PRC-E covered process certificate of compliance form, and no updates are required to the NRCI-PRC-E covered process certificate of installation form to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

## 3. Daylight Responsive Controls for Greenhouses

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### 3.1 Daylight Responsive Controls for Greenhouses - Measure Description

#### 3.1.1 Proposed Code Change

The proposed code change would introduce a new mandatory daylight responsive control requirement for greenhouses with supplemental electric lighting. The requirement would apply to greenhouse facilities with more than 40 kW of connected horticultural lighting load and would provide two compliance options:

- **Option 1: Timeclock + PAR Sensor-Based Control**  
Combines a scheduling device with dimming control in response to instantaneous Photosynthetic Photon Flux Density (PPFD) levels.
- **Option 2: Daily Light Integral (DLI) Control**  
Automatically adjusts supplemental lighting based on cumulative PPFD measured over the daily photoperiod to meet, but not exceed, a user-defined DLI target.

The proposed code change would apply to both new construction and alterations of greenhouse facilities. The requirement would not be climate-zone dependent, and no compliance software updates are anticipated. An acceptance test protocol for use by field technicians at the time of installation is proposed to ensure the proper functionality of the required controls. The controls installation and acceptance test will likely be completed by field technicians or an equivalent role. These are the installers currently responsible for CEH controls. A certified acceptance technician would not be required for this added test.

The proposed code change would also clarify requirements for indoor grow facility lighting controls. Through stakeholder outreach, including discussions with consultants conducting education and outreach on this topic, the Statewide CASE Team received feedback indicating inconsistent interpretations of the current indoor grow facility lighting control requirements. Specifically, it was reported that some designers may erroneously interpret the current code requirements for control strategies to imply that a simple time switch is sufficient and that astronomical time switches are appropriate for indoor growing. The proposed code language explicitly specifies that automatic scheduling devices capable of dimming the horticulture lighting and turning it on and off are required for indoor grow facilities.

In addition, the proposed code change would move the indoor grow facility electrical power distribution systems requirement that is currently in the broader CEH section to instead be in the CEH Lighting Controls section and explicitly include greenhouse lighting under the same 40-kW threshold.

Table 24 summarizes the scope of the proposed code change. This proposal has acceptance testing performed by a field technician. Because the field technician is typically a member of the installation team, this acceptance testing is not considered “third party verification.”

**Table 24: 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 type="checkbox"/> Prescriptive
<input checked="" type="checkbox"/> Nonresidential (not including Group R uses)	<input checked="" type="checkbox"/> Alterations	<input type="checkbox"/> Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	<ul style="list-style-type: none"> <li>Part 6, Section 120.6 and 141.1</li> <li>Nonresidential Reference Appendix 7</li> </ul>	NRCC-PRC-E NRCI-PRC-E NRCA-PRC-X	<ul style="list-style-type: none"> <li>N/A</li> </ul>

Third Party Verification	Updates to Compliance Software
<input checked="" type="checkbox"/> No changes to third party verification	<input checked="" type="checkbox"/> No updates
<input type="checkbox"/> Update existing verification requirements	<input type="checkbox"/> Update existing feature
<input type="checkbox"/> Add new verification requirements	<input type="checkbox"/> Add new feature
<input checked="" type="checkbox"/> New acceptance testing requirements performed by a field technician	

### 3.1.2 Benefits of Proposed Change

CEH is one of California’s fastest-growing and most energy-intensive energy end-uses, driven by the rapid expansion of greenhouses that use supplemental light for crops like cannabis, leafy greens, and vine vegetables (Cooper, 2024). Based on published field

studies, the proposed daylight responsive controls requirement would deliver measurable and persistent energy savings ranging from an estimated 9 percent to 26 percent while improving crop consistency and grower control (Energy Solutions, 2023; NYSEERDA, 2020). Additionally, a recent model-based study shows that some specific pairings of greenhouse locations and crops in California can save up to 81 percent of lighting energy use by deploying DLI controls as compared to basic scheduling or photoperiod timers where the lights turn on at full power for 12 hours (Schimelpfenig, 2025). The measure prevents over-lighting by automatically adjusting lighting levels based on available daylight. This practice reduces electricity use and lowers cooling loads. This reduction is particularly impactful during the grid's critical peak hours—typically mid-to-late afternoons—when energy use is typically at its highest, notably from air conditioning during warm months.

This proposal builds directly upon the 2022 and 2025 Title 24, Part 6 CEH measures, which first set minimum PPE requirements for horticultural lighting along with time-clock controls and dimming requirements. By layering in daylight responsive controls, Title 24 can take the next step in California's multi-cycle strategy for CEH efficiency and decarbonization.

The proposal provides growers with flexibility by offering a compliance choice between a timeclock + PAR sensor pathway or a more advanced DLI pathway. Both options reduce energy use, though the DLI option enables even greater savings and performance improvements.

Compliance verification remains straightforward with enhancements through an acceptance test protocol.

### **3.1.3 Background Information**

CEH involves growing crops either inside a building or in a greenhouse, where they are protected from outside conditions. The California Energy Code defines “Indoor Growing” as a type of CEH space in a building with a Skylight Roof Ratio less than 50 percent in §100.1(b) (California Energy Commission, 2025); and it defines “Greenhouses” as buildings with a skylight-to-roof ratio greater than or equal to 50 percent. This proposed code change is focused on greenhouses.

Supplemental lighting is typically the single largest electricity load in greenhouses (US DOE, 2022). Greenhouse lighting is a rapidly expanding energy end-use in California, driven by increased year-round demand for crops such as cannabis, leafy greens, and vine crops. Without improved lighting control strategies, the sector risks long-term inefficiencies, higher operational costs, and greater strain on the state's electrical grid.

To address these challenges, the proposed code change introduces two compliance pathways for daylight responsive controls in greenhouses with 40 kW or more of

horticultural lighting load. These control strategies are designed to improve system efficiency, reduce peak loads, and align lighting operation with plant needs and available daylight.

The first compliance pathway, which is use of a timeclock + a PAR sensor, combines preset lighting schedules with instantaneous light measurements to optimize energy use. Timeclock controls operate lighting based on programmed on/off times aligned with plant photoperiods, with astronomical versions adjusting automatically to sunrise and sunset. PAR sensors, or quantum sensors, measure light intensity in micromoles per square meter per second, enabling dimmable LED fixtures to modulate output based on actual light levels, reducing unnecessary energy consumption.

The second compliance pathway, which is DLI, focuses on delivering a specific amount of light over the course of the day. This more advanced method utilizes DLI control systems that use instantaneous and forecasted light data to automatically adjust light output. Integrated software and hardware platforms continuously send dimming or shut-off commands to meet the daily cumulative PPFD target, ensuring optimal plant growth while minimizing energy waste. DLI systems deliver a more consistent daily total, improving crop quality and yield predictability (van Iersel & Gianino, 2017; Shelford & Mattson, 2023), but have a higher initial cost for sensors, software, and integration (Shelford & Mattson, 2023; NYSERDA, 2020).

Both control strategies significantly reduce energy use by automatically adjusting lighting based on natural daylight availability, which minimizes unnecessary use. These strategies limit operating hours by responding to cloud cover and seasonal changes, and they lower cooling demands by reducing heat generated from electric lighting, resulting in less energy needed for ventilation and temperature control.

Today, dimmable LED lighting and PAR sensors have evolved into industry-standard technologies, offering improved efficiency, reliability, and cost-effectiveness. Their adoption is widespread in CEH facilities, particularly in high-performance greenhouses. Utilities have supported this transition through targeted and custom incentive programs focused on energy-efficient lighting and controls, accelerating market uptake, and validating the benefits of advanced lighting systems (Agriculture Energy Savings Action Plan, 2025). Some utilities outside of California offer deemed incentives for greenhouse lighting controls, such as Commonwealth Edison which offers an incentive \$0.40 per Watt controlled for LED Grow Networked Lighting Control Systems (ComEd, 2025). Section 3.1.5 offers additional information on current regulatory practices and market trends on regulatory practices, and Sections 3.3.1 and 3.3.2 provide additional information on market practices in California.

Both PAR sensor-based controls and DLI controls reduce energy use compared with static or time-based controls (Resource Innovation Institute, 2024). PAR-based controls offer a cost-effective, simple solution for many growers, while DLI-based controls

provide superior crop consistency and higher potential savings, making them the preferred choice where crop value and daylight variability justify the investment. Although this specific measure has not yet been included in Title 24, Part 6 rulemakings, these control approaches are already being successfully implemented in commercial greenhouse operations across California.

### **3.1.4 Modifications to Energy Code Documents**

This section provides descriptions of how the proposed code change will affect each Energy Code document. Section 2.6: Horticultural Lighting Efficacy - Proposed Code Language of this report offers the detailed revisions to code language.

#### **3.1.4.1 Energy Code Change Summary**

##### **SECTION 100.1(b) – DEFINITIONS AND RULES OF CONSTRUCTION**

**Subsection 100.1(b):** The proposed measure would add new definitions for Daily Light Integral (DLI), Daily Light Integral (DLI) Control, Photosynthetic Active Radiation (PAR), Photosynthetic Photon Flux Density (PPFD), and PAR Sensor.

##### **SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES**

**Subsection 120.6(h)2:** The proposed measure would move the indoor growing electrical power distribution systems to the horticultural lighting section to improve the clarity of the code and therefore make it easier for building owners and energy consultants to comply with, and for building officials to enforce, the Energy Code. This provision will now also apply to greenhouses.

**Subsection 120.6(h)4:** The proposed measure would update the existing requirements for Horticultural Lighting to have separate requirements for indoor growing space lighting controls and greenhouse lighting controls. The greenhouse lighting control requirements would require control by either a combination of automatic scheduling and PAR-based sensor, or by DLI controls. This requirement will require controls that respond to lighting conditions in greenhouses, cost-effectively increasing the stringency of the Energy Code, thereby minimizing the energy use of covered processes, which in turn improves the state's economic and environmental health.

The proposed measure would clarify the indoor growing space lighting control requirements and bring them into one section to improve the clarity of the code and thus simplify compliance for building owners and energy consultants and simplify enforcement for building officials.

#### **3.1.4.2 Reference Appendices Change Summary**

Nonresidential Appendix (NA) 7 - Appendix NA7 - Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes: The proposed

changes would add acceptance testing, performed by a field technician for CEH lighting controls.

### **3.1.4.3 Compliance Manuals Change Summary**

Section 10.12.2 of the Nonresidential and Multifamily Compliance Manual, which outlines mandatory requirements for CEH spaces, would be updated to reflect the changes and additions to the mandatory code. These updates are expected to include clarifications and technical guidance related to PAR- and DLI-based daylight responsive control requirements, such as:

- Explanations and diagrams related to the real-world use of new key terms (e.g., PAR, PPF, and DLI)
- Minimum functional capabilities for dimming and scheduling controls and best practices
- Recommended sensor placement and zoning practices
- Calibration and maintenance considerations
- Example compliance pathways for both new construction and retrofit projects
- Commissioning and functional testing procedures to verify proper operation

The intent is to support consistent interpretation, accurate implementation, and enforceable compliance with PAR- and DLI-based control provisions.

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

No changes are proposed to the Alternative Calculation Method (ACM) Reference Manuals for this proposed measure. Horticultural lighting is not included in the ACM Reference Manuals.

### **3.1.4.5 Compliance Forms Change Summary**

The existing Process System Certificate of Compliance form (NRCC-PRC-E, Section P: Controlled Environment Horticulture) and Process System Certificate of Installation form (NRCI-PRC-E, Controlled Environment Horticulture Lighting section) would both need new input fields added to ensure that CEH lighting controls meet new and revised requirements. A new form (NRCA-PRC-XX-F, Nonresidential Certificates of Acceptance) would need to be created to demonstrate compliance with new field technician acceptance testing requirements for CEH facilities.

### 3.1.5 Measure Context

#### 3.1.5.1 Comparable Model Codes or Standards

The United States Department of Agriculture (USDA) NRCS Conservation Practice Standard Energy Efficient Lighting System (Code 670) includes lighting controls (such as switches, dimmers, photosensors, occupancy sensors, and timers) as eligible components to reduce energy use in agricultural facilities, highlighting the alignment of the daylight responsive controls measure with federal conservation practice standards (United States Department of Agriculture, 2021). The proposed daylight responsive controls measure would mandate automatic control, advancing required energy efficiency in greenhouse lighting.

#### 3.1.5.2 Interactions with Other Regulations

Review finds no known federal, state, or local regulatory requirements that conflict with or duplicate the proposed change. The proposal requires daylight responsive controls for greenhouses with at least 40 kW of supplemental lighting. Currently, greenhouses have no control requirements.

## 3.2 Daylight Responsive Controls for Greenhouses - Compliance and Enforcement

### 3.2.1 Compliance Considerations

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. The proposal would close a compliance gap by explicitly stating that automatic scheduling devices capable of dimming the horticulture lighting and turning it off are required, preventing misapplication of lower-performing strategies in energy-intensive facilities. The proposed changes would also simplify compliance verification for building officials by consolidating the electrical power distribution monitoring requirements into the CEH Lighting Controls section and extending them to greenhouse facilities under the same 40-kW threshold. This practice ensures consistent treatment of CEH lighting systems, reduces ambiguity for enforcement staff, and streamlines compliance forms for project teams. By clarifying compliance pathways, the proposal minimizes confusion in plan review and field inspection, addressing a commonly cited barrier to effectively enforcing CEH measures according to Statewide CASE Team Compliance Improvement experts and a published report on *Improving Energy Code Compliance* (Arup, 2025)<sup>[66]</sup>.

The proposed measure adds new lighting controls requirements for greenhouses with 40 kW of lighting load or greater, including acceptance testing performed by the

installing field technician. For this proposal, field technicians are generally the controls installer or an equivalent role and are not required to be certified acceptance technicians. Additional verification would be required to be conducted by the plans checker and the building inspector. Because these provisions apply only to facilities already subject to regulation under the same existing threshold for PPE requirement, compliance officials are already checking plans and inspecting buildings for CEH lighting system new construction, additions, and alterations.

**Designers:** Designers would need to be aware that daylight responsive controls are now required by Title 24, Part 6 for greenhouses so they can specify compliant controls in their designs.

**AHJ Plan Checkers:** During the permit application phase, AHJ plan checkers would need to review the submitted NRCC-PRC-E form and design documents to confirm that the greenhouse lighting design includes controls meeting the updated requirement. However, reviews for indoor horticultural lighting controls and for electrical power distribution requirements would be simplified.

**Installation contractors:** Installation contractors would be required to install compliant control systems in greenhouses. The installation will be consistent with current practice for control systems installers. The installing contractor would typically be the field technician performing acceptance testing, filling in new sections of the NRCI-PRC-E form and a new NRCA-XX-F form, and making the forms available to the building inspector. When the installation contractor fills in the Certificate of Installation (NRCI) form, they would need to include information on the lighting controls, with additional fields for greenhouses, as currently required for indoor growing facilities.

**AHJ Building Inspectors:** The AHJ building inspector would need to verify the installation of compliant horticultural lighting controls and for greenhouses would need to check completion of the new NRCA-XX-F form.

Statewide CASE Team review finds that the edited requirement would not conflict with any existing definitions in other parts of Title 24.

### **3.2.2 Impact on Market Actors**

Table 25 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 25: Impacts on Market Actors and Suggested Training and Education Opportunities**

Market Actor	Impact(s)	Suggested Outreach and Education
<b>Builders<sup>a</sup></b>	Be aware of new requirements, increased upfront costs, and acceptance testing requirements.	CEH Energy Code Ace Fact Sheet and training resources should be updated to include new requirements.
<b>Design Professionals<sup>b</sup></b>	Be aware of the updated horticultural lighting controls requirements and specify horticultural lighting controls meeting the updated requirement.	CEH Energy Code Ace Fact Sheet and training resources should be updated to include new requirements.  Greenhouse lighting design firms should be provided with training on the energy code, including compliance requirements and compliance documentation.
<b>Construction Team<sup>c</sup></b>	Install controls meeting the new and updated requirements.  Conduct acceptance testing as field technician. The acceptance test will require a handheld PPF meter.	Horticultural lighting controls installers should be provided training on the Energy Code updates and supporting documentation, compliance requirements, acceptance testing, and compliance documentation.
<b>Building Departments<sup>d</sup></b>	Plans checker will review the submitted NRCC-PRC-E form and design documents to confirm that the design includes lighting controls meeting the updated requirement.  Building inspector will review the submitted NRCA-PRC-XX-F form and the NRCI-PRC-E form and confirm that the installed controls meet the horticultural lighting controls requirements.	Additional outreach and education are needed to ensure building departments are aware of CEH code requirements. Smaller AHJs and those with a high concentration of greenhouses may require more outreach.
<b>Verification Testers<sup>e</sup></b>	See construction team, as installing technician will typically act as the field technician performing acceptance testing.	N/A
<b>Building Owners, Managers, and Occupants</b>	Increased first costs.  Need to train staff to operate greenhouses with lighting control system.	Outreach to owners and operations personnel could improve understanding of the benefits of daylight responsive controls for greenhouses.  Updates to the Energy Code Ace Fact Sheet and training resources to include daylight responsive controls.

Market Actor	Impact(s)	Suggested Outreach and Education
<b>Manufacturers and Distributors</b>	Sales of compliant lighting controls systems will increase.  May need to update “code guideline” documents.	Outreach to manufacturers will help manufacturers understand the code changes and what products can comply with the code.

- a. Builders include builders and developers
- b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
- c. Construction team includes general contractors, 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 sustainability department staff.
- e. Verification 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, energy consultants, and building owners and occupants. The analysis in the methodology report is not specific to the changes presented in this report. 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 likely affect commercial builders. However, it would likely 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 commercial building industry. Instead, it would primarily affect specific subsectors within the industry.

Under the proposed changes, builders must ensure that a new acceptance test is completed by a field technician and a new Nonresidential Certificates of Acceptance (NRCA) form is completed and provided to the building inspector. Previously, builders were not required to conduct acceptance tests for CEH facilities, so this adjustment represents a change in their workflow. An installation or controls technician that the builder currently coordinates with can complete this test to minimize impacts. Table 26 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

**Table 26: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)**

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
<b>Nonresidential Electrical Contractors</b>	3,245	72,794	\$7.8
<b>Other Nonresidential Equipment Contractors</b>	580	9,749	\$1.1
<b>All Other Nonresidential Trade Contractors</b>	948	17,084	\$1.7

- a. Source: (State of California, n.d.)
- b. \* 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>

**Manufacturers:** The proposed standard is not expected to create compliance challenges based on technology availability but will reinforce California’s leadership in high-efficiency horticultural lighting and support continued growth in local clean technology and manufacturing sectors.

Major manufacturers are further discussed in Section 3.3.1. Section 3.3.4. provides additional information on market impacts and employment considerations

### 3.2.3 Compliance Software Updates

The compliance software does not need to be updated for this proposal.

### 3.2.4 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.

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

Assuming state and local government staffing is unavailable, the state would need to allocate resources to ensure compliance with updated Title 24, Part 6 measures.

Compliance updates would include the following:

- Revisions to the Covered Process Compliance Form (NRCC-PRC-E) to document the type of daylight responsive controls used;

- **Updates to the Installation Form (NRCI-PRC-E)** to allow inspectors to confirm control strategies and record make/model details for components such as timeclocks, PAR sensors, and DLI systems; and
- **Introduction of a new Acceptance Test Protocol Form (NRCA-PRC-XX-F)** requiring field verification of daylight responsive controls to confirm functionality, dimming behavior, and system integration (if relevant) at the time of installation.

The state will incur costs to update standards, compliance materials, and publicly funded trainings and to respond to inquiries. These activities are expected to fall within existing code development and enforcement budgets. Training for enforcement officials will be necessary to ensure proper application of new forms and protocols. Existing education programs and resources can be leveraged to minimize expense. Similarly, local governments will need to retrain building department staff on the revised standards. This retraining aligns with the regular triennial code update cycle and is supported by resources such as Energy Code Ace. The acceptance testing would be performed by a field technician (a member of the construction team) but would result in additional enforcement costs for the building inspector to confirm that the acceptance test form is completed.

If workforce training for the construction industry is required to ensure correct design and installation of daylight responsive controls, costs are expected to be limited to short courses or online modules, which can be integrated into existing industry training programs.

The Statewide CASE Team will work with the key building departments in the state where greenhouses are a dominant building type, as well as the Compliance Improvement Team to estimate the total cost of enforcement.

### **3.3 Daylight Responsive Controls for Greenhouses - Market and Economic Analysis**

#### **3.3.1 Market Structure and Availability**

##### **3.3.1.1 Current Market Structure and Availability**

Daylight responsive control options, including timeclock + PAR sensors solutions and DLI control systems, are widely available from multiple manufacturers and distributors. Products are available from multiple vendors with no known patent or proprietary restrictions, ensuring competitive supply and flexibility for growers. Major manufacturers offering timeclock and PAR sensors include LI-COR Biosciences, Apogee Instruments, Spectrum Technologies, Inc., and Campbell Scientific. Major manufacturers offering DLI solutions include Autogrow, Argus Controls, Priva, Wadsworth Controls, TroiMaster, and Link4. The market for these daylight responsive controls systems is supported by a

broad network of distributors and resellers, which includes e-commerce channels and regional operations within California. Most CEH lighting vendors, in addition to the advanced DLI and greenhouse control systems manufacturers, offer virtual or on-site technical assistance and commissioning support. A notable portion of the market is served by key California-based companies that provide manufacturing, distribution, and local market support. These companies include Link4 in Anaheim and Micro Grow Greenhouse Systems in Temecula, which manufacture their control systems and components within the state. Additionally, TrolMaster manages its U.S. distribution through its affiliate ThinkGrow Agricultural Technology, Inc. in Sacramento.

Adoption of daylight responsive controls technologies is already accelerating. A 2024 Cannabis Business Times survey found that 75 percent of growers use dimming technology. Among those growers, 91 percent use an automated control system (Cannabis Business Times, 2024). A survey of growers across the state of California indicated that larger facilities are more likely to incorporate smart controls than smaller facilities and that facilities that grow food crops are more likely to use smart controls than those that grow cannabis (Schimelpfenig, 2025). That same report indicated that about 60 percent of respondents had some sort of sensor-integrated lighting controls (Schimelpfenig, 2025). These findings indicate strong market familiarity with the core components of the proposed daylight responsive controls measure for cannabis growers. Absent regulation, daylight responsive controls adoption is projected and will likely continue to increase gradually, particularly driven by large-scale and new facilities seeking energy cost savings and more advanced operational control granularity. However, smaller facilities or retrofit projects will be more likely to continue relying on manual or timeclock-only on/off controls without regulatory support.

Section 3.2.2 covers broader market impacts and workforce training needs, such as ensuring broad light meter availability to the installation teams who will need to implement the proposed acceptance test.

### ***3.3.1.2 Market Challenges and Solutions***

During proposal development, the Statewide CASE Team engaged with lighting control manufacturers, researchers, and agricultural consultants to identify barriers and design practical solutions. Stakeholder feedback was gathered through targeted interviews, market surveys, and coordination with industry programs to ensure both technical feasibility and market readiness.

In interviews performed by the Statewide CASE team, consultants and manufacturers noted that, although DLI systems deliver measurable energy savings and yield benefits, their higher initial cost might make them infeasible for some growers. In response to this stakeholder input, the Statewide CASE Team updated the proposed code change to

include a compliance pathway for simpler, lower-first cost PAR-based controls as an alternative to full DLI controls.

Further, interviews with greenhouse consultants indicated that smaller operators often face practical barriers to implementing sensor-based lighting controls, including limited familiarity with PAR sensor placement and calibration, uncertainty about how to configure the controls, and concerns about integration with existing control systems. Consultants noted that while the technology is commercially available, smaller operators may rely on simpler time-based control strategies because they are perceived as lower risk, easier to commission, and less dependent on in-house technical expertise.

This feedback suggests a gap not in technology availability, but in applied guidance for specification, commissioning, and ongoing operation of PAR- and DLI-based control strategies in small- to mid-scale greenhouse settings. In response to this stakeholder input, the Statewide CASE Team recommends the developing targeted implementation guidance that focuses on practical topics such as sensor placement best practices, example DLI setpoints by crop type, commissioning checklists, and troubleshooting considerations. The compliance manual is one potential vehicle for providing this guidance, supplemented by coordination with industry groups to ensure the information reflects real-world operational conditions.

### **3.3.2 Design and Construction Practices**

#### **3.3.2.1 *Current Design and Construction Practices***

The proposed daylight responsive controls measure introduces a new design requirement for new construction, additions, and alterations of greenhouses with horticultural lighting loads greater than 40 kW. Under the current Energy Code, greenhouse lighting systems are controlled via timeclock or manual on/off operation, with no automatic adjustment for available daylight (Resource Innovation Institute, 2024). The proposed measure requires the addition of technologies capable of dimming supplemental electric lighting in response to daylight, using either timeclock + PAR-based sensors or DLI systems, combined with dimming luminaires.

Best design practices when implementing daylight responsive control systems include the following:

1. **Sensor placement and calibration** at representative canopy locations to ensure accurate measurement of photosynthetically active light levels;
2. **Integration with lighting controllers** to modulate fixture output in real time;
3. **Programming setpoints** based on target DLI; and
4. **Commissioning and functional testing** to confirm sensor response, communication between devices, and consistency across zones.

### **3.3.2.2 Health and Safety Considerations**

The proposed code change does not introduce any new health or safety risks and does not modify existing federal, state, or local safety regulations, including those enforced by the Department of Occupational Safety and Health in California (Cal/OSHA or DOSH). All current safety requirements related to electrical systems, lighting installations, and greenhouse operations remain in effect. No changes are expected to structural, seismic, fire safety, or indoor environmental quality provisions.

Stakeholders did not raise concerns about health or safety during engagement activities, and no adverse impacts are anticipated for building occupants, operators, or maintenance personnel.

### **3.3.2.3 Design and Construction Challenges and Solutions**

Preliminary stakeholder engagement with agricultural consultants identified several design and implementation challenges related to introducing daylight responsive controls as a new code requirement. These consultants routinely specify lighting and environmental control systems for both new construction and alteration greenhouse projects, and their input reflects direct experience with design, commissioning, and troubleshooting in commercial greenhouse facilities.

First, many existing greenhouses rely on standalone time clocks or manual switching without dimming capability. Retrofitting these systems to enable dimming-based daylight response may require replacement of luminaire and/or drivers, addition of compatible control wiring (e.g., 0–10V or digital protocols), and integration with existing environmental control systems. Consultants noted that these upgrades can introduce compatibility issues, commissioning complexity, and uncertainty regarding contractor scope.

Second, stakeholders emphasized that PAR-based control performance depends heavily on sensor placement, glazing transmittance characteristics, structural shading, and crop canopy density. Improper sensor location or lack of calibration can result in inaccurate DLI calculations. Consultants reported variability in field practice regarding sensor mounting height, number of sensors per zone, and recalibration frequency, which can affect system reliability and grower confidence.

These challenges point to a need for more detailed technical implementation guidance. In response, the Statewide CASE Team is coordinating with stakeholders and the compliance improvement team to identify specific resources that could support consistent application, such as:

- Clear delineation of control capability requirements (e.g., dimming compatibility, control zoning expectations)
- Example retrofit pathways outlining typical electrical and control upgrades

- Recommended sensor placement practices and minimum zoning guidance
- Commissioning and functional testing checklists for DLI-based controls

The Title 24 Compliance Manual is one potential vehicle for incorporating this guidance, supplemented by coordination with industry associations and control manufacturers to ensure technical accuracy and alignment with standard greenhouse practice. Section 3.2.2 describes complementary workforce development efforts focused on equipping designers, installers, and commissioning agents with the skills needed to implement these systems effectively.

### 3.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on ESJ communities, including impacts related to race, class, and gender. The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Specific impacts identified to date include the following:

- **Cost and Affordability:** Initial equipment and installation costs may disproportionately affect small or independent CEH operators serving local markets, particularly in rural or low-income regions (Food and Agriculture Organization of the United Nations, 2022).
- **Health and Safety:** Added daylight responsive controls requirements may reduce waste heat, thereby increasing worker comfort.

**Economic Participation:** Over time, energy savings can improve the financial viability of operations, creating more sustainable employment opportunities in ESJ communities engaged in agriculture and indoor production.

Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with Community-Based Organizations to facilitate meaningful engagement. Stakeholders who wish to provide input on how the proposal may impact ESJ communities or otherwise offer their perspective should reach out to Lydia Miner ([lminer@westmonroe.com](mailto:lminer@westmonroe.com)).

### 3.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

### 3.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

## **3.4 Daylight Responsive Controls for Greenhouses - Cost Effectiveness**

### **3.4.1 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 sufficient details to replicate the savings and cost-effectiveness estimate summarized here.

Per California Law (Public Resources Code 25000), a measure is considered cost-effective if the benefit-to-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 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. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

The relevant factors are not utility rates, forecasts, or bill estimates, but instead costs considered 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.

### **3.4.2 Energy and Energy Cost Savings Results**

The Statewide CASE Team completed an energy savings analysis using prototypical greenhouse facilities representative of typical operations across California. To model energy savings, the Statewide CASE Team used custom spreadsheet-based simulation tools tailored to CEH applications. The analysis did not use the CBECC software because it does not currently support modeling of greenhouses. The prototype being developed in support of the Indoor CEH Space Conditioning measure will support high lighting intensity indoor growing rooms only. The prototype is described in Section 4.2.3.

Prototypes were adapted from those used in the 2025 CEH CASE Report and reflect industry-standard geometry, crop mix, and operational characteristics (Energy Solutions, 2023) for each simulated crop type. The Statewide CASE Team simulated cannabis, tomatoes, and leafy greens as representative crops. Microgreens and herbs are represented by leafy greens, and vine crops and flowering crops are represented by tomatoes due to similar light and temperature requirements. For purposes of this analysis, the Statewide CASE Team conservatively assumed that only cannabis flower would be impacted by the measure. This assumption reflects greenhouse canopy

composition, where cannabis is typically 65% flowering, 33% vegetative, and 2% clone by canopy area; therefore, 65% was used in the calculations. The CASE Team is continuing to seek stakeholder feedback, and this assumption may be updated in the final CASE report. The three prototypes analyzed were: greenhouse: leafy greens, greenhouse: tomatoes, and greenhouse: cannabis.

The analysis simulated energy use for each prototype on an hourly basis to capture lighting power. In greenhouses, variations in daylight throughout the year impacted the amount of light used and were analyzed by climate zone. The simulations assumed venting as the primary cooling mechanism and did not include interactive effects with an HVAC system. The proposed model was identical to the baseline model except for reduced hourly lighting load profiles reflecting the proposed code update.

This analysis uses the assumptions from the 2025 CEH CASE Report unless otherwise noted (Energy Solutions, 2023). Table 27 highlights key lighting assumptions. The assumptions will be updated as new inputs are provided via ongoing stakeholder outreach to industry groups, academic researchers, luminaire manufacturers, agricultural lighting consultants, and CEH owners/operators. Stakeholders will be asked to review the proposed savings methodology, key assumptions, and analytical framework.

**Table 27: Greenhouse CEH Lighting Assumptions for Daylight Responsive Controls Energy Savings Analysis**

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft <sup>2</sup> )	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μMol/m <sup>2</sup> /s)	600	400	200	200	350
Baseline PPE (μmol/J)	2.5	2.5	2.5	2.5	2.5
Proposed PPE (μmol/J)	2.5	2.5	2.5	2.5	2.5

Baseline values reflect the minimum compliant controls (timeclock on/off) required by the 2025 Energy Code, with lights on at 100% power (not dimmed) for the full photoperiod. Proposed values reflect the proposed (timeclock + PAR-based sensor with dimming) updates presented in this report. Appendix A provides more details on the methodology for calculating energy savings from the proposed code change. For each

prototype, the analysis calculated lighting energy use based on canopy area per luminaire, photoperiod, required PPFD, PPE, and dimming based on daily sunlight availability for each climate zone.

Table 28 through Table 32 present energy savings and peak demand reductions per square foot of plant canopy. Per-unit savings for the first year are expected to range from 25 to 45 kWh/yr per ft<sup>2</sup> of plant canopy, depending upon climate zone and crop type. No natural gas savings are expected. Demand reductions are expected to range between 0.001 and 0.002 kW/ft<sup>2</sup>, depending on climate zone and crop type. The per-unit energy savings do not vary between new construction and additions/alterations.

Energy and energy cost savings results will be updated for the Final CASE Report to incorporate adjustments in assumptions from ongoing stakeholder feedback, as described above. The savings from this measure are expected to persist over the 30-year analysis period, assuming equipment is maintained and replaced as necessary.

**Table 28: First Year Electricity Savings (kWh) Per Canopy Square Foot by Climate Zone (CZ) – Daylight Responsive Controls**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Greenhouse Cannabis	31.41	36.63	37.38	40.99	40.55	41.14	40.34	40.85	41.75	41.62	36.63	38.46	40.27	43.27	43.06	37.51
Greenhouse Leafy Greens	24.70	26.36	26.71	27.83	27.74	27.80	27.58	27.68	27.90	27.84	26.17	27.06	27.50	28.34	28.30	26.73
Greenhouse Tomatoes	36.37	40.11	40.87	43.67	43.47	43.84	43.35	43.64	44.21	44.11	40.10	41.82	43.16	45.34	45.30	41.04

**Table 29: First Year Peak Demand Reduction (kW) Per Canopy Square Foot by Climate Zone (CZ) – Daylight Responsive Controls**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Greenhouse Cannabis	0.0015	0.0018	0.0019	0.0018	0.0018	0.0018	0.0018	0.0018	0.0019	0.0018	0.0016	0.0018	0.0017	0.0018	0.0019	0.0016
Greenhouse Leafy Greens	0.0014	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0014	0.0015	0.0015	0.0015	0.0015	0.0015
Greenhouse Tomatoes	0.0019	0.0021	0.0022	0.0022	0.0021	0.0022	0.0022	0.0022	0.0022	0.0021	0.0020	0.0021	0.0020	0.0022	0.0022	0.0020

**Table 30: First Year Natural Gas Savings (kBtu) Per Canopy Square Foot by Climate Zone (CZ) – Daylight Responsive Controls**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Greenhouse Cannabis	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
Greenhouse Leafy Greens	N/A	N/A	N/A	N/A	N/A	N/A	N/A									
Greenhouse Tomatoes	N/A	N/A	N/A	N/A	N/A	N/A	N/A									

**Table 31: First Year Source Energy Savings (kBtu) Per Canopy Square Foot by Climate Zone (CZ) – Daylight Responsive Controls**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Greenhouse Cannabis	8.59	9.86	10.25	11.70	12.01	12.55	12.70	12.40	12.61	12.18	9.91	10.64	10.43	12.92	13.13	11.30
Greenhouse Leafy Greens	10.07	11.15	11.56	12.69	12.87	13.07	13.28	13.03	13.19	13.01	10.94	11.85	11.77	13.51	13.65	12.35
Greenhouse Tomatoes	11.75	13.21	13.77	15.69	16.01	16.49	16.92	16.43	16.65	16.30	13.21	14.30	14.13	17.19	17.46	15.17

**Table 32: Total 30-Year LSC Savings (2029 PV\$) Per Canopy Square Foot by Climate Zone (CZ) – Daylight Responsive Controls**

<b>Prototype</b>	<b>CZ 1</b>	<b>CZ 2</b>	<b>CZ 3</b>	<b>CZ 4</b>	<b>CZ 5</b>	<b>CZ 6</b>	<b>CZ 7</b>	<b>CZ 8</b>	<b>CZ 9</b>	<b>CZ 10</b>	<b>CZ 11</b>	<b>CZ 12</b>	<b>CZ 13</b>	<b>CZ 14</b>	<b>CZ 15</b>	<b>CZ 16</b>
<b>Greenhouse Cannabis</b>	\$186.59	\$218.19	\$221.88	\$243.99	\$243.60	\$244.52	\$242.21	\$239.84	\$250.70	\$243.57	\$216.57	\$233.12	\$237.29	\$252.46	\$258.54	\$224.62
<b>Greenhouse Leafy Greens</b>	\$156.30	\$168.36	\$169.68	\$178.51	\$180.07	\$176.06	\$175.47	\$173.61	\$182.09	\$175.11	\$166.11	\$176.42	\$174.73	\$175.68	\$182.98	\$173.73
<b>Greenhouse Tomatoes</b>	\$220.84	\$245.48	\$249.45	\$268.54	\$270.00	\$268.41	\$267.73	\$263.86	\$275.69	\$266.43	\$243.44	\$260.91	\$262.45	\$272.68	\$282.41	\$253.36

### 3.4.3 Incremental First Cost

The baseline for this analysis reflects horticultural lighting control systems meeting the 2025 Title 24, Part 6 requirements for general lighting control, where fixtures are controlled by time clocks only. Because both baseline and proposed systems use the same lighting fixtures and general electrical infrastructure, incremental first costs arise solely from the addition of PAR sensors and commissioning activities.

Incremental first costs were calculated as the difference between the proposed and baseline systems and include the following:

- **Baseline Control Costs:** Timeclocks on/off per lighting zone (\$/zone).
- **Proposed Control Costs:** PAR sensors with dimming controller (\$/zone).
- **Installation:** Incremental wiring and control calibration required for daylight-responsive operation.

For the Draft CASE Report, the equipment costs were obtained from a survey of prices from online stores in November and December of 2025.

Incremental labor costs include sensor placement, wiring, and control commissioning. The Statewide CASE Team anticipates no first cost differences between new construction and alterations, as both scenarios involve similar integration of sensors and control equipment into the greenhouse lighting system.

Costs and all associated calculations for cannabis were based on cannabis flower only, representing 65 percent of greenhouse cannabis canopy area. For all crops, the size of the zone was assumed to be 40 kW of connected lighting load. Fixture coverage areas were assumed to be 20, 58, and 56 square feet of plant canopy for cannabis, leafy greens, and tomatoes, respectively, resulting in total canopy areas 1,025, 5,126, and 2,929 canopy square feet. The cost of labor was assumed to be the average prevailing wage for an electrician in 2029 dollars at \$110.32 per hour (State of California Department of Industrial Relations, 2026). Equipment first costs and incremental costs per square foot of canopy are presented in Table 33. The size of a 40kW zone was calculated for each crop using the fixture coverage area, PPE, and PPFD. The calculated canopy square feet and total incremental first cost for a 40-kW zone is presented in Table 33. One control system is required per zone, so the total cost per zone is consistent across crop types.

First cost estimates will be collected through February 2026 using a combination of manufacturer quotes, distributor pricing, and stakeholder interviews. The Statewide CASE Team will interview stakeholders, including greenhouse system integrators, control manufacturers, and agricultural design professionals to confirm costs. The Statewide CASE Team will update these cost assumptions for the Final Report.

**Table 33: Baseline, Proposed, and Incremental Cost for Equipment and Installation, Per Canopy Square Foot – Daylight Responsive Controls (\$/canopy square foot)**

Prototype	Baseline Equip. Cost	Proposed Equip. Cost	Incremental Equipment Cost	Baseline Install Cost	Proposed Install Cost	Incremental Installation Cost	Total Incremental First Cost
<ul style="list-style-type: none"> <li>Greenhouse</li> <li>Cannabis</li> </ul>	• \$0.06	• \$1.25	• \$1.12	• \$0.16	• \$0.43	• \$0.27	• \$1.46
<ul style="list-style-type: none"> <li>Greenhouse</li> <li>Leafy Greens</li> </ul>	• \$0.01	• \$0.25	• \$0.24	• \$0.03	• \$0.09	• \$0.05	• \$0.29
<ul style="list-style-type: none"> <li>Greenhouse</li> <li>Tomatoes</li> </ul>	• \$0.02	• \$0.44	• \$0.42	• \$0.06	• \$0.15	• \$0.09	• \$0.51

**Table 34. Canopy Square Footage and Total Incremental Cost per 40 kW Zone – Daylight Responsive Controls**

Prototype	Canopy Square Feet per 40kW Zone (sf)	Incremental Cost per Canopy Square Foot (sf)	Total Incremental Cost per 40kW Zone (\$)
<b>Greenhouse Cannabis</b>	1,025	\$1.46	\$1,497
<b>Greenhouse Leafy Greens</b>	5,126	\$0.29	\$1,497
<b>Greenhouse Tomatoes</b>	2,929	\$0.51	\$1,497

### 3.4.4 Incremental Maintenance and Replacement Costs

The proposed daylight responsive controls measure for greenhouse lighting systems is expected to deliver long-term, persistent energy savings due to the reliability and durability of modern lighting control components and sensors.

Based on the California Energy Data and Reporting System (CEDARS) Database for Energy Efficient Resources (DEER), time clocks and daylight sensors have an EUL of eight years (California Public Utility Commission, 2014; California Energy Data and Reporting System, 2025). The Statewide CASE Team will confirm this assumption through stakeholder engagement with greenhouse control manufacturers, system integrators, and facility operators during development of the Final CASE Report. The incremental replacement cost analysis assumes replacement of all components every eight years. As an example for the controls serving the cannabis greenhouse, the current incremental cost is \$1.46/ft<sup>2</sup>, assuming the same inflation adjusted cost would occur at 9 years, 17 years and 25 years, and using a 3% real discount rate, the total present valued incremental cost of the measure including equipment replacement, PVinc, would be:

PVinc =

$$\$1.46/\text{ft}^2 + \$1.46/\text{ft}^2 \times (1/1.03)^9 + \$1.46/\text{ft}^2 \times (1/1.03)^{17} + \$1.46/\text{ft}^2 \times (1/1.03)^{25}$$

$$\text{PVinc} = \$4.16/\text{sf}$$

Routine maintenance for daylight responsive controls includes periodic cleaning of sensors, calibration, and regular verification of control functionality. These tasks are typically performed annually or semiannually, are aligned with standard facility maintenance schedules, and are anticipated to have minimal impact on maintenance costs. Most daylight responsive controls components are solid-state devices with no moving parts and therefore require little to no mechanical servicing. The routine maintenance requirements and costs remain unchanged between the baseline and proposed cases. Occasional recalibration may be required to maintain accurate sensor response, but this recalibration is generally performed as part of routine greenhouse environmental control system maintenance already taking place and was not included as an additional incremental cost.

Energy savings from this measure are expected to persist throughout the analysis period, provided that time clocks and sensors are properly maintained, recalibrated, and replaced when needed. Incremental maintenance, calibration, and replacement cost assumptions will be validated through stakeholder engagement with greenhouse control manufacturers, system integrators, agricultural energy consultants, and CEH facility operators. Feedback will be used to refine assumptions on useful life, maintenance frequency, maintenance costs, and persistence of savings for inclusion in the Final Report.

### **3.4.5 Cost Effectiveness**

The cost-effectiveness analysis evaluates incremental first costs, labor costs, maintenance costs, and replacement costs relative to the baseline, and quantifies the

PV of benefits over a 30-year analysis period using a three percent real discount rate. All values are expressed in 2029 present valued dollars to align with the expected code implementation year.

Energy and cost savings were modeled using prototype greenhouse facilities that represent typical CEH applications, as described in Section 3.4.2. Each prototype incorporates representative operating schedules, lighting densities, and control strategies. Savings were calculated as the difference in site energy use and annualized energy cost between the baseline and proposed daylight adaptive control strategies, applied across all California climate zones. Incremental first costs were calculated as described in Section 3.4.3 and incremental maintenance costs were estimated as described in Section 3.4.4.

Results of the per-unit cost-effectiveness analyses are presented in Table 35 and Table 36 for new construction/additions and alterations, respectively. Appendix A presents results of the per-unit cost-effectiveness analysis for each climate zone and each building prototype.

**Table 35: 30-Year Cost-Effectiveness Summary Square Canopy Foot Area – New Construction and Additions – Climate Zones 1-16**

<b>Prototype</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to- Cost Ratio</b>
<b>Greenhouse Cannabis</b>	\$231.54	\$4.16	56
<b>Greenhouse Leafy Greens</b>	\$172.97	\$0.83	208
<b>Greenhouse Tomatoes</b>	\$257.77	\$1.46	177

**Table 36: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot Area – Alterations – Climate Zones 1-16**

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to- Cost Ratio
Greenhouse Cannabis	\$237.80	\$4.16	57
Greenhouse Leafy Greens	\$175.34	\$0.83	211
Greenhouse Tomatoes	\$263.34	\$1.46	181

### 3.5 Daylight Responsive Controls for Greenhouses - Statewide Impacts

#### 3.5.1 Statewide Energy and Energy Cost Savings

Statewide savings for both new construction and alterations were estimated using a bottom-up approach consistent with the 2028 CASE Methodology Report. The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts provided by the CEC. These forecasts estimate new construction and additions anticipated to occur in 2029, the first year the 2028 Title 24, Part 6 requirements are in effect, as well as the total existing building stock forecasted in 2029, which was used to approximate savings from building alterations. The 2028 CASE Methodology Report provides further 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.

Table 37 presents statewide energy and LSC savings for new construction by prototype, with values summed across all climate zones. Table 38 presents statewide energy and LSC savings for new construction by climate zone, with values summed across all prototypes. Different climate zones have different total square footage of CEH space, so their statewide savings vary despite having the same energy savings per square foot. Table 39 presents statewide energy and LSC savings for alterations by prototype with values summed across all climate zones. Because alterations impact more CEH square footage per year than new construction, the statewide energy savings from alterations is significantly higher than it is for new construction. The proportion by climate zone of square footage of CEH facilities is not the same as it is for forecasted new construction, so the proportion of savings in each climate zone differs between alterations and new construction. The energy savings per canopy square foot is the same for alterations and

new construction. Table 40 presents statewide energy and LSC savings for alterations by climate zone, with values summed across all prototypes. The first-year statewide energy and LSC savings from newly constructed buildings, additions, and Appendix C presents alterations by climate zone and prototype. Table 41 shows total first-year savings by new construction vs. alterations and Table 42 shows total first-year savings by prototype.

**Table 37: Statewide Energy and LSC Impacts – New Construction and Additions – Climate Zones 1-16**

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Natural Gas Savings (Million Therms) First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
Greenhouse Cannabis	0.07	2.89	131.29	N/A	0.82	\$17.21
Greenhouse Leafy Greens	0.11	3.10	168.70	N/A	1.38	\$19.78
Greenhouse Tomatoes	0.15	6.42	323.06	N/A	2.25	\$39.30
<b>Total</b>	<b>0.34</b>	<b>12.41</b>	<b>623.06</b>	<b>N/A</b>	<b>4.45</b>	<b>\$76.30</b>

**Table 38: Statewide Energy and LSC Impacts – New Construction and Additions – Cannabis, Leafy Greens, and Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0152	0.48	24.58	N/A	0.160	\$2.91
2	0.0127	0.44	23.45	N/A	0.150	\$2.72
3	0.0524	1.85	100.11	N/A	0.643	\$11.36
4	0.0065	0.25	12.17	N/A	0.090	\$1.52
5	0.0331	1.25	61.16	N/A	0.467	\$7.76
6	0.0423	1.60	78.84	N/A	0.612	\$9.82
7	0.0002	0.01	0.45	N/A	0.004	\$0.06
8	0.0038	0.14	7.12	N/A	0.055	\$0.88
9	0.0043	0.16	7.98	N/A	0.062	\$1.02
10	0.0456	1.74	83.99	N/A	0.652	\$10.53
11	0.0496	1.72	85.16	N/A	0.582	\$10.51
12	0.0501	1.81	92.36	N/A	0.635	\$11.34
13	0.0148	0.55	26.11	N/A	0.185	\$3.36
14	0.0018	0.07	3.29	N/A	0.027	\$0.42
15	0.0079	0.31	14.94	N/A	0.120	\$1.92
16	0.0008	0.03	1.34	N/A	0.010	\$0.17
<b>Total</b>	<b>0.3412</b>	<b>12.41</b>	<b>623.06</b>	<b>N/A</b>	<b>4.455</b>	<b>\$76.30</b>

**Table 39: Statewide Energy and LSC Impacts – Alterations – Climate Zones 1-16**

<b>Prototype</b>	<b>Statewide New Construction &amp; Additions Impacted by Proposed Change in 2026 (Million Square Feet)</b>	<b>First-Year Electricity Savings (GWh)</b>	<b>First-Year Peak Electrical Demand Reduction (kW)</b>	<b>First-Year Natural Gas Savings (Million Therms)</b>	<b>First-Year Source Energy Savings (Million kBtu)</b>	<b>30-Year Present Valued LSC Savings (Million 2029 PV\$)</b>
<b>Greenhouse Cannabis</b>	0.26	10.25	457.47	N/A	2.95	\$61.02
<b>Greenhouse Leafy Greens</b>	0.39	10.83	582.66	N/A	4.91	\$69.22
<b>Greenhouse Tomatoes</b>	0.53	22.58	1118.60	N/A	8.08	\$138.62
<b>Total</b>	<b>1.18</b>	<b>43.67</b>	<b>2158.73</b>	<b>N/A</b>	<b>15.94</b>	<b>\$268.86</b>

**Table 40: Statewide Energy and LSC Impacts – Alterations – Cannabis, Leafy Greens, and Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.020	0.64	33.11	N/A	0.21	\$3.92
2	0.013	0.46	24.69	N/A	0.16	\$2.86
3	0.077	2.71	146.51	N/A	0.94	\$16.63
4	0.031	1.19	58.46	N/A	0.43	\$7.32
5	0.185	6.96	341.88	N/A	2.61	\$43.38
6	0.242	9.17	451.29	N/A	3.51	\$56.21
7	0.031	1.17	58.49	N/A	0.46	\$7.26
8	0.022	0.82	40.27	N/A	0.31	\$4.96
9	0.047	1.79	87.46	N/A	0.68	\$11.19
10	0.106	4.03	194.70	N/A	1.51	\$24.40
11	0.074	2.55	126.25	N/A	0.86	\$15.58
12	0.133	4.80	244.87	N/A	1.68	\$30.08
13	0.157	5.85	277.29	N/A	1.97	\$35.72
14	0.014	0.54	25.53	N/A	0.21	\$3.23
15	0.019	0.74	35.84	N/A	0.29	\$4.60
16	0.007	0.24	12.10	N/A	0.09	\$1.52
<b>Total</b>	<b>1.178</b>	<b>43.67</b>	<b>2158.73</b>	<b>N/A</b>	<b>15.94</b>	<b>\$268.86</b>

**Table 41: Total First-Year Energy Savings**

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
<b>New Construction &amp; Additions</b>	12.41	0.62	N/A	4.45	\$76.30
<b>Alterations</b>	43.67	2.16	N/A	15.94	\$268.86
<b>Total</b>	<b>56.08</b>	<b>2.78</b>	<b>N/A</b>	<b>20.39</b>	<b>\$345.16</b>

**Table 42: Total First-Year Energy Savings By Crop Type**

Crop Type	Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
<b>Cannabis</b>	New Construction & Additions	2.89	0.13	N/A	0.82	\$17.21
	Alterations	10.25	0.46	N/A	2.95	\$61.02
<b>Greens</b>	New Construction & Additions	3.10	0.17	N/A	1.38	\$19.78
	Alterations	10.83	0.58	N/A	4.91	\$69.22
<b>Tomatoes</b>	New Construction & Additions	6.42	0.32	N/A	2.25	\$39.30
	Alterations	22.58	1.12	N/A	8.08	\$138.62
<b>All</b>	<b>Total</b>	<b>56.08</b>	<b>2.78</b>	<b>N/A</b>	<b>20.39</b>	<b>\$345.16</b>

### 3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 43 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 1,080 metric tons of CO<sub>2</sub>e emissions. These reductions, along with their associated monetary value, were calculated using hourly 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. The 2028 CASE Methodology Report provides additional information. Note that the GHG emissions reductions per unit of energy savings are lower than many other measures because the energy savings are highest when solar radiation, and therefore, solar generation, is highest.

**Table 43: First-Year Statewide GHG Emissions Impacts**

Prototype	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions (\$)
Greenhouse Cannabis	200	N/A	200	\$24,598
Greenhouse Leafy Greens	333	N/A	333	\$40,961
Greenhouse Tomatoes	547	N/A	547	\$67,310
<b>TOTAL</b>	<b>1,080</b>	<b>N/A</b>	<b>1,080</b>	<b>\$132,869</b>

### 3.5.3 Statewide Water Use Impacts

Review finds that the proposed code change will not result in water use impacts.

### 3.5.4 Statewide Material Impacts

The proposed code change does not replace existing equipment but introduces requirements that increase the use of photosensors, advanced control technologies, and potentially additional wiring or low-voltage cabling. To estimate material impacts, the Statewide CASE Team applied a structured methodology adapted from the 2025 Daylighting CASE Report (Wen, Daylighting: Final CASE Report, 2023). This approach involved:

- Identifying material composition for key components (e.g., photocontrols, cables, connectors, batteries) using manufacturer data and environmental profiles.
- Calculating per-unit material changes based on the daylighting control model and scaling estimates by weight or volume where direct data was unavailable.

- Deriving statewide material impacts by applying per-unit changes to projected new construction and alteration scenarios.

The analysis focused on materials required to implement automatic daylighting controls for 170 watts of controlled lighting power, then normalized impacts on a per-watt basis (Wen, Daylighting: Final CASE Report, 2023). Impacts were converted to pounds per canopy square foot using the fixture coverage area, PPE, and PPFD for a 40kW zone. Statewide estimates were developed by multiplying these per-unit values by the first-year impacted square footage.

Table 44 shows the per-unit impacts, first-year statewide impacts, and embodied GHG emissions savings. The conversion from pounds per canopy square foot to the statewide values follows the same approach as the conversion of energy saved per canopy square foot to statewide energy savings, including both new construction and alterations. No change is expected for mercury; however, increases are anticipated for lead, copper, steel, plastic, zinc, aluminum, lithium, and manganese dioxide. Additional minor material increases are expected in metals used in circuit boards and chemicals found in batteries.

**Table 44: First-Year Statewide Impacts on Material Use**

Material	Impact	Per-Unit Impacts (Pounds per Canopy Square Foot)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO <sub>2</sub> e)
Mercury	No Change	0	0	0
Lead	Increase	0.0001	72	-0.04
Copper	Increase	0.0521	28,540	-36.25
Steel	Increase	0.0622	34,046	-18.73
Plastic	Increase	0.6442	352,695	-296.26
Zinc	Increase	0.0005	252	-0.36
Aluminum	Increase	0.0022	1,188	-4.43
Lithium	Increase	0.0006	324	-1.05
Manganese Dioxide	Increase	0.0014	756	-0.34
<b>TOTAL</b>	<b>N/A</b>	<b>0.76</b>	<b>417872</b>	<b>-357.45</b>

### **3.5.5 Environmental Impacts**

Requiring daylight responsive controls for greenhouses with at least 40 kW of supplemental lighting is expected to provide clear environmental benefits by lowering energy use and, in turn, reducing GHG emissions from electricity generation. The Statewide CASE Team did not identify any indirect benefits or any adverse environmental impacts, whether direct or indirect, associated with this measure, so mitigation strategies are not needed. In addition, review found no reasonable alternatives that could achieve the same reduction in CEH lighting energy consumption with fewer environmental effects. Because the proposed requirement improves efficiency without introducing negative consequences and no other options offer comparable results, the proposed changes represent the most practical and environmentally responsible approach. At the time of the draft report, the Statewide CASE Team anticipates no impact on material consumption. However, these impacts will continue to be evaluated through stakeholder outreach and updated as new information becomes available.

### **3.5.6 Other Non-Energy Impacts**

The proposed measure may lead to several non-energy impacts relevant to CEQA analysis. Initial equipment and installation costs could affect small or independent CEH operators, particularly those serving rural or low-income markets. Health and safety benefits include reduced waste heat from added daylight responsive controls, which can improve worker comfort. Lower energy use also enhances grid resilience and reduces pollution exposure for communities near industrial or power generation sites, improving environmental quality. Over time, energy savings can strengthen the financial viability of CEH operations, supporting sustainable employment and economic participation in ESJ communities engaged in agriculture and indoor production. No additional impacts beyond these have been identified at this stage, but the Statewide CASE Team will continue to evaluate potential effects through stakeholder engagement.

## **3.6 Daylight Responsive Controls for Greenhouses - Proposed Code Language**

### **3.6.1 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 should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

### **3.6.2 Administrative Code (Title 24, Part 1)**

There are no proposed changes to Title 24, Part 1.

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

#### SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

**DAILY LIGHT INTEGRAL (DLI):** Photosynthetic photon flux density (PPFD) of daylight and electric light integrated over 24 hours in units of mol/m<sup>2</sup>/day.

**DAILY LIGHT INTEGRAL (DLI) CONTROL:** A lighting control strategy that uses the calculated Daily Light Integral (DLI) of the daylight and electric light to adjust supplemental lighting intensity to achieve a DLI target.

**LUMINAIRE PHOTOSYNTHETIC PHOTON EFFICACY (PPE)** is photosynthetic photon flux emitted by a luminaire between 400 and 700 nm divided by input electric power in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.

**PHOTOSYNTHETIC PHOTON FLUX (PPF)** is the rate of flow of photons between 400 to and 700 nanometers in wavelength from a radiation source, expressed in units of μmol/s, as defined by ANSI/ASABE S640.

**PHOTOSYNTHETIC ACTIVE RADIATION (PAR):** A unit of measure of radiation relevant to plant growth, falls in the wavelength range of 400-700 nm.

**PHOTOSYNTHETIC PHOTON FLUX DENSITY (PPFD):** Photosynthetic Photon Flux per unit of surface area, expressed in micromoles per square meter per second (μmol/m<sup>2</sup>/s), as defined by ANSI/ASABE S640.

**PAR SENSOR:** A device that measures photosynthetic photon flux density (PPFD) in the photosynthetically active radiation (PAR) range of 400 to 700 nanometers, typically expressed in micromoles per square meter per second (μmol/m<sup>2</sup>/s) and used to monitor light levels for the purpose of managing and controlling CEH lighting systems.

SECTION 120.6(h) - Mandatory requirements for Controlled Environment Horticulture (CEH) spaces.

**1. Indoor growing, dehumidification.** Dehumidification equipment shall be one of the following: ...

~~**2. Indoor growing, electrical power distribution systems.** Electrical power distribution systems serving CEH spaces shall be designed so that a measurement device is capable of monitoring the electrical energy usage of aggregate horticultural lighting load.~~

3. Conditioned greenhouses, building envelope....

4. Conditioned greenhouses, space-conditioning systems...

**5. Horticultural lighting.** ~~In a building with CEH spaces or a greenhouse with more than~~ Where more than 40 kW of aggregate horticultural lighting load is installed to serve

indoor growing spaces or greenhouse spaces, the electric lighting system used for plant growth and plant maintenance shall meet the following requirements:

~~A. The horticultural lighting systems shall have a photosynthetic photon efficacy (PPE) rated in accordance with ANSI/ASABE S640 for wavelengths from 400 to 700 nanometers and meet one of the following requirements:-~~

~~i. Integrated, nonserviceable luminaires shall have a rated PPE of at least 1.72.3 micromoles per joule; or~~

~~ii. Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 1.72.3 micromoles per joule.~~

**A. Luminaire PPE and Dimmability.** Horticultural lighting shall have a luminaire photosynthetic photon efficacy (PPE) of at least 2.5  $\mu\text{mol}/\text{J}$  when tested at the manufacturer-designed state with the highest power consumption. Horticultural lighting shall be capable of continuous dimming between 100% and 10% of full power in response to a line voltage, low voltage, or wireless signal.

**B. Separation of horticultural lighting circuits for electrical energy monitoring.** Electrical power distribution systems shall be designed so that horticultural lighting circuits are separated from other loads. This separation enables measurement devices to monitor horticultural lighting energy use if desired, per 130.5(b).

~~B. Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4 and applicable sections of Reference Nonresidential Appendix NA7.6.2.~~

~~C. Multilevel lighting controls shall be installed and comply with Section 130.1(b).~~

**C. Indoor growing space lighting control.** Horticultural lighting systems serving indoor growing spaces shall be controlled by an automatic scheduling device that complies with all of the following:

i. The control shall be capable of scheduling at least four different control levels per day per control zone, where the scheduled control levels are capable of dimming lighting between 100% and 10% of full power and capable of turning lighting off.

ii. The lighting scheduling device shall be configured to control each zone separately.

iii. The lighting scheduling device shall be configured to control no more than 20 kW of lighting separately.

iv. The lighting scheduling device shall have program backup capabilities that prevent the loss of the device's schedule for at least 7 days and the device's date and time for at least 72 hours if power is interrupted.

**D. Greenhouse lighting control.** Horticultural lighting systems serving greenhouse spaces shall be controlled by items i and ii, or by item iii.

**i. Automatic greenhouse lighting scheduling control.** An automatic lighting scheduling device in greenhouses must meet the following requirements:

a. A scheduling device that can automatically turn lights on and off at least 4 times per day per control zone must be installed.

b. Each scheduling device shall control no more than 40 kW of connected lighting per control zone.

c. The device must include program backup capabilities that retain the lighting schedule for at least 7 days during power loss and preserve the date and time settings for at least 72 hours during a power interruption.

1. Greenhouse daylight responsive control. The PAR-sensor and controller shall:

Appendix A Control up to 40 kW of connected lighting per control zone,

Appendix B Be capable of automatically dimming lighting continuously from 100% to 10% of full power based on available PPFD,

Appendix C Turn off the electric lighting when daylight PPFD exceeds the crop's target user-defined PPFD, and

Appendix DA single sensor may serve multiple control zones if each zone has separately configured calibration settings.

2. Greenhouse Daily Light Integral (DLI) control. Control shall:

Appendix E Be capable of dimming electric lighting between 100% and 10% of full power and turning lighting off.

Appendix F Automatically dim the electric lighting based on user-defined DLI from both daylight and electric light.

Appendix G Each control zone may include up to 40 kW of connected lighting load.

Appendix HA single sensor may serve multiple control zones, as long as:

i. Each zone has independent calibration settings, and

ii. DLI is calculated separately for each zone.

### **3.6.4 Reference Appendices**

Appendix NA7.X Controlled Environment Horticulture Acceptance Tests

NA7.x.1 Horticulture Lighting Controls Acceptance Tests

NA7.x.1.1 Indoor Growing Space Lighting Control Construction Inspection

Prior to Functional testing, verify and document the following:

- (a) Lighting control zones are shown on plan documents.
- (b) Electric lighting power for each control zone is shown on plan documents, and maximum lighting power for all zones does not exceed 20 kW per zone.
- (c) The automatic time schedule controls showing at least four different schedule periods per day and lighting dimming setpoints for each period are shown on plan documents.
- (d) Automatic time schedule control is installed and programmed to match the schedule and lighting dimming setpoints on the plan documents.
- (e) The correct time and date are properly set in the lighting scheduling controller.
- (f) The battery back-up is installed and energized.

#### NA7.x.1.2 Indoor Growing Space Automatic Scheduled Dimming Control Functional Testing

For buildings with up to 5 lighting control zones, all control zones shall be tested. For buildings with more than 5 lighting control zones, sampling may be performed provided at least 25% of lighting control zones are tested and at least 5 lighting control zones are tested. Record all measurements within a zone at the same location for all test steps.

- (a) **Full Output Test.** Using the lighting control system, set the lighting to full (100%) output.
  - 1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured.
- (b) **75% Output Test.** Using the lighting control system, set the lighting to 75% output.
  - 1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 25% from Full Output Test.
- (c) **50% Output Test.** Using the lighting control system, set the lighting to 50% output.
  - 1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 50% from Full Output Test.

**(d) 10% Output Test.** Using the lighting control system, set the lighting to 10% output.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 90% from Full Output Test.

**(e) Full Off Test.** Using the lighting control system, set the lighting system to full off.

1. Verify all lights in the control zone turn off.

### NA7.x.1.3 Greenhouse Lighting Control Construction Inspection

Prior to Functional testing, verify and document the following:

- (a) Lighting control zones are shown on plan documents.
- (b) Electric lighting power for each control zone is shown on plan documents, and maximum lighting power for all zones does not exceed 40 kW per zone.
- (c) Electric lighting control method is shown on plans:
  1. Automatic Scheduling with Daylight Responsive control, or
  2. Daily Light Integral (DLI) control
- (d) PAR sensor locations and associated lighting control zone(s) are shown on plan documents.
- (e) If Automatic Scheduling with Daylight Responsive control is used, verify the following information:
  1. The automatic time schedule controls showing at least four different schedule periods per day and lighting dimming setpoints for each period are shown on plan documents.
  2. Automatic time schedule control is installed and programmed to match the schedule and lighting dimming setpoints on the plan documents.
  3. The correct time and date are properly set in the lighting scheduling controller.
  4. The battery back-up is installed and energized.

### NA7.x.1.4 Greenhouse Automatic Scheduled Dimming Control Functional Testing

For greenhouses with up to 5 lighting control zones, all control zones shall be tested. For greenhouses with more than 5 lighting control zones, sampling may be performed provided at least 25% of lighting control zones are tested and at least 5 lighting control zones are tested. Record all measurements within a zone at the same location for all test steps.

**(a) Full Output Test.** Using the lighting control system, set the lighting to full (100%) output. Override or cover PAR sensors if needed so that daylight does not affect electric lighting levels registered by the lighting control system.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured.

**(b) 75% Output Test.** Using the lighting control system, set the lighting to 75% output. Override or cover PAR sensors if needed so that daylight does not affect electric lighting levels registered by the lighting control system.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 25% from Full Output Test.

**(c) 50% Output Test.** Using the lighting control system, set the lighting to 50% output. Override or cover PAR sensors if needed so that daylight does not affect electric lighting levels registered by the lighting control system.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 50% from Full Output Test.

**(d) 20% Output Test.** Using the lighting control system, set the lighting to 20% output. Override or cover PAR sensors if needed so that daylight does not affect electric lighting levels registered by the lighting control system.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 80% from Full Output Test.

**(e) Full Off Test.** Using the lighting control system, set the lighting system to full off.

1. Verify all lights in the control zone turn off.

#### NA7.x.1.5 Greenhouse Daylight Responsive Control Functional Testing

Greenhouses complying via with 120.6(h)5D via automatic scheduling and daylight responsive controls shall be subject to this test. For greenhouses with up to 5 lighting control zones, all control zones shall be tested. For greenhouses with more than 5 lighting control zones, sampling may be performed provided at least 25% of lighting control zones are tested and at least 5 lighting control zones are tested. Record all measurements within a zone at the same location for all test steps.

**(a) Full Output Test.** Using the lighting control system, set the lighting system to full (100%) output. Override or cover PAR sensors if needed so that daylight does not affect electric lighting levels registered by the lighting control system.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured.

**(b) No Daylight Test.** Simulate or provide conditions without daylight. Verify and document the following:

1. Daylight responsive control system turns on all controlled lighting to meet PPFD setpoint.
2. Record the PPFD, which should be equal to the setpoint PPFD.
3. Light output is stable with no visible flicker.
4. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.

**(c) Full Daylight Test.** Simulate or provide bright conditions where the daylight PPFD is above the setpoint PPFD. Verify and document the following:

1. All lights in the control zone turn off.
2. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.

**(d) 95% Daylight Test.** Simulate or provide bright conditions where the daylight PPFD is 95% of the setpoint PPFD. Verify and document the following:

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 80% from Full Output Test.
2. Light output is stable with no visible flicker.
3. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.

**(e) Partial Daylight Test.** Simulate or provide daylight conditions where the daylight PPFD is 20-95% of the setpoint PPFD. Verify and document the following:

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a reduction of 5-80% from Full Output Test.
2. Light output is stable with no visible flicker.
3. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.

### NA7.x.1.b Greenhouse Daily Light Integral Control Functional Testing

Greenhouses complying via with 120.6(h)5D via DLI Controls shall be subject to this test. For greenhouses with up to 5 lighting control zones, all control zones shall be tested. For greenhouses with more than 5 lighting control zones, sampling may be performed provided at least 25% of lighting control zones are tested and at least 5 lighting control zones are tested. Record all measurements within a zone at the same location for all test steps.

**(a) Design DLI Setpoint Test.** Using the lighting control system, set the lighting system DLI setpoint to the design setpoint.

1. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured.

**(b) Reduced DLI Setpoint Test.** Using the lighting control system, set the lighting system DLI setpoint to 50% of the design setpoint.

1. Daylight responsive control system dims all controlled lighting to meet reduced DLI setpoint.
2. Record the lighting illuminance level at the grow table surface. Alternatively, total electrical current for the lighting control zone may be measured. Measured value must show a 50% reduction (but from the Design DLI Setpoint Test).
3. Light output is stable with no visible flicker.
4. Only luminaires in the lighting control zone are affected by the zone's DLI setpoint.

### **3.6.5 Compliance Manuals**

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published. See Section 3.1.4.3 for more information about recommended revisions.

### **3.6.6 ACM Reference Manual**

The Statewide CASE Team finds necessary no proposed changes to the ACM Reference Manual for this measure.

### **3.6.7 Compliance Forms**

As discussed in Section 3.1.4 and Section 3.2.4, the existing Process System Certificate of Compliance form (NRCC-PRC-E, Section P: Controlled Environment Horticulture) and Process System Certificate of Installation form (NRCI-PRC-E, Controlled Environment Horticulture Lighting section) would both need new input fields

added to ensure that CEH lighting controls meet new and revised requirements. A new form, (NRCA-PRC-XX-F, Nonresidential Certificates of Acceptance), would need to be created to demonstrate compliance with new field technician acceptance testing requirements for CEH facilities.

The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

# 4. Space Conditioning Systems

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## 4.1 Space Conditioning Systems - Measure Description

### 4.1.1 Proposed Code Change

This proposed measure would establish mandatory sizing requirements and controls requirements for space conditioning systems providing heating, cooling, and dehumidification to support plant growth in CEH indoor growing spaces and would prescriptively require these systems meet key functional and performance metrics.

These requirements would only apply to space conditioning systems serving CEH spaces with a lighting power density greater than 30 watts (W) per plant canopy square foot in indoor CEH facilities with at least of 5000 ft<sup>2</sup> of plant canopy<sup>4</sup>. California indoor CEH spaces with this level of lighting intensity are typically found only in cannabis production facilities. California's Department of Cannabis Control (DCC) issues cultivation licenses for five different sizes of indoor cultivation facilities, based on plant canopy area. These requirements would only apply to the three largest types of facilities regulated by DCC (Small, Medium, and Large) and would exclude the two smallest types (Specialty Cottage and Specialty).

The Statewide CASE Team has developed a new indoor CEH prototype and building energy model for facilities meeting these conditions. The Statewide CASE Team is recommending that these capabilities be introduced to the California Building Energy Code Compliance Software (CBECC) software. Should this space type be available in the CBECC software, facilities subject to these new prescriptive requirements would also have the option to comply via the performance pathway.

These proposed requirements recognize that functions of cooling and dehumidification equipment are highly interactive and must be considered together, as a part of a space conditioning system that manages both temperature and humidity in CEH spaces. The prescriptive requirements would require the applicant to identify a primary space conditioning system on the design documents. This primary system would be required to have a variable sensible heat ratio, to be capable of modulating the amount of dehumidification process heat recovered to reheat dehumidified air between 10 percent

<sup>4</sup> Plant Canopy Area is the aggregate horizontal surface area occupied by actively growing vegetation within a cultivation facility. It is measured by the boundaries of the specific grow trays/benches utilized, excluding non-productive spaces such as aisles, walkways, ancillary equipment zones, and structural columns.

and 90 percent, and to be sized to meet at least 80 percent of the peak combined sensible and latent load.

These prescriptive requirements of variable SHR (sensible heat ratio), modulating heat recovery, and minimum size of a combined cooling and dehumidifying system would be used to set an energy budget for compliance via the performance approach where any system that can be modelled could comply if it requires less long-term energy cost than the base system.

Because the prescriptive requirements are based on a functional description of range of required sensible heat ratios, range of heat recovery modulation and minimum combined cooling and dehumidification size to design capacity, a variety of primary systems could comply with the requirements such as an integrated direct expansion (DX) system, a desiccant-based system, or a heat recovery chiller system.

An example compliant integrated DX system is repurposed DX Dedicated Outdoor Air System (DOAS) or pool dehumidification equipment that has configured, sized, and programmed for 100% recirculated air. Integrated DX systems use variable speed or staged compressor systems in combination with variable speed fans to modulate the ratio of sensible cooling to dehumidification that occurs at the evaporator coil, depending on supply air conditions and humidity and temperature setpoints. The dehumidified air then passes over an indoor reheat coil to reheat the air to desired supply air temperature using waste heat from the dehumidification process. These systems modulate the amount of waste heat that goes to the indoor reheat coil versus rejecting the heat to an outdoor condenser coil, in a process known as modulating hot gas reheat.

An example of a compliant desiccant system is Mojave HVAC's liquid desiccant cooling and dehumidification system that cools incoming air and dehumidifies with a liquid desiccant. This system uses condenser heat for the regeneration (desiccant drying) process.

A four-pipe heat recovery chiller system uses a chilled water loop and fan coils to dehumidify and cool return air, with a separate hot water loop that reheats the dehumidified air to the desired temperature. Water in the hot water reheat loop is heated using waste heat generated through the process of cooling the water supplied to the chilled water loop.

The mandatory sizing requirement would require the submission of calculated sensible and latent loads and sizing calculations for space conditioning systems serving indoor CEH spaces with a lighting power density greater than 30 W per canopy square foot. The method for calculating the load and the sizing requirements would be defined in a new Nonresidential Appendix.

In addition to the primary space conditioning system, the proposed requirements would allow the use of supplemental equipment to meet sensible or latent loads exceeding the primary system's capacity.

Mandatory requirements would require the installation of a central control system that fully utilizes the capacity of the primary space conditioning system, modulates heat recovery to provide the minimum heat needed, and when additional capacity is needed, stages the minimum amount of supplemental capacity.

Mandatory requirements for the primary system would require that it be controlled to do the following:

- Modulate sensible heat ratio (SHR) in response to room conditions and temperature and humidity setpoints;
- Modulate reheat to reject or recover dehumidification process heat, as needed to meet supply air setpoints; and
- Limit the use of primary heating (i.e. resistance, furnace, or boiler) heat to periods when the use of recovered process heat cannot meet supply air setpoints.

Controls for supplemental unitary dehumidification equipment without variable SHR or heat rejection capability would be required to do the following:

- Integrate and stage supplemental equipment with primary system to meet temperature and humidity setpoints;
- Stage unitary dehumidifiers in response to humidity sensors (including those that measure relative humidity, dewpoint, or wet bulb);
- Only activate dehumidification equipment when either: 1) all waste heat can be used in the space without creating additional cooling load, or 2) the primary system cannot satisfy 100 percent of cooling, heating, and dehumidification loads.

The requirements would be the same for all 16 California Climate Zones. The proposed requirements would apply to new construction, additions, and major alterations. Replacing a single piece of equipment in a larger system would not trigger the requirements. The code would be triggered by additions or alterations that increase plant canopy area by at least 5000 square feet. The code would also be triggered by alterations that replace greater than 50 percent of the total capacity of heating, ventilation, air conditioning, cooling, and dehumidification systems serving at least 5000 square feet of plant canopy area in indoor growing.

This code change proposal would also revise requirements for outdoor air ventilation requirements, that may negatively impact plant growth or efficiency in CO2 enriched spaces.

Title 24, Part 6 does not currently include prescriptive measures for CEH spaces, and CBECC does not currently include an indoor CEH prototype. To provide facility designers with flexibility in equipment selection, the Statewide CASE Team recommends that CBECC is updated so it can be used to demonstrate compliance using the performance approach.

Table 45 summarizes the scope of the proposed code change.

**Table 45: 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 including 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	<ul style="list-style-type: none"> <li>Part 6, Sections 100.1, 120.6(h), 140.9, and 141.1(c)</li> <li>Nonresidential Reference Appendix Sections 7 and 9</li> </ul>	NRCC-PRC-E NRCI-PRC-E NRCA-PRC-X	<ul style="list-style-type: none"> <li>NRACM Section 2.4, 2.6.2, 5.1.3, 5.4.9, Appendix 5.4 A&amp;B</li> </ul>

Third Party Verification)	Updates to Compliance Software
<input checked="" type="checkbox"/> No changes to third party verification	<input type="checkbox"/> No updates
<input type="checkbox"/> Update existing verification requirements	<input type="checkbox"/> Update existing feature
<input type="checkbox"/> Add new verification requirements	<input checked="" type="checkbox"/> Add new feature
<input checked="" type="checkbox"/> New acceptance testing requirements performed by a field technician	

### 4.1.2 Benefits of Proposed Change

CEH facilities, particularly indoor facilities with high lighting power density, are among the most energy-intensive buildings in California. In these facilities, the lighting and space conditioning systems make up about 80 percent of energy consumption, split roughly evenly between the two systems. Each of these two end-uses provides significant opportunities for savings. Until this code cycle, CEH lighting has been the primary focus of Title 24, Part 6, leaving significant opportunity for code to regulate CEH space conditioning systems and achieve deep statewide savings. For indoor cannabis facilities, flower rooms contribute roughly 86 percent of facility energy use. A field study of flower rooms in two California CEH facility found an average Energy Use Intensity (EUI) of 760 kBtu/yr per ft<sup>2</sup> (Stober & Weitze, 2024).

Since large-scale indoor farming is relatively new, driven primarily by legalization of cannabis in California, CEH facility designers initially had little choice but to repurpose conventional HVAC equipment and dehumidifiers to manage sensible and latent loads in indoor farms. However, space conditioning systems designed to support plant growth need to adapt to highly variable latent and sensible loads (room SHR), which can most effectively be conditioned by HVAC and dehumidification systems with variable equipment SHR<sup>5</sup> (sensible heat ratio). Sizing methods, design approaches, and equipment requirements are vastly different from those for spaces designed primarily for human occupancy, and equipment designed to maintain human comfort is poorly suited to the unique conditions found in CEH process spaces. (A CEH process space is any room or area where the primary function is the cultivation of plants, and the environmental conditions are controlled for the plant-growing process, not for human comfort.)

Over the past decade, industry has significantly advanced the development of variable capacity, fully integrated space conditioning systems suitable for high latent loads, and capable of quickly adjusting to highly variable loads, which offer better environmental control and far more efficient operation than fixed-capacity fully decoupled<sup>6</sup> systems. Unfortunately, many designers continue to use inefficient fully decoupled equipment in the design of new facilities, even though much more efficient, better performing, integrated equipment is now available from multiple manufacturers and has been recommended for energy efficiency and more precise environmental control in industry best practices guides for several years (Resource Innovation Institute, 2022; Harris Design Studio, 2022).

<sup>5</sup> Room SHR refers to the ratio of sensible to total (both latent and sensible) heat in the space, while Equipment SHR refers to the ratio of sensible cooling capacity to total cooling capacity of the cooling/dehumidification equipment (prior to reheat).

<sup>6</sup> Background section provides relevant definitions.

The market's failure to broadly adopt this more efficient space conditioning equipment presents an excellent opportunity for the energy code to develop new efficiency requirements for CEH facilities.

The opportunity for energy savings is very high because energy intensity of indoor farms is very high, market adoption of efficient space conditioning systems is relatively low, and the current energy code language does not address CEH HVAC systems or the interaction between HVAC and dehumidification systems. Statewide CASE Team energy modeling of HVAC and dehumidification systems indicate that energy used by more efficient integrated HVAC/dehumidification (HVAC/D) systems is approximately 25 to 40 percent less than energy use by a decoupled, code-minimum HVAC and dehumidification system, consistent with measured and modeled data discussed in Section 4.1.3.

Furthermore, the more precise temperature and humidity control provided by variable-capacity integrated systems can increase crop yields, reduce mold risk, and help avoid crop loss. As demonstrated in a on Statewide CASE team review of recent unpublished data from 10 flower rooms and 42 grow cycles, facilities using these systems can produce more dried product per square foot and per kWh, improving both space and energy resource efficiency. Note that this study was a parallel comparison across different facilities, not a before/after upgrade.

### **4.1.3 Background Information**

CEH refers to the practice of growing plants in controlled in a protected, enclosed space where factors such as light, temperature, humidity, and airflow can be carefully managed. CEH can refer to cultivation in greenhouses or in indoor facilities without external light sources. CEH methods and spaces can be used to grow crops like vegetables, herbs, microgreens, flowers, and mushrooms, although over 90 percent of indoor CEH facilities in California are used to grow cannabis. The proposed code changes apply to indoor growing spaces with lighting power density greater than 30 W per square foot of plant canopy area. The Statewide CASE Team attributes these high-density lighting applications specifically to cannabis flowering rooms in indoor grow facilities.

#### **4.1.3.1 Cannabis Indoor CEH Facilities**

Although cannabis is also grown outdoors and in greenhouses, many growers opt for indoor CEH because it offers control over every environmental variable, including artificial light, temperature, humidity, and carbon dioxide at a level of precision impossible to achieve in greenhouses or outdoors. This precise management significantly increases yields and allows growers to engineer specific product characteristics that command premium prices in the medicinal and recreational markets. The tradeoff is that these complex facilities are inherently energy intensive, relying on

specialized, climate-controlled spaces for every stage of the cannabis lifecycle from germination up to the final flowering and harvestable phase.

Indoor cannabis cultivation is among the most energy-intensive building types, second only to data centers (Sabeh, Miner, & Perman, 2022). However, unlike data centers, which can relocate to states with lower electricity costs, cannabis sold in California must be grown and processed within the state due to federal regulations.

The cannabis flowering cycle lasts eight to ten weeks under a twelve-hour photoperiod, progressing through early (weeks 1–3), mid (weeks 4–6), and late bloom (weeks 7–9), with each stage requiring distinct temperature, humidity, and HVAC setpoints (Mr. Grow It, 2025). Cannabis flower rooms have been found to be the most energy-intensive spaces among CEH facilities and present unique HVAC challenges due to their highly variable thermal loads, primarily driven by dehumidification demands from evapotranspiration throughout the grow cycle (Stober & Weitze, 2024). Since evapotranspiration also provides a cooling effect, the volume of water transpired by mature plants can offset most or all the sensible load generated by lighting. However, since far less water is transpired by immature plants, the early stage of each flower cycle is dominated by sensible cooling load.

Lighting and space conditioning systems together account for approximately 80 percent of total energy use in facilities using high-pressure sodium (HPS) lighting (Mills, 2012; Stober & Weitze, 2024; Energy & Resource Solutions, Inc., 2020; Electricity Consumption from Northwest Cannabis Production, 2017). As growers transition to more efficient LED lighting, the proportion of energy used for space conditioning is expected to increase. This shift highlights the growing importance of regulating HVAC and dehumidification systems to achieve energy savings.

#### **4.1.3.2 Cannabis Space Conditioning Systems**

Space conditioning systems in indoor cannabis farms are engineered not for human comfort, but for crop optimization. Just like light and nutrients, strict control over temperature and humidity is critical for ensuring the quality and maximizing the yield of the final product. To achieve the best production and most desirable characteristics, growers maintain extremely tight environmental tolerances to ensure the correct Vapor Pressure Deficit (VPD) is consistently provided throughout the plant's development.

Vapor pressure deficit quantifies the driving force of transpiration, defined as the difference between the saturation vapor pressure and the actual vapor pressure of the surrounding air. This relationship is expressed as  $VPD = \text{Saturation Pressure} \times (1 - RH)$ . Because saturation vapor pressure increases exponentially with air temperature, maintaining a constant VPD as temperatures rise, requires an increase in relative humidity. Consequently, effective facility management requires precise, simultaneous control of both temperature and humidity.

#### **4.1.3.2.1 Equipment Sensible Heat Ratio vs. Room Sensible Heat Ratio**

Sensible heat ratio (SHR) is often used interchangeably to refer to room conditions and space conditioning equipment performance parameters. However, room SHR refers to the heating/cooling load of the air in a space, while equipment SHR refers to the performance of air conditioning and dehumidification equipment. Room SHR is the ratio of sensible heat load to the total (latent plus sensible) heat load of a space, while equipment SHR is the ratio of sensible cooling capacity to total (latent plus sensible) cooling capacity or a specific piece of equipment.

In California's relatively dry climate, in nonresidential settings like office buildings commercial HVAC equipment with a high SHR rating (such as variable refrigerant flow, or VRF) tends to operate more efficiently, since it does not unnecessarily expend energy on latent removal. However, since it is ineffective at dehumidification, high SHR rating equipment must be used in combination with low SHR equipment, such as standalone dehumidifiers, to control both latent and sensible loads in cannabis farms.

#### **4.1.3.2.2 Evolution of Space Conditioning Systems in California Cannabis Facilities**

Historically, indoor CEH facilities have used residential and commercial-grade equipment that does not meet the dynamic environmental demands of modern indoor agriculture facilities.

Some of the first cannabis facilities constructed used commercial comfort cooling equipment, such as fixed capacity rooftop units (RTUs), as the primary method to control both temperature and humidity. Although this equipment typically has a relatively high equipment SHR, it can remove some humidity during the cooling process. Due to the amount of heat generated by the lighting, early cannabis farms that used high intensity discharge lighting (such as high-pressure sodium and metal halide) had relatively high room SHRs during lights-on conditions. Since both cooling and dehumidification were needed during many of these hours, using comfort cooling equipment for both cooling and some dehumidification was a viable, if not ideal, solution.

However, when latent load exceeds sensible load in these spaces (such as when lights turn off but plants continue to transpire at a high rate), the evaporative cooling effect creates a condition where dehumidification and sensible heating are needed. Under these conditions, comfort cooling equipment is very poorly suited to the loads. The air conditioning (AC) must continue to run as an inefficient dehumidifier, but it must then reheat the supply air to a higher temperature than the return air to meet the high heating loads. In conventional commercial HVAC equipment, this heating is provided by a gas furnace or electric resistance (which offers more precise temperature control).

To address this issue, cannabis farmers paired standalone dehumidifiers with high-SHR cooling equipment. Since standalone dehumidifiers reject process heat into the space, operating them during lights out conditions is a much more efficient way to meet heating loads in the space, reducing or eliminating the need for the air conditioning to operate at night, and reducing or eliminating the need for a furnace or resistance heat during those periods.

Most small, medium, and many large indoor cannabis farms in California now rely on these decoupled systems using standard commercial packaged or split DX or VRF units for sensible cooling, in combination with standalone dehumidifiers for latent load removal. Compared with using a commercial HVAC system to provide cooling, dehumidification, and heating, these systems offer a more efficient solution, especially if controlled correctly.

Decoupled systems remain significantly less efficient than integrated solutions. Stand-alone dehumidifiers exhaust all their condenser heat back into the grow space. When decoupled systems operate during lights-on conditions, this heat adds to the cooling load, and the air conditioning system needs additional capacity to meet the additional load. This inefficiency is exacerbated if the stand-alone dehumidifiers are not properly staged, causing alternating pulses of heat and humidity within the grow room.

In contrast, integrated space conditioning systems combine cooling and dehumidification into a single unit capable of adapting to daily latent and sensible load shifts. They respond dynamically as lights turn on, increasing sensible load, and as plant transpiration increases latent load. Furthermore, integrated systems improve efficiency by intelligently managing condenser heat; waste heat can be rejected outdoors when not needed or recovered indoors to reheat the supply air to the precise desired temperature.

#### **4.1.3.2.3 Integrated Cannabis Space Conditioning Systems**

The most common type of integrated space conditioning system is integrated DX (Direct Expansion). Integrated DX dehumidification systems operate by using a refrigeration cycle to chill an incoming airstream below its dew point, which forces water vapor to condense into liquid water that is then drained. This process, however, results in air that is both dry and cold. To avoid overcooling the space, the "integrated" design channels the cool, dry air over a hot condenser coil. This reheat process recycles waste heat from the refrigeration cycle back into the airstream when needed. The system ultimately delivers dehumidified air at a neutral or warm temperature, allowing for precise control of humidity independent of cooling demands.

Integrated DX systems typically use variable speed compressors and variable speed fans to adjust coil temperature and fan speed, thereby adjusting the equipment sensible heat ratio. These integrated DX systems feature both indoor and outdoor condenser

coils, giving them precise control over heat re-use versus rejection. This design allows them to modulate how much waste heat is reclaimed to reheat the dehumidified air indoors, versus how much is rejected and discarded outdoors.

Some integrated DX equipment is purpose-built and marketed to the indoor agriculture industry, while other systems use commercially available DX dedicated outdoor air system (DOAS) equipment that is reconfigured by the mechanical designer for 100 percent recirculated air. Examples of purpose-built integrated DX equipment include products from manufactures such as Agronomic IQ, DesertAire, and Cultiva. Examples of off-the-shelf DX DOAS equipment that can be configured for 100% recirculated air include products from AAON, CaptiveAire, and Trane.

Four-pipe chilled water systems with heat recovery chillers have the have similar functionality as integrated DX systems, offering both variable equipment SHR and variable heat recovery/rejection. The key difference relies in operation: rather than modulating refrigerant temperature in the dehumidification coil, the Fan Coil Unit adjusts chilled water flow or fan speed to match the zone's dehumidification and cooling loads. When latent loads are high, the system sub-cools the air to remove moisture, then uses hot water generated by the heat recovery chiller to reheat air to the target supply air temperature.

#### **4.1.3.2.4 Decoupled Space Conditioning Systems**

Fully decoupled systems use cooling equipment designed for high-SHR applications in combination with dehumidification equipment designed for very low SHR, providing little overlap or redundancy between each piece of equipment. In these systems, cooling equipment is controlled by a thermostat and dehumidification equipment by a humidistat.

An example of a fully decoupled system is fixed capacity or two-stage RTUs controlled by a wall-mounted thermostat combined with multiple unitary, fixed-capacity dehumidifiers controlled by a single humidistat. The performance of the unitary dehumidifiers can be improved by staging each unitary dehumidifier to operate in sequence, in response to increasing dehumidification load. However, since unitary dehumidifiers do not have an outdoor condenser coil, staging fixed-capacity dehumidifiers does not allow them to modulate the total amount of process heat rejected into the space. As dehumidification load increases, so does the amount of heat rejected into the space, which must be removed (i.e., rejected outdoors) by the cooling system. Not only are these minimum efficiency dehumidifiers inefficient in terms of the dehumidification process, but they also generate more heat per liter of water removed, increasing the sensible load on cooling equipment. As such, decoupled system performance can be improved by using commercial dehumidifiers that exceed federal minimum efficiency requirements.

Although there are inefficiencies associated with their use as part of a decoupled system, standalone dehumidifiers are not inherently inefficient. Several of the units commonly used in cannabis flower rooms significantly exceed the federal minimum efficiency ratings for “federal appliance standards tested in accordance with 10 CFR 430.23(z) and Appendix X or X1 to Subpart B of 10 CFR Part 430 as applicable and complying with 10 CFR 430.32(v)2”.

Decoupled system performance can also be improved by using variable capacity cooling equipment, such as VRF. However, VRF cooling equipment can only modulate cooling capacity. Since standard space-conditioning VRF equipment is designed for high-SHR applications, it is ineffective for dehumidification, increasing the latent load that must be handled by standalone dehumidifiers.

Standard commercial DX and VRF systems, which rely solely on thermostat control, often struggle with humidity and airflow management during lights-off periods when sensible loads are minimal. In this scenario, standalone dehumidifiers become an efficient solution. Since plant’s evaporative cooling creates a heating requirement, the waste heat generated by the dehumidifiers can effectively offset this load, maintaining the room’s temperature while managing latent moisture.

This strategy – using standalone dehumidifiers during the lights off period – can be effectively paired with integrated systems that manage lights-on loads. However, this hybrid approach requires a central control system to synchronize the standalone dehumidifiers with the primary variable-SHR HVAC system. Accordingly, the proposed prescriptive code change permits the use of supplemental dehumidification, provided the equipment is automated to operate when the primary system cannot meet the full load, or when the waste heat generated by the dehumidifiers contributes usefully to the room’s heating requirements.

While optimization strategies exist for decoupled systems, integrated HVAC and dehumidification systems remain more efficient. These units intelligently manage waste heat - recovering it for reheat or rejecting it outdoors – which significantly reduces the burden on cooling components. A unified control system manages both functions, adjusting output precisely to match the grow room’s specific demands. Furthermore, the use of variable-speed compressors and fans allow the system to modulate output rather than inefficiently cycling at full power, ensuring precise temperature and humidity control across the full range of sensible and latent loads.

#### **4.1.3.2.5 Conventional HVAC Standards in CEH Process Spaces**

Conventional commercial HVAC codes and standards are ineffective for ensuring the efficiency of CEH facilities for several reasons. First, due to the significant overlap and interaction between dehumidification and cooling equipment, the performance of individual pieces of equipment is best evaluated in the context of the overall system.

Second, federal standards regulating commercial HVAC equipment and standalone dehumidifiers are based on operation in commercial and residential buildings. Federal test procedures and energy performance ratings, such as Energy Efficiency Ratio (EER) for air conditioning and Integrated Part Load Value IPLV – for chillers) establish baseline efficiency of regulated equipment, but the test procedures used to obtain these ratings are typically based on typical commercial building load profiles and set points. Critically, these standardized test conditions do not reflect the extreme, dynamic, sensible, and latent loads characteristic of indoor agriculture (Waite, 2023). Consequently, HVAC equipment's actual performance and efficiency in a CEH facility can deviate significantly from its official rating, underscoring the need for specialized code requirements tailored to grow environments. Furthermore, some of the most common integrated DX systems used in CEH facilities are based on pool dehumidifiers, which federal standards do not cover. As such, these products have no test procedures or minimum efficiencies, while similar systems are based on DX DOAS equipment, which are rated using the ISMRE2 (Integrated Seasonal Moisture Removal Efficiency) metric.

Efficiency ratings are often unavailable for equipment used in CEH facilities and existing test procedures do not reflect the actual operating conditions in these facilities. Therefore, the proposed code changes focus on other performance-based requirements including modulating dehumidification capacity, load sizing calculations, and controls verification, which are not addressed by federal or ASHRAE standards. These additions aim to improve energy performance and system reliability for CEH applications.

#### **4.1.3.2.6 Minimum Ventilation Rates**

Section 120.1 – Requirements for Ventilation and Indoor Air Quality, includes minimum ventilation rates for different categories nonresidential buildings. However, there are no specific requirements for CEH spaces, including those enriched with CO<sub>2</sub> to support plant growth. As such, the cannabis design and construction industry and building officials have had to interpret how ventilation requirements should apply to these unique spaces. Several SMEs involved with HVAC/D design for CEH spaces in cannabis facilities report that industry standard practice is to provide little-to-no outdoor air ventilation to these spaces. This design practice is employed to retain CO<sub>2</sub> and exclude plant pathogens from the growing space.

Absent specific requirements for CEH spaces, designers and code officials must interpret how these spaces should be categorized. The most logical classifications in Table 120.1-A – Minimum Ventilation Rates include Miscellaneous Spaces such as Warehouse and All Others, which require a Total Outdoor Air rate of 0.15 cfm/ft<sup>2</sup>.

However, several SMEs have reported that many code officials recognize the reasoning behind eliminating continuous outdoor air ventilation in CO<sub>2</sub>-enriched CEH spaces, and either exempt or fail to enforce these requirements.

Since workers enter these CEH spaces periodically, it is important to consider impacts and risks to occupant health when determining what ventilation rate is appropriate. The primary risk to occupant health in CO<sub>2</sub>-enriched CEH spaces is elevated CO<sub>2</sub> levels. However, this risk is addressed and mitigated by the California Fire Code, Title 24, Part 9.

Section 5307.4 of the 2025 fire code covers the design, installation, and maintenance of carbon dioxide enrichment systems. Requirements include a gas detection system that activates an alarm when CO<sub>2</sub> concentration is 5,000ppm or above. The gas detection system is also required to stop the flow of CO<sub>2</sub> and activate the mechanical exhaust ventilation system. This exhaust ventilation system must have a flow rate of at least one cfm/square foot and shall remain on until manually reset. Rooms or indoor areas with CO<sub>2</sub> enrichment must also be maintained at a negative pressure in relation to surrounding areas in the building. This can be accomplished by using supply ventilation in surrounding areas and therefore does not require continuous exhaust ventilation to be used in the CO<sub>2</sub>-enriched CEH space.

The only nonresidential space in Table 120.1-A that does not have a minimum requirement for outdoor air ventilation rate is Miscellaneous Spaces – Freezer and refrigerated spaces (<50F). Much like CO<sub>2</sub>-enriched CEH spaces, freezers and refrigerated spaces are process spaces that are occasionally occupied, but which conditioned for a commercial purpose other than human occupancy.

Since mechanical ventilation requirements addressing the primary indoor air quality risk to occupants is already covered by the fire code, and since there is precedent to eliminating minimum continuous ventilation requirements for process spaces, a new “CO<sub>2</sub>-Enriched CEH space) category could be added to Table 120.1-A, setting minimum ventilation rates to zero, in-line with industry practice.

#### **4.1.3.2.7 Estimated Energy Savings from Integrated Systems**

Energy modeling by the Statewide CASE Team shows that integrated systems can reduce HVAC and dehumidification energy use by approximately 40 percent compared with code-minimum systems. A recent unpublished field study reviewed by the Statewide CASE Team measured energy consumption in 10 cannabis flower rooms, finding an average of 38 percent energy savings for integrated HVAC systems on a kWh per ton basis, when compared with non-integrated systems. This was a parallel comparison, not a before/after upgrade. In a case study, a facility in Portland, Oregon, achieved a 44 (Smith, Redding, Braddock, & Svaren, 2019)<sup>[OBJ]</sup>. In another case study, a cannabis farm in Canby, Oregon had 30 percent HVAC energy savings with installation of (Energy Trust of Oregon, 2018)<sup>[OBJ]</sup> (Southern California Edison, 2021)<sup>[OBJ]</sup> of CEH facilities and the slow pace of market transformation, updating the code to support integrated space conditioning systems could yield significant statewide energy savings and help buildings become better grid citizens.

A chilled water system with heat recovery can offer additional energy savings over integrated DX and becomes cost effective for facilities above 4,000 to 6,000 square feet of flower room canopy (Kolwey, 2017; Southern California Edison, 2021). Heat recovery is typically achieved using either a flat plate heat exchanger or a wrap-around heat pipe. These devices are installed within the air handling unit to efficiently precool the return air and simultaneously reheat the supply air. Utilizing this process can effectively reduce cooling requirements by 35 percent or more, resulting in a smaller system required to meet the facility's loads (ACHR, 2021). While chilled water systems are typically more expensive than traditional HVAC for small and mid-sized facilities, their initial cost can become competitive with other options in large-scale facilities (Cannabis Sustainability Work Group, 2022).

#### **4.1.3.2.8 Sizing CEH Space Conditioning Systems**

The core difficulty in sizing for high lighting power density CEH facilities lies in the fact that cannabis flower rooms with LED lighting are dominated by latent loads (loads caused by moisture from plant transpiration), whereas traditional commercial load calculations are optimized for sensible loads and therefore not suited to these environments. While designers that specialize in designing HVAC systems for indoor CEH facilities understand how to estimate the load and size HVAC and dehumidification systems properly, HVAC designers who have not worked in the field often make errors in the process.

A common error is adding sensible and latent loads without accounting for the evaporative cooling effect of the plants, which lowers the total sensible load (Schimpelfenig, 2019). Load calculations also frequently do not include the sensible loads from standalone dehumidifiers that reject their condenser heat into the space. When these sizing calculations are incorrect, the equipment often struggles with humidity control, leading to over-drying, mold, reduced yields, or crop loss.

To address these deficiencies, growers may add resistance heating, standalone dehumidifiers, and, in some cases, humidifiers (Remillard & Collins, 2017; Desert Aire, 2019). Since this supplemental equipment is not part of the original design, it is typically controlled by a separate thermostat or humidistat, competing with existing equipment rather than complementing it. Therefore, designers must use approaches that accurately account for the changing environment as the plant matures, variable latent loads, and sensible process heat from dehumidifiers that do not reject process heat.

Since latent and sensible loads are handled separately, when sized correctly, decoupled systems need more total capacity than integrated systems, which can address latent, sensible, or both simultaneously, as needed.

There are currently no well-documented, standardized industry sizing methods for controlled environment agriculture. Most designers rely on proprietary approaches and

internal tools developed from experience rather than published tables based on crop type.

However, the proprietary sizing inputs and assumptions used to size systems for indoor cannabis farms share many commonalities. Although more detailed proprietary methods may still be useful for highly precise sizing approaches, the basic assumptions needed to estimate the appropriate system sizing can be distilled into a relatively simple calculation. The Statewide CASE Team has identified these key inputs and is in the process of developing the Nonresidential Appendix load calculation and sizing guide.

#### **4.1.3.2.9 Market Adoption**

Despite the process stability and energy savings benefits, market adoption of integrated systems has been slow. A recent PG&E Emerging Technologies report surveyed eight indoor farms in California and found that most facilities use a combination of split DX systems (86% of respondents) and standalone dehumidifiers (75% of respondents) (Sabeh, Miner, & Perman, 2022). However, recent advances have made integrated systems more reliable, more responsive to room conditions, and more widely available. In fact, adoption of these systems appears to be higher in other U.S. states, where cannabis laws were updated more recently. One multi-state operator's portfolio of 55 cannabis facilities reviewed by the CASE team consists of 30 percent 4-pipe chilled water systems, 25 percent integrated DX, and 45 percent decoupled systems. The limited adoption of these systems in California presents a strong opportunity for energy code updates to drive efficiency improvements.

A similar measure was proposed in the 2025 Title 24, Part 6 code cycle, including requirements for modulating capacity dehumidification equipment, system commissioning, and load sizing calculations. However, all three HVAC/dehumidification proposals were ultimately dropped due to limited time to address industry feedback.

#### **4.1.3.3 Indoor Growing Facilities in California**

Over 90 percent of indoor CEH facilities in California are used to grow cannabis. The California Department of Cannabis Control reports active licenses of 10 large indoor cultivation facilities (greater than 22,001 square feet of canopy), 151 medium indoor cultivation facilities (10,001 to 22,000 square feet of canopy), and 319 small indoor cultivation facilities (5,001 to 10,000 square feet of canopy) as of November 3, 2025 (California Department of Cannabis Control, n.d.). Facilities can engage in license stacking where multiple small facilities are used for one larger facility.

A small percentage of California indoor CEH facilities are used for mushroom cultivation, which is much less energy intensive (SureHarvest, 2017) than cannabis cultivation. Some of the indoor mushroom growing facilities in California are large, such as the Mushroom Farm's 250,000 square foot facility in Pescadero, M2 Ingredients' 155,000 square foot facility in Vista, Smallhold Farm's 34,000 square foot facility in Los

Angeles County, and Far West Fungi's 60,000 square foot facility in Moss Landing (Vertical Farm Daily, 2022; Foodwise, n.d.; The Mushroom Farm, n.d.; BusinessWire, 2025).

Leafy greens vertical farms have largely exited California, evidenced by the closure of Plenty's South San Francisco (AgFunderNewsletter, 2023) and Compton facilities (Herrick, 2024). Industry analysis suggests that indoor leafy green farming is not financially viable in the region; California's mild climate makes greenhouse and outdoor farming significantly less expensive and more profitable than indoor methods (Taylor, 2025).

Small indoor facilities grow specialty food crops indoors, such as Malaia's Microgreens (Malaias Microgreens, 2025) and Cai Foods Wasabi Farm (Cai Foods, 2025). Some of California's universities have indoor growing research facilities, such as California Polytechnic State University, San Luis Obispo (Cal Poly BRAE Vertical Farm, 2025) and University of California, Davis (Stumbos, 2021). Some California-based agriculture technology companies have had small indoor farms for their research and development facilities such as Verdical, Willo Farms, and Iron Ox (Omdena, 2024) (Willo Farms, 2025; Omdena, 2024). Plant growth chambers are commonly used for seed testing and plant propagation at farms that primarily grow plants in greenhouses or outdoors (Darwin Chambers, 2025).

#### **4.1.4 Modifications to Energy Code Documents**

This section provides descriptions of how the proposed code change will affect each Energy Code document. Section 4.6 of this report provides detailed revisions to code language.

##### **4.1.4.1 Energy Code Change Summary**

###### **SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION**

**Subsection 100.1(b):** The proposed new definition of Plant Canopy Area enables the code to trigger requirements based on canopy area and/or lighting intensity per unit of canopy area. Canopy area, lighting intensity, and crop type are the primary determinants of space conditioning loads in a CEH facility.

The proposed edit to the definition of Directly Conditioned Space to exclude Controlled Environment Horticulture (CEH) Space clarifies that not all Nonresidential space conditioning requirements do not apply to CEH process loads.

###### **SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES**

**Subsection 120.6(h):** The proposed Indoor growing, space conditioning systems section reflects that humidity control and temperature control are intertwined, especially for facilities with high lighting intensity.

The proposed requirement for sizing of space conditioning systems to meet latent and sensible loads ensures that the CEH space conditioning systems is correctly sized, reducing the need to later add supplemental equipment.

The proposed regulations would require central controls that ensure that supplemental heating is not used when reheat energy is available, and stage equipment based on temperature and humidity.

#### SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

**Subsection 140.9(d):** The proposed regulations would create new prescriptive requirements that a primary space conditioning system be sized to meet the majority of the peak latent and sensible loads, and that the primary systems meet performance metrics.

#### SECTION 141.1 – REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONS, ALTERATIONS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS

**Subsection 141.1(c):** The proposed regulations specify the percentage of capacity that must be replaced to trigger code requirements.

#### **4.1.4.2 Reference Appendices Change Summary**

Nonresidential Appendix (NA) 7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes Process Boiler Acceptance Tests: The proposed changes would expand this appendix to include acceptance tests for CEH facilities, with the specific requirements verifying that the controls are configured correctly.

**Nonresidential Appendix (NA) X – Controlled Environment Horticulture Space Conditioning System Sizing:** This new nonresidential appendix would specify how to calculate latent and sensible loads and ensure that the space conditioning system is sized in accordance with requirements in 120.6(h) and 140.9(d).

#### **4.1.4.3 Compliance Manuals Change Summary**

Section 10.12.2 of the Nonresidential Compliance Manual, which outlines mandatory requirements for CEH facilities, would be updated to reflect the changes and additions to mandatory code.

Section 10.12.3 of the Nonresidential Compliance Manual, which outlines prescriptive requirements for CEH facilities, would be updated to add the new CEH prescriptive requirement.

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

Section 2.4 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual would be updated to specify that unmet load hours for Horticulture space types would be calculated during both occupied and unoccupied periods.

Section 2.6.2 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual would be updated to specify sizing for Horticulture space types.

Section 5.1.3 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual, which describes HVAC systems in the Standard Design by space type, would be updated to add Horticulture space types to the Nonresidential HVAC System Map and to add a new system type to the System Description.

Section 5.4.9 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual, which describes process loads, would be updated to add the process loads for indoor growing.

Section 5.7.1 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual would be updated to add a new system type.

Section 5.7.2 of the Nonresidential Alternative Calculation Method (ACM) Reference Manual, which describes HVAC system controls in the Standard Design by space type, would be updated to specify humidity and temperature control.

Appendix 5.4A of the Nonresidential Alternative Calculation Method (ACM) Reference Manual would be updated to add Horticulture space types.

Appendix 5.4B of the Nonresidential Alternative Calculation Method (ACM) Reference Manual would be updated to add schedules for the new space types.

#### **4.1.4.5 Compliance Forms Change Summary**

The existing Process System Certificate of Compliance form (NRCC-PRC-E, Section P: Controlled Environment Horticulture) and Process System Certificate of Installation form (NRCI-PRC-E, Space Conditioning for Plant Production section) would both need new input fields added to ensure that CEH facilities meet sizing requirements and space conditioning requirements. The existing Nonresidential Performance Certificate of Compliance form (NRCC-PRF) would need to be revised to support the requirements being included in the model for CEH spaces. A new form, (NRCA-PRC-XX-F, Nonresidential Certificates of Acceptance), would need to be created to demonstrate compliance with new field technician acceptance testing requirements for CEH facilities.

## 4.1.5 Measure Context

### 4.1.5.1 Comparable Model Codes or Standards

The proposed requirements for space conditions systems in CEH spaces align with existing state and federal standards, while addressing current regulatory gaps:

- a. **Title 24, Part 6 (2022):** Section 120.6(h) outlines mandatory requirements for CEH spaces, including a requirement that dehumidification equipment be one of the following: federally regulated dehumidifiers tested per 10 CFR 430.23(z) and Appendix X/X1, integrated HVAC systems with on-site heat recovery designed to meet at least 75 percent of annual dehumidification reheat energy, chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50 degrees Fahrenheit (°F) or less. These requirements form the baseline for CEH space conditioning in California. (California Energy Commission, 2023)
- b. **Federal Appliance Standards:** Standalone dehumidifiers are subject to federal efficiency standards under 10 CFR 430.32(v)(2), which preempt more stringent state-level regulations for this equipment category. However, these test procedures do not reflect the unique environmental conditions of indoor agriculture. (Regulations, 2025)
- c. **ASHRAE Standards:** ASHRAE's HVAC Applications Handbook offers guidance for plant environments but lacks mandatory HVAC or dehumidification standards, creating a regulatory gap for integrated and specialized indoor agriculture systems. (American Society of Heating, 2023)

### 4.1.5.2 Interactions with Other Regulations

Review finds no known conflicts with existing federal, state, or local regulations. The proposed changes enhance Title 24, Part 6 by specifying performance and design requirements for space conditioning systems in CEH spaces, without introducing new equipment mandates that would conflict with federal appliance standards.

While federal regulations govern standalone dehumidifiers and HVAC equipment, the test procedures and performance metrics (such as EER) regulated by federal standards do not reflect equipment performance in CEH applications. As such, the proposal focuses on system integration and other performance-based criteria that are not currently addressed by federal standards. Additionally, the proposal does not alter the existing exemption of CEH processes from ASHRAE HVAC requirements, and it maintains consistency with California's broader nonresidential energy code, aside from limited exemptions already specified in Title 24.

## 4.2 Space Conditioning Systems - Compliance and Enforcement

### 4.2.1 Compliance Considerations

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced.

The CEC<sup>7</sup> interprets the current code to require indoor CEH facilities to meet all nonresidential requirements other than those where the code provides a specific exception for this type of space, such as the HVAC economizer requirement. Sections of the code commonly interpreted to be required for CEH facilities include mandatory envelope requirements, prescriptive envelope requirements, nonresidential prescriptive HVAC equipment and controls requirements, and mandatory outdoor air ventilation.

Some requirements in the nonresidential code do not align with common practice for indoor CEH facilities (such as outdoor air ventilation requirements). Stakeholder input indicates that compliance officials often created their own exceptions. The proposed updates would clarify that CEH HVAC/D systems must only comply with code in or referenced by the CEH code section.

Compliance with the proposed prescriptive requirement that a primary HVAC system meets 80 percent of peak latent and sensible loads, have a variable sensible heat ratio, and modulate heat recovery and rejection is highly feasible for cannabis flower rooms, particularly when the performance path is an alternative. This requirement prescribes performing accurate load calculations, which is feasible given the proposed Nonresidential Appendix which will include instructions for sizing calculations. The compliance documents must clearly demonstrate the heat recovery/rejection modulation and the required range of equipment sensible heat ratios. For systems that cannot meet all prescriptive criteria, the availability of a performance path allows the designer to model the proposed system's efficiency against a benchmark energy budget, providing flexibility by demonstrating equivalent energy saving.

The designer of the controls system would prepare a sequence of operations that would state how the system integrates and stages all units and how it prevents non-recovered heating from operating unless the heating load exceeds the primary equipment's reheat capacity. Controls schematics would show the location and connection of temperature and humidity sensors, and communication pathways between the central control system and individual space conditioning primary and supplementary equipment (if used). The plans examiner reviews submitted project documentation to ensure that it matches what is indicated on the NRCC form. This plans examiner would confirm that the design documents support the requirements in a way that supports the Energy Code. To perform a functional test of the control system, the field technician performing acceptance testing would simulate specific load conditions by changing setpoints or overriding sensor readings and confirm that the controller responds accordingly. The field technician would also verify that the sensors are correctly installed, calibrated, and located to accurately reflect the conditions in the plant canopy space. The building

<sup>7</sup> [https://www.energy.ca.gov/sites/default/files/2023-09/2022\\_CEC-Controlled\\_Environment\\_Horticulture\\_ADA.pdf](https://www.energy.ca.gov/sites/default/files/2023-09/2022_CEC-Controlled_Environment_Horticulture_ADA.pdf)

inspector will verify the acceptance test documentation and perform a visual inspection of equipment, sensor location and presence, and control panel to ensure that it matches the installation form (NRCI). Compliance with the proposed controls requirement relies on the acceptance testing, which would be performed by a field technician, who may be the installing contractor that sets up the controls system. In most cases, the installer of the controls system will run through the checks and sign off on the acceptance form (NRCA) while doing the typical set up and commissioning of the controls system.

The code clarifications will reduce the burden of compliance. Because current regulations do not provide clarity on whether the nonresidential HVAC code should apply to CEH process dehumidification and cooling systems, plans examiners and building inspectors have had to make their own interpretations. The new HVAC/D requirement with new forms and acceptance testing performed by a field technician will increase the burden of compliance with the code. The net increase/decrease of burden on compliance officials is not known. Outreach to California Building Officials (CALBO) and authorities having jurisdiction will provide additional insight.

New definitions are being harmonized with existing definitions in Section 100.1 of Title 24, Part 6 to avoid confusion and conflicts.

#### 4.2.2 Impact on Market Actors

Table 46 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 46: Impacts on Market Actors and Suggested Training and Education Opportunities**

Market Actor	Impact(s)	Suggested Outreach and Education
<b>Builders<sup>a</sup></b>	Be aware of the new Energy Code language and how it dictates selection of HVAC/D equipment, the incremental costs of the new requirements, and of the new acceptance testing step to be performed by the installing technician.	<p>Updates to the Energy Code Ace Fact Sheet for Controlled Environment Horticulture can help ensure that code consultants, designers, and mechanical contractors are aware of the updated code requirements.</p> <p>Targeted CEH HVAC+D training will help builders understand the impacts of the code on the facilities they are developing, sizing calculation, and the paths for compliance. This training can leverage existing trainings such as the Indoor Agriculture Resiliency training offered by PG&amp;E Energy Centers.</p>
<b>Design Professionals<sup>b</sup></b>	Design Professionals must be aware of the new code requirements and design HVAC/D systems, including equipment	Designers of HVAC+D systems for high lighting intensity rooms in indoor CEH facilities should be provided training on

Market Actor	Impact(s)	Suggested Outreach and Education
	<p>and controls, that comply with the proposed mandatory code requirements.</p> <p>Engineers and HVAC/D system designers will need to perform and document load and sizing calculations for CEH HVAC/D in compliance with new Nonresidential Appendix.</p> <p>For systems that do not comply prescriptively, Energy Consultants would perform energy modeling to demonstrate compliance via the performance approach.</p> <p>Designers, Engineers, or Energy Consultants would complete new sections of the NRCC-PRC-E form and the NRCC-PRF-E form if using the performance approach.</p>	<p>the energy code, sizing requirements, and prescriptive and performance pathways.</p> <p>Updates to the Energy Code Ace Fact Sheet and topic-specific training for Controlled Environment Horticulture can help ensure that builders and designers are aware of the updated code requirements.</p> <p>Updates to performance modeling trainings can help ensure that Energy Consultants are prepared to model the new space types.</p>
<b>Construction Team<sup>c</sup></b>	<p>HVAC system installers will install HVAC/D systems according to current practice. Controls technicians will install and configure compliant controls systems.</p> <p>HVAC system installers and controls technicians will complete new fields in the process CEH section of NRCC-PRC-E form.</p> <p>Controls technicians will perform verification testing to confirm controls comply with requirements, put results on NRCA-XX-F form, and make the form available to the building inspector.</p>	<p>Indoor CEH controls technicians should be provided training on the energy code updates and supporting documentation, compliance requirements, acceptance testing requirements, and compliance documentation.</p> <p>The Statewide CASE Team does not anticipate that HVAC system installers will require additional training because the ducting and electrical requirements for integrated systems are generally simpler than those for decoupled systems.</p>
<b>Building Departments<sup>d</sup></b>	<p>AHJ plan checkers will need to check that loads and sizing have been calculated.</p> <p>Plan checkers will need to review additional sections on the NRCC-PRC-E and NRCC-PRF-E (when applicable) forms and confirm that the design complies with code requirements.</p> <p>Inspectors will need to verify installation of the specified HVAC/D system and will need to review the NRCA-XX-F form to confirm acceptance testing was performed, in addition to reviewing</p>	<p>Provide education and training to local building department plans examiners to familiarize with new code language, prescriptive/performance paths for compliance and new acceptance tests.</p>

Market Actor	Impact(s)	Suggested Outreach and Education
	additional fields on the NRCI-PRF-E form.	
<b>Verification Testers<sup>e</sup></b>	See Construction Team section as verification testing is performed by installing technician.	N/A
<b>Building Owners, Managers, and Occupants</b>	Building owners, managers, and system operators can expect reduced energy bills, reduced maintenance costs, and improved crop yield.  System operators will need to operate the central HVAC controls system.	Outreach to and training of owners and operations personnel could improve understanding of the benefits of controls and integrated HVAC+D systems and address concerns. Additional training could reinforce the yield and energy savings benefits of the newly required system enhancements.
<b>Manufacturers and Distributors</b>	HVAC manufacturers/distributors must provide data on SHR ranges and reheat capabilities for equipment and provide appropriate curves for accurate modeling of HVAC/D systems.  Manufacturers of integrated systems will likely see increased sales.  HVAC controls system and environmental control system providers will see increased sales. Technicians that install and configure these systems will need to perform acceptance testing and fill out the NRCA-XX-F form accordingly.	Outreach to HVAC+D system manufacturers and distributors is required so that manufacturers are prepared to provide the documentation and data required to prove compliance with the prescriptive code. Manufacturers also must understand the code changes so they can support California customers and clients in selection of compliant equipment.  Outreach to CEH Controls providers is needed so that control packages with compliant sequences of operation will be readily available with documentation to realize the proposed mechanism of savings.

- a) Builders include builders and developers.
- b) Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
- c) Construction team includes general contractors, 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 sustainability department staff.
- e) Verification 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, energy consultants, and building owners and occupants. The analysis in the methodology report is not specific to the code changes presented in this report. 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 likely affect commercial builders; however, it would likely 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 specific subsectors within the industry. Table 47 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

**Table 47: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)**

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
<b>Nonresidential Electrical Contractors</b>	3,245	72,794	\$7.8
<b>Nonresidential Plumbing &amp; HVAC Contractors</b>	2,270	55,182	\$5.8
<b>Other Nonresidential Equipment Contractors</b>	580	9,749	\$1.1
<b>Nonresidential Site Preparation Contractors</b>	1,147	19,273	\$1.9
<b>All Other Nonresidential Trade Contractors</b>	948	17,084	\$1.7

- a. Source: (State of California, n.d.)
- d. \* 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>

**Facility owners and operators:** Building owners would have to cover the upfront costs of the required HVAC+D and controls equipment and installation and the ongoing maintenance costs, but they would also save money from reduced fuel costs due to decreased energy consumption. Overall, for California building owners, the proposed code changes would result in lower energy bills.

**Manufacturers:** As discussed in Section 4.3.1.1 , several manufacturers of HVAC systems that would comply with the proposed code change are headquartered in California. See Section 4.3.4 for more information on impact on California jobs.

One manufacturer stakeholder stated that although manufacturers do not typically disclose the SHR ranges for their systems, they do not expect that reporting that for

code compliance would be an issue. However, since this parameter is not measured in accordance with an established test procedure, this manufacturer notes that other manufacturers of integrated DX equipment may report a wider range of SHRs than they can consistently maintain over long periods. Still, this manufacturer supported a SHR range as an appropriate metric for this proposed code change.

Controls provider stakeholders have indicated that their systems can meet the proposed code requirements.

### 4.2.3 Compliance Software Updates

CBECC needs to be updated to enable use of the Performance Approach. This strategy will include adding a new prototype for Indoor CEH spaces. Prior to publication of the Draft CASE report, the Statewide CASE Team is vetting the prototype inputs and assumptions through a public review process. This process includes hosting public workshops, direct outreach and requests for input from CEH experts and stakeholders, and coordination with California Building Energy Modeling (CalBEM) members to review the energy modeling approach. Updates to the ACM are specified in Section 4.6.6. The current prototype assumptions are shown in Appendix A.

The Statewide CASE Team will provide detailed recommendations of additional software enhancements in summer 2026.

### 4.2.4 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 does not anticipate the proposed code changes will have a measurable impact on California's General Fund, state special funds, or local government budgets. If state and local staffing is unavailable, resources may be needed to ensure compliance with updated Title 24, Part 6 measures. Compliance updates would include the following:

- 1 **Field Verification Testing:** Evaluate requirements for verification of control settings by a field technician;
- 2 **Updates to Compliance Software:** Modify software to support new CEH compliance requirements;
- 3 **Updates to NRCI-PRC-E:** Document key installed equipment specifications;
- 4 **Updates to NRCC-PRF-E:** Document compliance via performance approach.
- 5 **Updates to NRCC-PRC-E (New HVAC+D system Requirements, load calculations, and sizing calculations):** Document compliance with equipment

requirement, controls requirements, grow room assumptions for calculations, HVAC/D equipment capacity, and calculate room loads and sensible heat ratio to confirm sizing compliance; and

- 6 **Develop a new NRCA-PRC-XX-F form:** Document field verification of control settings.

Costs for updating standards, compliance materials, and responding to inquiries are expected to remain within existing code development and enforcement budgets. Training for enforcement officials will be required but can leverage current education programs to minimize expenses. Local governments will need to retrain building department staff; however, this practice aligns with the regular triennial code update cycle and is supported by resources such as Energy Code Ace.

If workforce training is needed to ensure correct design and installation of space conditioning measures, costs should be limited to short courses or online modules integrated into existing industry programs.

The Statewide CASE Team will work with building officials in jurisdictions with a significant number of indoor farms and the Compliance Improvement Team to determine the cost of enforcement.

## 4.3 Space Conditioning Systems - Market and Economic Analysis

### 4.3.1 Market Structure and Availability

#### 4.3.1.1 *Current Market Structure and Availability*

The California market for CEH space conditioning systems that comply with the proposed prescriptive measure includes leading HVAC manufacturers such as AAON, Zero Cool, Desert Aire, Agronomic IQ, Inspire Transpiration Solutions, RuppAir, and Accelerated Growth Solutions. Desiccant systems that would comply with the measure include Mojave Energy. CEH HVAC+D systems can be manufactured, supplied, and installed by multiple parties, and review finds no known patent restrictions limiting competition. Early adoption was slow due to the limited availability of purpose-built equipment, but current offerings now include reliable, variable-capacity products such as reconfigured DOAS units and dedicated CEH systems. These solutions deliver better performance and energy savings when properly sized, compared with split dehumidification and cooling systems. Off-the-shelf horticulture controls are widely available, and custom solutions can address unique operational needs. Based on current availability and market trends, the Statewide CASE Team expects products to be offered by several manufacturers well before the effective date of the Energy Code. For details on suggested training requirements to prepare market actors for this transition, refer to Section 4.2.2.

Historically, about 75 percent of small and medium CEH facilities have relied on conventional commercial cooling equipment paired with standalone dehumidifiers and basic thermostats, while only about 25 percent use variable-SHR<sup>8</sup>. About 25 percent of large facilities already employ four-pipe chilled water systems that comply with the proposed measure. Despite this slow adoption, the market is shifting toward integrated systems capable of modulating sensible and latent loads, driven by the need for precise environmental control throughout the grow cycle. The proposed regulation is expected to accelerate this trend, incentivizing innovation in integrated DX and chilled water systems and improving controls integration. While upfront costs may challenge smaller operators, long-term energy savings and operational benefits will support broader adoption. Without regulation, adoption of these advanced systems would remain limited, so the proposed measure would help achieve statewide efficiency goals. The availability of multiple manufacturers and proven technologies provides confidence that the market will be ready by the effective date.

#### **4.3.1.2 Market Challenges and Solutions**

Through stakeholder outreach and technical analysis, the Statewide CASE Team identified several market barriers to implementing the proposed space conditioning requirements for CEH facilities. Few energy modeling tools accurately represent CEH conditions, making compliance modeling difficult. The Statewide CASE Team plans to vet an indoor CEH prototype and provide CEH-specific improvements to the CBECC team to ensure accurate modeling capabilities before the effective date.

Some stakeholders also expressed concerns about unreliable first-generation integrated systems, creating skepticism about performance, but other stakeholders confirmed that more recently installed integrated systems are reliable. To address the skepticism issue, the Statewide CASE Team intends to confirm that the latest generation of integrated equipment avoids prior issues and develop documentation explaining how these improvements resolve earlier reliability concerns.

Additional challenges include perceptions of higher incremental costs, a shortage of design professionals familiar with CEH environments, and limited access to conventional financing and tax benefits. The Statewide CASE Team will demonstrate that correctly sized, modulating integrated systems require less total capacity, reducing both upfront and lifecycle costs. To prepare the workforce, the Statewide CASE Team plans to develop a standard sizing methodology, provide design guidelines in the compliance manuals, and support development targeted training programs. Training programs can include information on leasing strategies that enable depreciation benefits

<sup>8</sup> Based on review of Title 24 compliance data for indoor CEH facilities collected by the Statewide Compliance Improvement program in 2024 and 2025.

and conventional financing options, reducing financial barriers and supporting adoption of compliant systems.

Section 4.2.2 provides description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

## 4.3.2 Design and Construction Practices

### 4.3.2.1 *Current Design and Construction Practices*

Current best practices for space conditioning focus on managing both temperature and humidity using either decoupled or integrated systems. Load calculations primarily account for internal heat from lights, fans, and equipment, along with moisture from plants. CEH facilities require tight environmental tolerances, with setpoints and loads changing throughout the grow cycle. Most indoor CEH spaces have nearly all internal loads and minimal air exchange or envelope gains, making precise control critical. Equipment that can modulate across a wide SHR range and adjust heat rejection or recovery is best suited for these varying latent and sensible loads.

Key design and construction differences include the following:

- **Load Calculations:** Equipment with variable capacity and wide SHR modulation simplifies load calculations by managing temperature and humidity together, reducing complexity and eliminating iterative adjustments.
- **Redundancy:** Modular systems allow capacity to be added or adjusted easily, improving reliability without major redesigns.
- **Airflow:** Integrated systems provide airflow and supply air temperature management, reducing the need for circulation fans to provide uniform distribution across the grow space.
- **Controls:** Advanced controls with built-in sensor integration streamline automation and monitoring, minimizing design and commissioning complexity.
- **Construction:** Fewer components and simplified ductwork reduce installation time, labor, and space requirements, which is especially beneficial in tight environments.
- **Commissioning:** Variable systems minimize the need for extensive balancing and additional sequences of operation, enabling faster and more straightforward commissioning.

Incorporating variable-capacity components into space conditioning designs improves flexibility, reduces complexity, and supports best practices by minimizing impacts on physical space, installation effort, and operational tuning.

#### **4.3.2.2 Health and Safety Considerations**

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California DOSH. All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have any adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

Using integrated HVAC+D equipment in cannabis flower rooms significantly decreases the risk of mold by providing precise control over humidity and temperature. The system works to maintain the optimal VPD, which prevents the continuous high humidity (i.e., above 60% relative humidity) that allows pathogens like powdery mildew and Botrytis (bud rot) to flourish. This decrease in mold has a direct and positive impact on the health and safety of workers in the facility. By limiting the growth of mold and mildew, the integrated systems reduce the workers' exposure to airborne mold spores. This practice, in turn, decreases the risk of respiratory issues, allergies, and chronic health problems associated with inhaling bioaerosols in the workplace (ISHN, 2018; King, et al., 2024).

#### **4.3.2.3 Design and Construction Challenges and Solutions**

Through stakeholder engagement with manufacturers, vendors, designers, and compliance professionals, the Statewide CASE Team developed solution to technical challenges and developed solutions.

One barrier is the absence of space conditioning equipment standards or test procedures specific to CEH applications, creating uncertainty for compliance and performance verification. To address this, the Statewide CASE Team drafted code requirements and that do not rely on federal standards or test procedures. This approach instead leverages system performance information, such as latent and sensible capacity, which manufactures typically provide to mechanical designers. These inputs can be used to demonstrate that the system is appropriate for the loads in the applicant's facility. This approach will be supported by training for enforcement professionals and designers to ensure proper interpretation and application.

Another challenge includes the complexity of controls for integrated systems. Advanced control strategies can be difficult for installers and operators unfamiliar with these technologies, leading to improper setup and reduced efficiency. The Statewide CASE Team will work with manufacturers and vendors to identify simplified control configurations and best practices for integration. The proposal includes training programs for installers, commissioning agents, and operators to ensure correct implementation and long-term performance.

High load conditions and continuous operation in CEH environments can accelerate equipment wear and increase the risk of failure, raising concerns about reliability. To mitigate this, the Statewide CASE Team will ensure that sizing requirements will allow for additional capacity and use of multiple units to distribute loads, provide redundancy, and reduce the impact of individual equipment failures. Training will emphasize maintenance best practices and redundancy planning to ensure operational resilience.

By addressing these barriers, the Statewide CASE Team enables compliance and advances the expertise of California's design, construction, and enforcement professionals. Table 46 in Section 4.2.2 provides a description of workforce trainings that could support effective design, installation, and commissioning.

### 4.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on ESJ communities, including impacts related to race, class, and gender. The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive.

Specific impacts identified to date include the following:

- **Cost and Affordability:** Initial equipment costs may disproportionately affect small or independent CEH operators serving local markets, particularly in rural or low-income regions.
- **Health and Safety:** Improved humidity control may reduce mold and improve indoor air quality and worker comfort, providing long-term health and safety benefits for workers.
- **Resilience and Environmental Quality:** Reduced electricity use lowers strain on local grids and decreases pollution exposure in frontline communities located near energy generation or industrial facilities.
- **Economic Participation:** Over time, energy savings can improve the financial viability of operations, creating more sustainable employment opportunities in ESJ communities engaged in agriculture and indoor production.

Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with CBOs to facilitate meaningful engagement. Stakeholders with input on how this proposal may impact ESJ communities or have other input should reach out to Lydia Miner ([lminer@westmonroe.com](mailto:lminer@westmonroe.com)).

### 4.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

### **4.3.5 Economic and Fiscal Impacts**

This section will be completed for the Final CASE Report.

## **4.4 Space Conditioning Systems - Cost Effectiveness**

### **4.4.1 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 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 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. 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.

### **4.4.2 Energy and Energy Cost Savings Results**

The Statewide CASE Team completed an energy savings analysis using prototypical indoor facilities representative of typical CEH operations across California. The prototype was modeled for both baseline and measure cases using the software tools EnergyPlus, Trane TRACE 3D Plus (using the EnergyPlus engine), and Excel. Results were consistent between all modeling tools. The Statewide CASE Team has been developing an EnergyPlus full building model and will update the Final CASE Report to include energy savings estimates from the full building EnergyPlus model when complete. The Statewide CASE Team held a workshop to get feedback on the model prototype assumptions on December 10, 2025.

The Excel thermal loads model calculates the sensible and latent loads in a typical flower room over a year, based on empirical data measured at field sites such as hourly condensate volume, lighting type and density, plant density, environmental setpoints, and envelope loads. This model was developed during a PG&E Code Readiness program study taking place from 2022 to 2023 and provides a theoretical basis to

evaluate the energy impact of various mechanical systems serving flower rooms (Stober & Weitze, 2024).

The TraneTrace 3D Plus model represents cannabis flower rooms. The Statewide CASE Team developed lighting loads, dimensions, schedules, and other prototype assumptions based on SME input and review of data from past projects performed by the Statewide CASE Team. Table 86 in Appendix A shows several details of the prototype assumptions.

In EnergyPlus, a model was developed that represents cannabis flower rooms only, with the same prototype assumptions as the TraneTrace 3D Plus mode, listed in Appendix A. This is the model that was used for the energy savings per canopy square foot calculations in this draft CASE Report.

To support the development of compliance software, a full-building indoor CEH model was developed. These<sup>9</sup> and Appendix A. The Statewide CASE Team plans to update energy savings calculations to use the full building prototype following the vetting of prototype assumptions.

The baseline system includes humidistat-controlled standalone dehumidifiers and thermostat-controlled, single-stage space conditioning systems with electric resistance and/or natural gas reheat. The measure case system is an integrated, variable capacity, integrated space conditioning system with modulating hot gas reheat and with a low/variable sensible heat ratio.

Although there are typically other spaces in a cannabis facility used for cloning, vegetative growth, and drying, the proposed code changes only affect flower rooms, which have very high lighting intensity. The CASE team has developed a full-facility prototype including these other CEH spaces, as well as non-CEH spaces such as office, corridor, and processing. However, since none of the spaces aside from flower rooms will be affected by the proposed code changes, the flower room prototype provides the detail necessary to evaluate impacts of the proposed changes.

Cannabis facilities with over 5,000 square feet of plant canopy can range from 10,000 to over 100,000 square feet of total floor area. However, the area of the facility dedicated to flowering is typically partitioned into much smaller, individual flower rooms. These individual rooms will vary in size, but latent and sensible loads scale based on plant canopy area and lighting intensity, so the per-square foot energy use intensity of a flower room will be consistent, regardless of whether the individual flower room is one of a few flower rooms in the facility, or one of many. In contrast to other building types (such as multifamily, retail, or office) that have significant differences in construction

<sup>9</sup>CEH Prototype <https://title24stakeholders.com/wp-content/uploads/2025/12/2028-T24-CEH-Prototype-for-Vetting.xlsx>

type, window-to-wall ratios, and wall-to-floor area ratio that can significantly impact energy HVAC loads, cannabis flower rooms are typically insulated and opaque, and HVAC/D loads are almost entirely internal.

Furthermore, since cannabis flower rooms are designed and operated for the specific function of supporting plant growth and development, schedules and operating conditions are relatively uniform across the industry. Although lighting intensity and plant canopy area are significant variables that impact HVAC/D energy consumption, the most critical factor for HVAC/D system performance is the ability of the system to modulate in response to these highly variable internal loads.

The prototype model was developed based on data from design documents for multiple cannabis flower rooms constructed in California and other parts of the US, along with extensive review by SMEs with extensive experience designing HVAC/D systems for these facilities. The values for lighting intensity, latent loads, and humidity and temperature setpoints were selected to represent mid-points in the

The CASE team performed sensitivity analysis for variables including envelope insulation and the use of a dimming schedule and found little impact on overall energy consumption in the base case and proposed. As such, the team determined that the 2000 square foot flower room prototype is representative of new construction and major renovations in California cannabis facilities, and the development of additional prototypes would provide little improvement in the precision of the model.

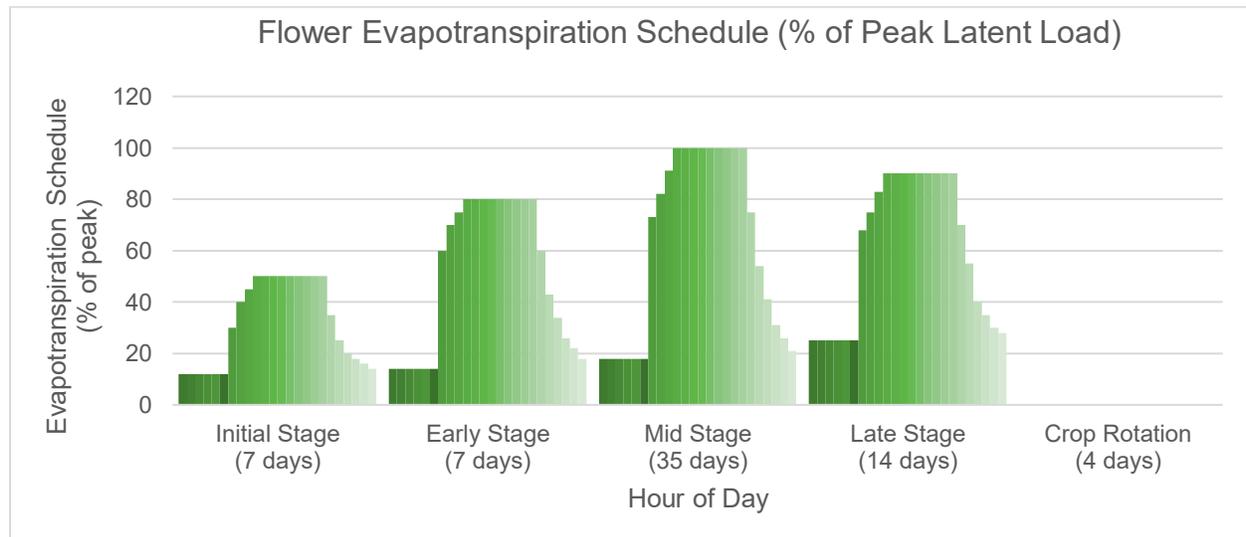
Table 86 summarizes the 2,000 square foot prototype flower room used to evaluate energy, demand, cost, and environmental impacts. The canopy area at 100 percent of the square footage is a weighted average single-tier and two-tier facilities. The Statewide CASE Team is using SME input to estimate that 60 percent of facilities growing with a single tier (with a canopy area 70 percent of room area) and 40 percent of facilities growing with two tiers of plants (with a canopy area of 140 percent of the room area).

High-level setpoint schedules in the prototype flower room are as shown in Table 48; detailed hourly schedules are shown in Table 63 in Section 4.6.6. Flower room evapotranspiration loads as a percent of the peak latent load are shown in Figure 1; a detailed schedule is in Table 99 in Appendix A.

**Table 48. Cannabis flower room prototype setpoint schedules**

Setpoint	Early (weeks 1-2)	Mid (weeks 3-7)	Late (weeks 8-9)
Lights on temperature setpoints	82°F	79°F	73°F
Lights on humidity setpoints	67% RH <sup>a</sup>	57% RH	48% RH
Lights off temperature setpoints	79°F	75°F	70°F
Lights off humidity setpoints	65% RH	54% RH	46% RH
Temperature Tolerance	±2°F	±2°F	±2°F
Humidity Tolerance	±2% RH	±2% RH	±2% RH

a. <sup>a</sup>RH is relative humidity



**Figure 1. Evapotranspiration load in cannabis flower room, presented as a percentage of the peak latent load for the grow cycle.**

All 16 climate zones were simulated in Energy Plus using the prototypes described above and 2028 weather files. For each climate zone, three simulations starting three weeks apart were averaged to obtain energy savings per square foot representing multiple flower rooms on staggered schedules, as SMEs suggested is most common in cannabis growing facilities.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 49 through Table 52. Per-unit energy savings for the first year are expected to range from 28.6 to 41.8 kWh/yr depending upon climate zone. The system was modeled as all-electric for both baseline and measure

cases, so there are no natural gas reductions. Demand reductions/increases are expected to range between 0.0037 kW and 0.0044 kW, depending on climate zone. The energy savings per canopy square foot are the same for new construction, additions, and alterations, and thus are not presented separately.

Table 53 presents total per-unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 PV\$. The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. In indoor CEH facilities, energy consumption is primarily driven by internal process loads, which greatly exceed external loads from the building envelope or infiltration; therefore, demand is largely weather-independent and does not exhibit sharp peaks with changing outdoor conditions.

This proposed measure reduces indoor CEH flower room HVAC energy use by about 40 percent. Across the 16 climate zones, the average energy use intensity for indoor CEH flower rooms was 281 kWh/canopy ft<sup>2</sup>/yr for the measure case and 319 kWh/canopy ft<sup>2</sup>/yr for the baseline. These values included lighting, which was approximately half of the energy consumption. The HVAC energy savings of about 30% aligns with energy savings found in the literature, described in detail in Section 4.1.3.2. The most significant source of energy waste in the baseline case is the simultaneous operation of separate cooling equipment and dehumidification equipment. Modulating systems can precisely match the output of the compressors and fans to the dynamically changing loads in the room. Modulating sensible heat ratio means that the system can adjust the balance between temperature removal and moisture removal.

The most direct demand management impact of the proposed code change is a substantial reduction in the overall peak electricity load required by the facility. The requirement that facilities use reheat prior to activating primary heat sources should reduce use of high-demand electric resistance heaters. Since most cannabis facilities operate with a 12-hour lighting cycle that includes grid peak hours (3 PM to 8 PM), using integrated systems instead of decoupled systems during lights-on conditions will reduce simultaneous operation of equipment, further reducing peak electricity demand. Should a facility choose to meet the proposed requirements with a heat recovery chiller, they can run adjacent flower rooms with offset schedules, so one room has lights off while the other room has lights on. In such a scenario, heat that would be rejected from the lights-on room could then be used to heat the lights-off room. Heat recovery chillers are also commonly paired with thermal energy storage systems.

The Statewide CASE Team anticipates that most of the savings from this measure will be persistent. Integrated HVAC/D systems are purpose-built for this high duty-cycle application will have a longer lifetime than equipment intended for residential or commercial applications. These systems allow better environmental control, leading to increased yields, and the energy savings will reduce operational costs. Savings from the

proposed controls requirements are more likely to have challenges with persistence. The sensors could drift if not calibrated. Growers may override automated controls based on short-term needs or anecdotal experience.

Cannabis facilities generate high amounts of biological debris that can foul coils and filters. Dirty coils can reduce the efficiency of heat transfer and force compressors to work harder. These impacts are similar for both the baseline and proposed case and are not expected to impact persistence of energy savings.

**Table 49: First Year Electricity Savings (kWh) Per Canopy Square Foot by Climate Zone (CZ) – Space Conditioning**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Indoor (Warehouse) Cannabis	41.79	40.13	41.08	37.33	40.91	39.82	39.17	37.45	36.47	35.57	36.29	38.30	35.56	34.36	28.58	37.39

**Table 50: First Year Peak Demand Reduction (kW) Per Canopy Square Foot by Climate Zone (CZ) – Space Conditioning**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Indoor (Warehouse) Cannabis	0.004 <sub>4</sub>	0.004 <sub>3</sub>	0.004 <sub>4</sub>	0.004 <sub>2</sub>	0.004 <sub>4</sub>	0.0043	0.0042	0.0042	0.004 <sub>1</sub>	0.004 <sub>1</sub>	0.004 <sub>1</sub>	0.004 <sub>2</sub>	0.004 <sub>0</sub>	0.004 <sub>0</sub>	0.0037	0.004 <sub>1</sub>

**Table 51: First Year Natural Gas Savings (kBtu) Per Canopy Square Foot by Climate Zone (CZ) – Space Conditioning**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Indoor (Warehouse) Cannabis	N/A	N/A	N/A	N/A	N/A	N/A	N/A									

**Table 52: First Year Source Energy Savings (kBtu) Per Canopy Square Foot by Climate Zone (CZ) – Space Conditioning**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
<b>Indoor (Warehouse) Cannabis</b>	69.14	68.32	68.66	65.68	68.84	66.67	65.77	64.98	63.79	63.38	64.28	66.30	63.41	62.71	57.63	63.59

**Table 53: Total 30-Year LSC Savings (2029 PV\$) Per Canopy Square Foot by Climate Zone (CZ) – Space Conditioning**

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
<b>Indoor (Warehouse) Cannabis</b>	\$ 360.04	\$ 348.29	\$ 355.25	\$ 326.19	\$ 352.78	\$ 352.78	\$ 338.49	\$ 323.26	\$ 312.60	\$ 308.61	\$ 315.53	\$ 330.32	\$ 308.80	\$ 304.35	\$ 257.16	\$ 321.86

### 4.4.3 Incremental First Cost

Incremental first costs will be calculated as the difference between the proposed and baseline systems and include the following:

- **Baseline System:** Decoupled (code minimum fixed capacity RTU and standalone dehumidifiers)
- **Measure System:** Integrated (CEH purpose-built HVAC and dehumidification)
- **Installation:** Ductwork and connections
- **Controls Configuration and Commissioning:** labor for configuring and testing controls

For the draft report, the integrated system is assumed to consist of two 40-ton DX units, and the decoupled system is assumed to include 12 standalone dehumidifiers rated at 710 pints per day to meet the latent load, along with ten 5-ton DX units sized for the sensible load. This aligns with the systems used for the energy savings models described in Section 4.4.2 with a 2,000 square foot flower room. Subject matter expert members of the Statewide CASE Team and stakeholders agreed that cost is roughly linear with tonnage for typically sized cannabis flower rooms, so the values determined for a room of this size were used to set an incremental cost per canopy square foot.

For the baseline case, the equipment costs were sourced online on January 27, 2026, and included ten 5-ton DX RTUs priced at \$4,300 each (totaling \$43,000) and twelve Anden 710 dehumidifiers priced at \$9,000 each (totaling \$108,000), with pricing from HVACdirect.com and Hydrobuilder.com, respectively. The installation cost was estimated to be roughly double the equipment cost at \$332,000 based on Statewide CASE Team subject matter expert input due to the ducting, plumbing, and electrical connections needed, so the total up-front equipment plus installation cost would be \$483,000.

For the integrated system, the equipment consisted of two 40-ton units at \$100,000 each (totaling \$200,000), based on estimates provided by a Statewide CASE Team subject matter expert using recent equipment quotes from a cannabis flower room project. Installation cost was estimated at 1.5 times the equipment cost, at \$300,000 based on SME input. Installation of integrated systems is expected to cost less than installation of decoupled systems because less systems need to have electrical, piping, and ducting hookups. The total installed cost for the integrated system is estimated at \$500,000.

**Table 54. Equipment and Installation first cost per 2000 square foot flower room (1400 canopy square feet)**

<b>First Cost</b> ( <b>\$ per 1400 canopy square foot flower room</b> )			
	<b>Baseline</b>	<b>Measure</b>	<b>Incremental</b>
<b>DX RTUs</b>	\$43,000	N/A	-\$43,000
<b>Dehumidifiers</b>	\$108,000	N/A	-\$108,000
<b>Integrated HVAC/D</b>	N/A	\$200,000	\$200,000
<b>Installation</b>	\$332,000	\$300,000	-\$32,000
<b>Total</b>	<b>\$483,000</b>	<b>\$500,000</b>	<b>\$17,000</b>

Additionally, recently obtained construction estimates from a subject matter expert on the Statewide CASE Team had a 23% lower installation cost for an integrated system versus a decoupled system designed for the same cannabis flower room. In these estimates, the piping equipment and installation costs were comparable between the integrated system and the decoupled system. The sheet metal material and labor costs for ducting were about five times higher for the decoupled system than for the integrated system, accounting for most of the difference in the installation costs for these systems. This indicates that, for this project, differences in ducting costs accounted for most of the increased installation cost of the decoupled system.

One case study found an integrated HVAC+D system had lower equipment and installation first costs compared with systems that use decoupled cooling and dehumidification, including VRF systems with dehumidifiers and ductless mini-split systems with dehumidifiers (Megerson & Anderson, 2023). The decoupled equipment priced in this study is both more efficient and more expensive than the code minimum decoupled equipment used for the CASE Report incremental cost assessment. In this study, the decoupled systems have additional copper refrigerant lines and insulation and additional electrical connections vs. the integrated system, accounting for most of the difference in installation costs. In this study, installation of a ductless split decoupled system cost 12% more than installation of an integrated system, and installation of a VRF decoupled system cost 71% more than installation of an integrated system designed for the same grow room.

Multiple manufacturers confirmed that integrated system cost is typically approximately \$2,500 per ton when low-ambient operation is not required, which is true for most of California. (Low ambient equipment was estimated to cost \$3,200 per ton). As confirmation, another member of the Statewide CASE Team used inflation-adjusted project cost data for systems installed in cannabis flower rooms from four distinct facilities and three separate manufacturers to provide an average integrated HVAC cost. These systems were low-ambient integrated systems and included add-ons; they averaged \$3,500 per ton. The \$2,500 per ton estimate matches the integrated HVAC/D equipment estimate used for this analysis.

Two Statewide CASE Team members provided first cost assumptions for equipment costs of decoupled system equipment. Their estimates indicated that integrated equipment costs were approximately 33% higher than decoupled equipment, and installation costs for integrated systems were about 1.67 times the equipment cost, compared with 2.5 times the equipment cost for decoupled systems. The Statewide CASE Team adopted a more conservative assumption, using installation cost multipliers of 1.5 for integrated systems and 2.2 for decoupled systems.

Decoupled systems require higher total capacity than integrated systems because they address latent and sensible loads with separate equipment. In contrast, integrated systems can dynamically shift capacity to handle latent loads, sensible loads, or both simultaneously. The incremental cost assumptions were based on correctly sized systems, and thus the incremental equipment cost is substantially less than the difference in cost per ton for integrated compared with decoupled systems, if the tonnage of both the DX RTUs and the dehumidifiers is considered.

The Statewide CASE team also consulted a reputable purpose-built integrated manufacturer who confirmed that correctly sized integrated systems typically have higher equipment costs but lower installation cost than decoupled systems, and the total incremental cost is expected to be less than five percent of the total installation plus equipment cost.

Table 55 presents equipment and installation first costs and incremental costs per square foot of canopy.

**Table 55: Incremental Cost Per Canopy Square Foot – Space Conditioning**

	First Cost (\$ per Canopy Square Foot)		
	Baseline	Measure	Incremental
<b>Equipment</b>	\$107.86	\$142.86	\$35.00
<b>Installation</b>	\$237.14	\$214.29	-\$22.86
<b>TOTAL</b>	\$345.00	\$357.14	\$12.14

The Statewide CASE Team is in the process of designing and pricing baseline and measure case HVAC systems and installation for a real cannabis flower room in California. This equipment and installation price data will be used to update the incremental measure cost in the Final CASE Report.

The Statewide CASE Team based the measure case for cost-effectiveness analysis on an integrated cooling and dehumidification system sized to meet the full latent and sensible loads of the flower room, without any standalone dehumidifiers. These systems are delivered with mandatory integrated controls that meet all the mandatory controls requirements. Therefore, controls costs were not included in the incremental costs. The integrated cooling and dehumidification system sized to meet the full latent and sensible loads is more expensive, therefore this is the more conservative assumption to use for cost-effectiveness analysis.

Multiple CEH climate control equipment designer and facility operator stakeholders have told the statewide CASE Team that a more cost-effective design uses a smaller integrated cooling and dehumidification system, sized to meet both sensible and latent loads for most of the grow cycle and includes standalone dehumidifiers that are used for the portion of the grow cycle where the integrated system cannot meet all loads. One grower the Statewide CASE Team spoke with said they use large portable dehumidifiers in this way, moving them between flower rooms to achieve dryer conditions for the last weeks of each flower cycle.

However, for permanently installed standalone dehumidifiers regulated by the energy code, a control system that coordinates the operation of the integrated cooling and dehumidification system and the standalone dehumidifiers is required to achieve efficient operation and would be required to comply with the proposed mandatory controls requirement. This proposal would require this type of control system when standalone dehumidifiers are used. Costs for such a system are discussed in the following paragraph.

The Statewide CASE Team estimates that the cost for controls that would integrate and stage secondary HVAC and dehumidification equipment, if used would be approximately \$2,700 for equipment, and \$7,200 in labor, including design (\$2,000), control panel fabrication (\$1,050), installation (\$1,400), programming (\$1,250), and commissioning (\$1,500). This data is based on a Statewide CASE Team SME review of a recent project that included integration of cooling and dehumidification equipment in a 2,400 square foot flower room at a California indoor cannabis facility. The total equipment and installation cost is approximately \$9,900. The Statewide CASE Team plans to reach out to controls manufacturers to confirm this information for the Final CASE Report.

#### **4.4.4 Incremental Maintenance and Replacement Costs**

The 2028 CASE Methodology Report provides a description of the methodology accounting for incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs.

Statewide CASE Team members provided replacement cost assumptions for the analysis presented in this report. These assumptions will be updated based on ongoing stakeholder outreach for the Final CASE Report.

Per common practice observed by SMEs who work with the cannabis industry, routine maintenance for both systems occurs every grow cycle (about every 60 days). This typically involves filter changes, condensate trap cleaning, and component checks. Decoupled systems require more filters and fans than integrated systems, so the measure is expected to have negative incremental maintenance costs. However, for the current analysis, the Statewide CASE Team assumed no incremental costs due to routine maintenance and will update this assumption for the Final CASE Report.

Integrated systems have an assumed EUL of 17 years, with compressors replaced every six years based on typical compressor warranties for specialized systems of five years and SME estimates of replacement every five to seven years. Compressor replacement cost is \$15,000 for a variable 10-ton compressor for parts and installation. The 40-ton integrated systems described in the incremental first cost analysis have four 10-ton compressors per unit. Full replacement of the integrated system, including removal, replacement labor, and commissioning, costs about 1.2 times the original equipment cost. Replacement costs for the compressors were based on a recent equipment quote provided by a member of the Statewide CASE Team, while the estimated cost for full unit replacement was informed by Statewide CASE Team subject matter expert industry experience. These values were shared with several industry stakeholders who did not object to their use in this analysis.

The cooling equipment used in decoupled DX systems has an assumed EUL of six years, with compressors replaced every two years. Each decoupled system includes one 5-ton compressor. The replacement cost for a single-stage compressor is estimated at \$3,500 for parts and installation, and the replacement cost for each full decoupled DX system is estimated at \$2,000, based on input from a subject matter expert. These values were shared with several industry stakeholders who did not object to their use in this analysis.

This analysis assumes that half of the compressors are replaced each year in years three through six following installation, with the full system replaced in year 7. Standalone dehumidifiers are assumed to be replaced every six years at a cost approximately equal to the initial equipment price plus \$1,500 for removal and installation. These replacement assumptions are based on industry experience from a

Statewide CASE Team subject matter expert. These values were shared with several industry stakeholders who did not object to their use in this analysis.

Filters are replaced after each grow cycle or harvest, totaling four changes per year. The integrated system requires two filter sets per cycle at \$200 each. The decoupled system requires 22 filters per cycle, including 12 dehumidifier filters at \$50 each and 10 DX filter sets at \$120 each. These replacement frequencies reflect typical cultivation operations with approximately four to five harvests per year, based on industry experience from members of the Statewide CASE Team. These values were shared with several industry stakeholders who did not object to their use in this analysis.

Table 56 shows the expected replacement and maintenance costs, incremental costs, and the present value of incremental costs by year over a 30-year period. Each row represents a year, and values are included in the year they are expected to occur, based on the assumptions described above. Cells without a value indicate that the cost type is not expected to occur in that year. The present value of incremental costs assumes the inflation adjusted costs is staying fairly constant with a 3% real discount rate. The total net present value of incremental maintenance costs over the 30-year period is -\$372.38. The incremental and maintenance costs are assumed to be the same for new construction, additions, and alterations.

**Table 56: Incremental Replacement and Maintenance Cost Per Canopy Square Foot – Space Conditioning – New Construction, Additions, and Alterations**

Costs Year	Integrated Full System (\$)	Integrated Compressors (\$)	Integrated Filters (\$)	Total Integrated (\$)	Decoupled DX Full System (\$)	Decoupled DX Compressors (\$)	Decoupled De-humidifiers (\$)	Decoupled Filters (\$)	Total Decoupled (\$)	Incremental Cost (\$)	Incremental Cost (\$/canopy ft <sup>2</sup> )	Incremental Net Present Value per Canopy ft <sup>2</sup>
1	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$7,200	<b>\$ 7,200</b>	-\$5,600	-\$4.00	-\$3.88
2	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$ 7,200	<b>\$ 7,200</b>	-\$5,600	-\$4.00	-\$3.77
3	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$15.10
4	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$14.66
5	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$14.23
6	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$13.82
7	N/A	\$60,000	\$1,600	<b>\$61,600</b>	\$63,000	N/A	\$126,000	\$ 7,200	<b>\$196,200</b>	-\$134,600	-\$96.14	-\$78.17
8	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$ 7,200	<b>\$ 7,200</b>	-\$5,600	-\$4.00	-\$3.16
9	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$12.65
10	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$12.28
11	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$11.92
12	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	-\$23,100	-\$16.50	-\$11.57
13	N/A	\$60,000	\$1,600	<b>\$61,600</b>	\$63,000	N/A	\$126,000	\$ 7,200	<b>\$196,200</b>	-\$134,600	-\$96.14	-\$65.47
14	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$ 7,200	<b>\$ 7,200</b>	-\$5,600	-\$4.00	-\$2.64

Costs Year	Integrated Full System (\$)	Integrated Compressors (\$)	Integrated Filters (\$)	Total Integrated (\$)	Decoupled DX Full System (\$)	Decoupled DX Compressors (\$)	Decoupled De-humidifiers (\$)	Decoupled Filters (\$)	Total Decoupled (\$)	Incremental Cost (\$)	Incremental Cost (\$/canopy ft <sup>2</sup> )	Incremental Net Present Value per Canopy ft <sup>2</sup>
15	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$10.59</b>
16	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$10.28</b>
17	\$240,000	N/A	\$1,600	<b>\$241,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	\$ 216,900	\$ 154.93	\$93.73
18	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$9.69</b>
19	N/A	N/A	\$1,600	<b>\$1,600</b>	\$63,000	N/A	\$126,000	\$ 7,200	<b>\$196,200</b>	<b>-\$194,600</b>	<b>-\$139.00</b>	<b>-\$79.27</b>
20	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$ 7,200	<b>\$ 7,200</b>	<b>-\$5,600</b>	<b>-\$4.00</b>	<b>-\$2.21</b>
21	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$8.87</b>
22	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$8.61</b>
23	N/A	\$60,000	\$1,600	<b>\$61,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	\$ 36,900	\$ 26.36	\$13.35
24	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$8.12</b>
25	N/A	N/A	\$1,600	<b>\$1,600</b>	\$ 63,000	N/A	\$126,000	\$ 7,200	<b>\$196,200</b>	<b>-\$194,600</b>	<b>-\$139.00</b>	<b>-\$66.39</b>
26	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	N/A	N/A	\$ 7,200	<b>\$ 7,200</b>	<b>-\$5,600</b>	<b>-\$4.00</b>	<b>-\$1.85</b>
27	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$7.43</b>
28	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$7.21</b>
29	N/A	\$60,000	\$1,600	<b>\$61,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	\$ 36,900	\$ 26.36	\$11.18
30	N/A	N/A	\$1,600	<b>\$1,600</b>	N/A	\$17,500	N/A	\$ 7,200	<b>\$24,700</b>	<b>-\$23,100</b>	<b>-\$16.50</b>	<b>-\$6.80</b>

#### **4.4.5 Cost Effectiveness**

The cost-effectiveness analysis evaluates incremental first costs, maintenance costs, and replacement costs relative to the baseline, and quantifies the PV of benefits over a 30-year analysis period using a three percent real discount rate. All values are expressed in 2029 PV \$ to align with the expected code implementation year.

Incremental first costs were estimated using the values in Section 4.4.3. Incremental maintenance costs were estimated using lifetime and replacement assumptions outlined in Section 4.4.4.

Energy cost savings were modeled using a prototype indoor warehouse flower room representative of typical CEH grow spaces with LPD greater than 30 W/ft<sup>2</sup> and at least 5,000 ft<sup>2</sup> canopy area, incorporating standard operating schedules, lighting densities, and control strategies as described in Section 4.2.2.

The Statewide CASE Team calculated savings as the difference in site energy use and annualized energy cost between the baseline and proposed efficacy levels, applied across all California climate zones. The energy savings and incremental costs were calculated on a per canopy square foot basis.

Results of the per-unit cost-effectiveness analyses are presented in Table 57 for new construction/additions and in Table 58 for alterations. The incremental first costs are \$12.14 per canopy square foot. The benefits are the sum of the long-term system cost (LSC) savings from electrical energy savings, and the present value of the negative incremental maintenance costs (negative costs are included in benefits) of -\$372.38 per canopy square foot. Both are calculated on a per canopy square foot basis. The LSC savings vary by climate zone because the cost of electricity and the energy savings per canopy square foot both vary by climate zone. Because the incremental measure cost is low and the total benefits are high, the benefit to cost ratio is fairly high for this measure, ranging from 52-60. Because the measure assumes total replacement of the HVAC system, costs and benefits are the same for new construction and alterations.

**Table 57: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$732.42	\$12.14	60
<b>2</b>	\$720.67	\$12.14	59
<b>3</b>	\$727.62	\$12.14	60
<b>4</b>	\$698.57	\$12.14	58
<b>5</b>	\$725.16	\$12.14	60
<b>6</b>	\$719.26	\$12.14	59
<b>7</b>	\$710.87	\$12.14	59
<b>8</b>	\$695.64	\$12.14	57
<b>9</b>	\$684.98	\$12.14	56
<b>10</b>	\$680.99	\$12.14	56
<b>11</b>	\$687.90	\$12.14	57
<b>12</b>	\$702.70	\$12.14	58
<b>13</b>	\$681.18	\$12.14	56
<b>14</b>	\$676.72	\$12.14	56
<b>15</b>	\$629.53	\$12.14	52
<b>16</b>	\$694.24	\$12.14	57
<b>Weighted Average</b>	<b>\$704.56</b>	<b>\$12.14</b>	<b>58</b>

**Table 58: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Alterations**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$732.42	\$12.14	60
2	\$720.67	\$12.14	59
3	\$727.62	\$12.14	60
4	\$698.57	\$12.14	58
5	\$725.16	\$12.14	60
6	\$719.26	\$12.14	59
7	\$710.87	\$12.14	59
8	\$695.64	\$12.14	57
9	\$684.98	\$12.14	56
10	\$680.99	\$12.14	56
11	\$687.90	\$12.14	57
12	\$702.70	\$12.14	58
13	\$681.18	\$12.14	56
14	\$676.72	\$12.14	56
15	\$629.53	\$12.14	52
16	\$694.24	\$12.14	57
<b>Weighted Average</b>	<b>\$703.99</b>	<b>\$12.14</b>	<b>58</b>

## 4.5 Space Conditioning Systems - Statewide Impacts

### 4.5.1 Statewide Energy and Energy Cost Savings

To determine the impacted square footage for statewide savings estimates, the Statewide CASE Team used the CEH forecast in the CEC 2029 New Construction and Additions by Building Climate Zone and 2029 Existing Building Stock by Building Climate Zone.

The Statewide CASE Team applied the following assumptions:

- 32 percent of CEH square footage is indoor growing facilities (not greenhouse) (Energy Solutions, 2023)
- 92 percent of indoor growing square footage is in facilities growing cannabis (Energy Solutions, 2023)

- 87 percent of statewide cannabis canopy square footage is in facilities with at least 5,000 square feet of canopy (CASE Team Analysis of California Department of Cannabis Control number of licenses by license type (California Department of Cannabis Control, n.d.))
- 47 percent of square footage in an indoor cannabis growing facility is flower room. The Statewide CASE Team reviewed published cannabis indoor grow floorplans that flower room is typically over 50 percent of total square footage (Gillespie, 2025; Stober & Weitze, 2024) and an article that indicated flower room is about 70 percent of total square footage (Streit, 2022), with smaller facilities tending to have a smaller percentage of square footage allocated to flower rooms than larger facilities.
- Canopy square footage in a cannabis flower room is 100 percent of the room square footage. The Statewide CASE Team determined from its analysis that 60 percent of cannabis flower rooms have one tier of plants with canopy area approximately 70 percent of room area and 40 percent of cannabis flower rooms have two tiers of plants with canopy area approximately 140 percent of room area. The breakdown of single tier facilities vs. multiple tier facilities is estimated values in 2029, based on a 2024 Cannabis Business Times survey indicating that 30 percent of growers currently use multiple tiers for cannabis flowering, and 15 percent of those who do not are considering doing so in the next 12 months (Cannabis Business Times, 2024). Articles indicate that 60 to 75 percent (Thompson, 2025) or 85 percent (Staffa, 2023) are common flower room canopy ratios for single-tier rooms. Canopy ratios in two-tier facilities are typically double those in single-tier facilities (Sonoma County Cannabis, 2021).
- An existing HVAC/D system is fully replaced roughly every 12 years due to changing canopy area (such as adding an additional growing tier), changing to LED lights (which changes the sensible and latent loads), or for the purpose of getting more control over environmental conditions. This replacement interval reflects typical grower behavior as observed by members of the Statewide CASE Team, based on their industry experience. Furthermore, industry survey data supports that many growers are moving to increase canopy in cannabis flower rooms, which would necessitate a large increase in cooling and dehumidification load, triggering the code. A 2025 industry survey indicates that (Cannabis Business Times, 2026)<sup>OBJ:OBJ</sup>. A 2024 survey indicates that 15% of growers who currently do not use vertical rack systems in flower area considering doing so in the next 12 months.
- Current market share of systems compliant with the proposed code is roughly 25 percent on a square footage basis, so savings will be realized for 75 percent of the impacted square footage. Eight responses in a poll on this value in the Utility-

Sponsored Stakeholder Meeting held on September 24, 2025, led to an average value of 22.5 percent. (California Energy Codes & Standards, 2025)

The Statewide CASE Team plans to conduct additional stakeholder outreach to update and confirm these assumptions prior to publication of the Final CASE Report.

The 2028 CASE Methodology Report provides more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 59) and alterations (Table 60) by climate zone.

Table 61 presents first-year statewide savings from new construction, additions, and alterations.

**Table 59: Statewide Energy and LSC Impacts – New Construction and Additions**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0084	0.35	0.04	N/A	0.58	\$3.01
2	0.0070	0.28	0.03	N/A	0.48	\$2.44
3	0.0289	1.19	0.13	N/A	1.98	\$10.25
4	0.0036	0.13	0.01	N/A	0.24	\$1.17
5	0.0182	0.75	0.08	N/A	1.26	\$6.44
6	0.0233	0.93	0.10	N/A	1.55	\$8.07
7	0.0001	0.01	0.00	N/A	0.01	\$0.04
8	0.0021	0.08	0.01	N/A	0.14	\$0.68
9	0.0024	0.09	0.01	N/A	0.15	\$0.74
10	0.0251	0.89	0.10	N/A	1.59	\$7.75
11	0.0273	0.99	0.11	N/A	1.76	\$8.62
12	0.0276	1.06	0.12	N/A	1.83	\$9.11
13	0.0081	0.29	0.03	N/A	0.52	\$2.51
14	0.0010	0.03	0.00	N/A	0.06	\$0.30
15	0.0043	0.12	0.02	N/A	0.25	\$1.11
16	0.0004	0.02	0.00	N/A	0.03	\$0.14
<b>Total</b>	<b>0.1878</b>	<b>7.20</b>	<b>0.79</b>	<b>N/A</b>	<b>12.41</b>	<b>\$62.38</b>

**Table 60: Statewide Energy and LSC Impacts – Alterations**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0053	0.22	0.02	N/A	0.36	\$1.89
2	0.0034	0.14	0.01	N/A	0.23	\$1.20
3	0.0197	0.81	0.09	N/A	1.35	\$7.00
4	0.0081	0.30	0.03	N/A	0.53	\$2.63
5	0.0476	1.95	0.21	N/A	3.28	\$16.79
6	0.0622	2.48	0.27	N/A	4.15	\$21.57
7	0.0081	0.32	0.03	N/A	0.53	\$2.73
8	0.0056	0.21	0.02	N/A	0.36	\$1.80
9	0.0120	0.44	0.05	N/A	0.77	\$3.76
10	0.0272	0.97	0.11	N/A	1.72	\$8.38
11	0.0189	0.69	0.08	N/A	1.22	\$5.97
12	0.0341	1.31	0.14	N/A	2.26	\$11.27
13	0.0403	1.43	0.16	N/A	2.56	\$12.45
14	0.0035	0.12	0.01	N/A	0.22	\$1.07
15	0.0048	0.14	0.02	N/A	0.28	\$1.25
16	0.0018	0.07	0.01	N/A	0.11	\$0.57
<b>Total</b>	<b>0.3026</b>	<b>11.57</b>	<b>1.27</b>	<b>N/A</b>	<b>19.93</b>	<b>\$100.33</b>

**Table 61: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations**

<b>Construction Type</b>	<b>First-Year Electricity Savings (GWh)</b>	<b>First-Year Peak Electrical Demand Reduction (MW)</b>	<b>First -Year Natural Gas Savings (Million Therms)</b>	<b>First-Year Source Energy Savings (Million kBtu)</b>	<b>30-Year Present Valued LSC Savings (Million 2029 PV\$)</b>
<b>New Construction &amp; Additions</b>	7.2	0.792	N/A	12.4	\$62.38
<b>Alterations</b>	11.6	1.3	N/A	19.9	\$100.33
<b>Total</b>	<b>18.8</b>	<b>2.1</b>	<b>N/A</b>	<b>32.3</b>	<b>\$162.71</b>

### 4.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 62 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 1,711 metric tons of CO<sub>2</sub>e emissions. These reductions, along with their associated monetary value, were calculated using hourly 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. The 2028 CASE Methodology Report provides additional information.

**Table 62: First-Year Statewide GHG Emissions Impacts**

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO <sub>2</sub> e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO <sub>2</sub> e)	Total Reduced GHG Emissions (Metric Ton CO <sub>2</sub> e)	Total Monetary Value of Reduced GHG Emissions (\$)
New Construction, Additions, & Alterations	1,711	N/A	1,711	\$210,705

### 4.5.3 Statewide Water Use Impacts

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

### 4.5.4 Statewide Material Impacts

The Statewide CASE Team will update the statewide material impacts for this measure prior to publication of the Draft CASE Report. Less ducting is required for integrated systems, and when systems are correctly sized, integrated systems have less total tonnage than decoupled systems. Therefore, the Statewide CASE Team anticipates that this measure will reduce usage of most materials. The 2028 CASE Methodology Report provides more information on the Statewide CASE Team’s methodology and assumptions used to calculate embodied GHG emissions.

### 4.5.5 Environmental Impacts

Requirements for HVAC system controls and performance criteria for rooms with at least 30 W per canopy square foot lighting power density in indoor growing facilities with at 5,000 square feet of canopy are expected to provide clear environmental benefits by lowering energy use and, in turn, reducing GHG emissions from electricity generation. The Statewide CASE Team did not identify any indirect benefits or any adverse

environmental impacts, whether direct or indirect, associated with this measure, so mitigation strategies are not needed. In addition, the Statewide CASE Team found no reasonable alternatives that could achieve the same reduction in CEH lighting energy consumption with fewer environmental effects. Because the proposed requirement improves efficiency without introducing negative consequences and no other options offer comparable results, it represents the most practical and environmentally responsible approach. At the time of the draft report, the Statewide CASE Team expects that material consumption will be reduced; however, this conclusion will continue to be evaluated through stakeholder outreach and updated as new information becomes available.

#### **4.5.6 Other Non-Energy Impacts**

Other non-energy impacts include improved crop yields and improved space utilization. Growth can be optimized with these systems because integrated systems can provide a more stable vapor pressure deficit, plant transpiration, and nutrient uptake. Improved humidity control, with correctly sized systems, can reduce the risk of mold, leading to higher product yields, reduced pesticide use, and reduced exposure of workers to mold. Non-integrated, conventional HVAC systems often run constantly and inefficiently as they fight against separate humidifiers, leading to premature failure. Integrated systems that are purpose-built for this high-duty-cycle application result in fewer breakdowns and lower maintenance costs.

### **4.6 Space Conditioning Systems - Proposed Code Language**

#### **4.6.1 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 should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

#### **4.6.2 Administrative Code (Title 24, Part 1)**

No changes are proposed to Title 24, Part 1.

#### **4.6.3 Energy Code (Title 24, Part 6)**

### **SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION**

Section 100.1(b) – Definitions

**CONDITIONED SPACE, DIRECTLY** is an enclosed space that is provided with wood heating, mechanical heating that has a capacity exceeding 10 Btu/hr-ft<sup>2</sup>, or mechanical cooling that has a capacity exceeding 5 Btu/hr-ft<sup>2</sup>. Directly

conditioned space does not include process space or CEH space. (See “process space” and “Controlled Environment Horticulture (CEH) Space”)

...

**CONTROLLED ENVIRONMENT HORTICULTURE (CEH) SPACE** is a building space dedicated to growing plants production by manipulating indoor environmental conditions, through electric lighting, irrigation, mechanical heating, mechanical cooling, or dehumidification. CEH space does not include building space where plants are grown solely to decorate that same space.

...

**INTEGRATED DX HVAC/D SYSTEM** is a direct expansion HVAC and dehumidification system designed to handle both sensible and latent heat removal. Integrated DX HVAC/D systems may include but are not limited to: HVAC systems with a sensible heat ratio of 0.65 or less and the capability of providing cooling, dedicated outdoor air systems, single package air conditioners with at least one refrigerant circuit providing hot gas reheat, and dehumidifiers modified to allow external heat rejection.

...

**PLANT CANOPY AREA** is the area, in square feet, where mature, or flowering, plants are grown. Each part of the total canopy area is defined by clearly identifiable physical boundaries around all areas that will contain plants. Physical boundaries include, but are not limited to, interior walls, shelves, or greenhouse walls delineating the perimeter. Where plants will be grown in multiple tiers, the area of each tier shall be summed to determine the plant canopy area. Plant canopy area includes all actively used growing surfaces, and excludes aisles, non-plant production zones, and equipment-only areas.

...

**RECOVERED HEAT CAPACITY RATIO** is the percentage of reheat capacity provided by recovered heat.

...

**REHEAT CAPACITY** is the amount of energy introduced into the airstream, downstream of the cooling and dehumidification coil, for the purposes of meeting the required air supply temperature setpoints.

...

**SENSIBLE HEAT RATIO** is the percentage of an HVAC system's total cooling capacity that goes towards lowering air temperature (sensible heat) versus removing moisture (latent heat) calculated as Sensible Heat Capacity / Total Heat Capacity.

SECTION 120.1 – REQUIREMENTS FOR VENTILATION AND INDOOR AIR QUALITY

TABLE 120.1-A– Continued Minimum Ventilation Rates

• Occupancy Category – Miscellaneous Spaces	• Minimum Occupant • Load Density (persons • / 1000 ft <sup>2</sup> )	• Area-based • Minimum Ventilation • Ra (cfm/ft <sup>2</sup> )	• Air Class	• Notes
Bank vaults/safe deposit	5	0.15	2	F
Banks or bank lobbies	5	0.15	1	F
Computer (not printing)	5	0.15	1	F
Freezer and refrigerated spaces (<50°F)	0	0	2	E
<a href="#">Controlled Environment Horticulture Spaces with Carbon Dioxide Enrichment</a>	<u>0</u>	<u>0</u>	<u>2</u>	<u>-</u>

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(h) Mandatory requirements for Controlled Environment Horticulture (CEH) spaces.

1. **Indoor growing, dehumidification.** Dehumidification equipment [in Controlled Environment Horticulture \(CEH\) spaces with less than or equal to 5000 square feet of total plant canopy area or with lighting power density less than or equal to 30 Watts per square foot of plant canopy area](#) shall be one of the following:

A. Dehumidifiers subject to regulation under federal appliance standards tested in accordance with 10 CFR 430.23(z) and Appendix X or X1 to Subpart B of 10 CFR Part 430 as applicable, and complying with 10 CFR 430.32(v)2;

B. Integrated [DX](#) HVAC/[D](#) system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat;

C. Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or

D. Solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50°F or less.

...

**6. Indoor growing, space conditioning systems.** Facilities with greater than 5,000 square feet of total plant canopy area with lighting power density greater than 30 Watts per square foot of plant canopy area shall comply with all of the following:

**A. Sizing, space conditioning system.** Space conditioning system(s) shall be sized to meet the design heating, cooling, and dehumidification loads calculated according to NA9.

**B. Heat recovery.** Equipment used for dehumidification shall be capable of meeting a recovered reheat capacity ratio of at least 0.9.

**C. Supplemental heating.** If used, electric resistance heating or combustion heating equipment shall comply with the following:

i. Equipment shall be sized to meet steady state or transient heating loads that cannot be met with heat recovered from the dehumidification process according to NA.9.

ii. Equipment shall be controlled to only operate when heating load exceeds 100% of the available dehumidification process heat.

**D. Integrated temperature and humidity controls.** Controls for space conditioning equipment shall meet all of the following requirements:

i. One integrated control system shall control both humidity and temperature based on readings from humidity and temperature sensors co-located within the plant canopy.

ii. Controls shall automatically stage or modulate all space conditioning equipment to meet temperature and humidity setpoints.

**E. Dehumidification equipment without modulating heat recovery and modulating heat rejection.** If used, dehumidification equipment without modulating heat recovery and modulating heat rejection shall:

i. Be controlled from a central controller that sequences unitary dehumidifiers automatically based on dehumidification load.

ii. Only be activated during periods when all waste heat can be used in the space or when other space conditioning equipment cannot satisfy 100% of cooling, heating, and dehumidification loads.

**F. Field verification.** Field verification of specified control function tests shall demonstrate the correct installation and operation of components, systems and system-to-system interfaces in accordance with the test requirements in NA7.X.

## SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

(d) Prescriptive Requirements for Controlled Environment Horticulture (CEH) Indoor Growing Spaces.

**1. Space conditioning systems for CEH indoor growing spaces.** Facilities with greater than 5,000 square feet of total plant canopy area with lighting power density greater than 30 Watts per square foot shall comply with all of the following:

- A. Construction documents shall identify a primary space conditioning system capable of providing cooling, dehumidification, and reheat using heat recovered from the dehumidification process. The primary space conditioning system shall be one of the following:
  - i. An integrated DX HVAC/D system,
  - ii. A four-pipe chilled water system,
  - iii. A desiccant dehumidification system, or
  - iv. Another system meeting the specifications outlined in 140.9(d)1C.
- B. The primary system must be sized to meet at least 80% of peak latent and sensible load.
- C. The primary system and controls shall be capable of the following in response to process needs, indoor temperatures and humidity conditions:
  - i. Modulate sensible heat ratio in response to measured indoor growing space conditions and temperature and humidity setpoints;
  - ii. Modulate heat recovery between 0% and 90% of heat of rejection of the primary system, as needed to meet supply air setpoints;
  - iii. Modulate heat rejection outside of the space between 10% and 100% of heat of rejection of the primary system;
  - iv. Modulate supply fan speed in response to measured space conditions and temperature and humidity setpoints; and
  - v. Controlled in accordance with 120.6(h)6D.

SECTION 141.1 – REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONS, ALTERATIONS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS

(c) Controlled Environment Horticulture Spaces.

**1. Indoor Growing, Space-Conditioning Systems and Dehumidification.** For all additions or alterations that increase plant canopy area by at least 5000 square feet, and all alterations that replace greater than 50 percent of the total capacity of heating, cooling, and dehumidification systems serving at least 5000 square feet of plant canopy area in indoor growing spaces shall meet the applicable requirements of Sections 120.6(h)1, 120.6(h)2, 120.6(h)6, and 140.9(d).

## 4.6.4 Reference Appendices

### Appendix NA7.X Controlled Environment Horticulture Acceptance Tests

#### NA7.x.1 Indoor Growing Space Conditioning Controls Verification

Verify and document the following:

- a. Primary space conditioning equipment type and sensible cooling capacity, latent cooling capacity, dehumidification heat recovery capacity, and heating capacity are shown on plan documents.
- b. If supplemental electric resistance heating or combustion heating system is installed:
  1. Capacity is shown on plan documents.
  2. A control system is installed capable of limiting supplemental heating system operation to only turn on when the space heating load exceeds the dehumidification heat rejection capacity.
- c. If dehumidifiers without modulating heat rejection/recovery capacity are installed:
  1. Capacity is shown on plan documents.
  2. A control system is installed capable of automatically staging individual dehumidifiers based on space dehumidification load.
- d. Temperature and humidity sensors used for space conditioning system control are installed in the plant canopy.

### Appendix NA9 Controlled Environment Horticulture Space Conditioning System Sizing

#### NA 9.1 Purpose and Scope

The purpose of this load calculation and sizing calculations is to provide instructions for calculating loads and sizing space conditioning equipment in Controlled Environment Horticulture spaces. These calculations will enable determination of whether a design complies with the code in section 120.6(h)6A.

This load calculation and sizing procedure is applicable to CEH spaces with lighting power density greater than 30 Watts per canopy square foot in CEH facilities with canopy area of 5,000 square feet or larger.

#### NA9.2 Canopy Square Footage

To determine canopy area at indoor grow rooms, boundaries in the form of trellising, trays, shelves, etc. serve to demarcate the canopy of the cultivation area.

1. When plants will be cultivated on benches or tables above the floor, the bench is used as the identifiable boundary to demarcate the canopy in the room. Aisles or walkways are not included in the canopy area.
2. When plants are cultivated on shelving to grow vertically, the area of each shelf in each tier is summed to calculate the canopy area. In this case the canopy area may be greater than the room area.
3. For indoor facilities without tables or benches, the floor space area of the room that will be dedicated to growing plants is used.

### NA9.3 Load Calculations

#### NA9.3.1. Design Loads

In calculating design loads, the following inputs values shall be specified:

- a. Ambient design conditions, including the summer design (0.4%) dry bulb temperature, the summer design (0.4%) mean coincident wet bulb temperature, and the winter design (99%) dry bulb temperature.
- b. For each unique room or other CEH space where lighting intensity is greater than 30W/canopy square foot, provide the following:
  - i. Canopy square footage calculated as described in NA9.2 Canopy Square Footage.
  - ii. For the first week of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, provide the following inputs:
    - A. Dry bulb room conditions for lights on and lights off conditions.
    - B. Wet bulb room conditions for lights on and lights off conditions.
    - C. Horticultural lighting wattage. This is the total aggregate horticultural lighting power, including all ballast or driver multipliers. This value should account for any dimming used in different parts of the grow cycle.
    - D. Motor heat in the room for lights on and lights off conditions. This includes the circulation fan power and may be equal to the total circulation fan power.
    - E. Net plant irrigation per day, calculated as the amount delivered less runoff.
    - F. Percentage of net plant irrigation transpired during the lights-on period. This value shall be no less than 70% and no greater than 80%.

- G. Lights on period length in hours per day.
- H. Envelope load is optional and may be included.

NA9.3.2 Latent and Sensible Load Calculations.

- a. The Sensible Space Load is calculated for the first week of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.
  - 1. The Sensible Space Load is calculated as the sum of the Horticultural Lighting Load, The Motor Heat Load, and the Standalone Dehumidifier Load. Power in kW can be converted to load in BTU/hr by multiplying by 3415 BTU/hr/kW.

*Sensible Space Load*

$$= (\text{Horticultural Lighting Load} + \text{Motor Heat Load} + \text{Standalone Dehumidifier Load}) \times 3415 \frac{\text{BTU}}{\text{hour} \cdot \text{kW}}$$

- b. The Evapotranspiration Load is calculated for the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.
  - 1. The Evapotranspiration Load is calculated as the Plant Irrigation in gallons/day, converted to pounds per day by multiplying by 8.33 pounds/gallon, then multiplying by the % of Total Irrigation Transpired during lights on or lights off, and divided by the number of hours the lights are on or off per day, and multiplying by 1060 BTU/pound of water.

*Evapotranspiration Load*

$$= \frac{(\text{Net Irrigation}) \times 8.33 \frac{\text{lb}}{\text{gal}} \times (\% \text{ irrigation transpired while lights on/off}) \times \left(1060 \frac{\text{BTU}}{\text{lb}}\right)}{\text{hours lights on/off}}$$

NA9.4 Cooling or Integrated Space Conditioning System Equipment Specification

- 1. The Cooling or Integrated Space Conditioning System Performance is listed for the loads and operating conditions described the first week of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions, for a total of 6 conditions.
- 2. System Air Flow in CFM is the system load side (room) air flow at the performance condition at each of the 6 specified conditions.
- 3. Total Cooling Capacity in BTU/hr is the total system cooling capacity at the operating condition to address the highest combined sensible and latent load condition.

4. The Latent Removal Capacity in BTU/hr is the peak energy necessary used for the water removed from the load side of the equipment and is equal to 1060 BTU/pound of water removed, per hour.
5. The Sensible Heat Ratio is calculated as the sensible portion of the Total Cooling Capacity divided by the Total Cooling Capacity.

$$\text{Sensible Heat Ratio} = \frac{\text{Total Cooling Capacity} - \text{Latent Removal Capacity}}{\text{Total Cooling Capacity}}$$

6. The Reheat Capacity is the amount of air reheating that must be provided to the airstream to satisfy the room condition.
7. Recovered Heat Capacity is the amount of heat that is recovered using any of a variety of means to be utilized as reheat for the load air stream.

#### NA9.5 Additional Equipment Specification

Additional equipment, including standalone dehumidifiers and supplemental heating shall be specified as follows:

1. The quantity of standalone dehumidifiers shall be specified
2. The moisture removal capacity, the moisture removal efficiency, and the motor power of the standalone dehumidifiers shall be specified for the loads and operating conditions described the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.
3. The total hourly moisture removal capacity can be calculated as the moisture removal capacity per dehumidifier, converted to pounds per hour, and multiplied by the quantity of standalone dehumidifiers in the space. This shall be calculated for the loads and operating conditions described the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.
4. The supplemental heating capacity shall be specified in BTU/hr for the loads and operating conditions described the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.

#### NA9.6 System Capacity

1. The Total System Cooling Capacity shall be calculated as the total cooling operating capacity specified for the equipment for the loads and operating conditions described the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.
2. The Total System Latent Removal Capacity shall be calculated as The Cooling/Integrated System Latent Removal Operating Capacity plus the

[standalone dehumidifier Total Hourly Moisture Removal Capacity converted to BTU/hr. This shall. Be calculated for the loads and operating conditions described the first day of the grow cycle, the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions.](#)

#### **4.6.5 Compliance Manuals**

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

#### **4.6.6 ACM Reference Manual**

##### Unmet Load Hours (2.4)

This manual uses the term unmet load hours (UMLHs) as a criterion for determining if the proposed design heating/cooling capacities are sufficient to meet the simulated loads. The concept of unmet load hours applies to thermal zones. For a thermal zone, it represents the number of hours during a year when the HVAC system serving the thermal zone is unable to maintain the set point temperatures for heating or cooling or both. During periods of unmet loads, the zone temperature drifts above the cooling set point or below the heating set point. A thermal zone is considered to have one UMLH if the zone temperature is outside a specified tolerance below the heating or above the cooling set point for the entire hour. The set-point tolerance for nonresidential occupancies is defined in Chapter 5.3.5 Space Temperature Control.

UMLHs occur only during periods when the zone is occupied, [except in indoor CEH Spaces, where UMLH's occur during periods when plants are being grown](#). UMLHs are accounted for in each zone of the building. No zone in the building should exceed the maximum allowed UMLH.

##### Sizing Equipment in the Standard Design (2.6.2)

For sizing heating and cooling equipment capacities, the compliance software shall use design day schedules as specified in Chapter 5.2: Project Data. For cooling capacity sizing, compliance software shall use the OnDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules, respectively. For heating capacity sizing, compliance software shall use the OffDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules, respectively.

[For sizing heating, cooling, and dehumidification equipment capacities in CEH Spaces, \[TBD\].](#)

Equipment in the standard design is automatically sized by the program as described below. Net coil capacities are calculated using the adjustments described in Section 5.7.5 Cooling Systems and Section 5.7.6 Heating Systems. The compliance software

will tabulate the zone UMLH for the standard design in the same manner as the proposed design. However, standard design UMLH will not influence compliance analysis.

HVAC System Map (5.1.3)

Table 1: Nonresidential HVAC System Map

<u>Space Type</u>	<u>Above-Grade Floors</u>	<u>Climate Zone</u>	<u>System Cooling Capacity</u>	<u>Standard Design</u>
<u>Horticulture Vegetative</u>	<u>Any</u>	<u>1-16</u>	<u>TBD</u>	
<u>Horticulture Flowering</u>	<u>Any</u>	<u>1-16</u>	<u>TBD</u>	
<u>Horticulture Drying</u>	<u>Any</u>	<u>1-16</u>	<u>TBD</u>	
<u>Processing</u>	<u>Any</u>	<u>1-16</u>	<u>TBD</u>	

“Indoor CEH” building space types include “Horitculture vegetative,” Horticulture Flowering,” Horticulture Drying,” and “Processing.” To qualify for this system, [TBD].

Table 2: System Descriptions

<b>System Type</b>	<b>Description</b>	<b>Detail</b>
<u>System 16 – IntDX</u>	<u>Integrated DX</u>	<u>TBD</u>

Process Loads (5.4.9)

Indoor growing of crops includes horticultural lighting, at lighting power densities greatly exceeding those for human use, and operating on schedules determined by crop needs and not occupancy, evapotranspiration loads that vary based on stage in the grow cycle and whether lights are on or off, and humidity and temperature setpoints that vary based on the stage in the grow cycle and whether lights are on or off.

Horticultural Process Equipment Schedule

Applicability: All spaces with horticultural process loads

Definition: TBD

Units: TBD

Input Restrictions: TBD

Standard Design: TBD

*Standard Design: Existing Buildings: Same as newly constructed buildings.*

Horticultural Process Loads

*Applicability: All indoor CEH facilities*

Definition: TBD

Units: TBD

Input Restrictions: TBD

Standard Design: TBD

*Standard Design: Existing Buildings: Same as newly constructed buildings.*

Horticultural Process Load Schedule

*Applicability: All spaces with horticultural process loads*

Definition: TBD

Units: TBD

Input Restrictions: TBD

Standard Design: TBD

*Standard Design: Existing Buildings: Same as newly constructed buildings.*

Basic System Information (5.7.1)

System Type

Input Restrictions

IntDX – Integrated DX

System Controls (5.7.2)

Schedules (5.7.2.2)

Humidity and Temperature Control

*Applicability: All cooling and dehumidification systems in horticulture space types.*

Definition: TBD

Units: TBD

Input Restrictions: TBD

Standard Design: TBD

*Standard Design: Existing Buildings: Same as newly constructed buildings.*

ACM Appendix E – Plug Loads and Lighting Modeling

[TBD](#)

ACM Appendix G – Algorithms

[TBD](#)

ACM Appendix 5.4A Space Use Data

[The Statewide CASE Team will add the new space types, “Horitculture vegetative,” Horticulture Flowering,” Horticulture Drying,” and “Processing” throughout the document.](#)

ACM Appendix 5.4B Schedules

[The Statewide CASE Team will add schedules for the new space types, “Horitculture vegetative,” Horticulture Flowering,” Horticulture Drying,” and “Processing” throughout the document. Schedules for Horticulture Flowering are shown in Table 63. Prototype Flower Room Latent Load, Setpoint, and Lighting Dimming Schedules.](#)

**Table 63. Prototype Flower Room Latent Load, Setpoint, and Lighting Dimming Schedules.**

Schedule	Day	Hour																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Horticulture Flowering CEH Evapotranspiration Schedule (% of peak latent load)	Initial Stage (7 days)	12	12	12	12	12	12	30	40	45	50	50	50	50	50	50	50	50	50	35	25	20	18	16	14
	Early Stage (7 days)	14	14	14	14	14	14	60	70	75	80	80	80	80	80	80	80	80	80	60	43	34	26	22	18
	Mid Stage (35 days)	18	18	18	18	18	18	73	82	91	100	100	100	100	100	100	100	100	100	75	54	41	31	26	21
	Late Stage (14 days)	25	25	25	25	25	25	68	75	83	90	90	90	90	90	90	90	90	90	70	55	40	35	30	28
	Crop Rotation (4 days)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Horticulture Flowering CEH Setpoint Schedule (Cooling, °F)	Initial & Early Stages (14 days)	79	79	79	79	79	79	82	82	82	82	82	82	82	82	82	82	82	82	79	79	79	79	79	79
	Mid Stage (35 days)	75	75	75	75	75	75	79	79	79	79	79	79	79	79	79	79	79	79	75	75	75	75	75	75
	Late Stage (14 days)	70	70	70	70	70	70	73	73	73	73	73	73	73	73	73	73	73	73	70	70	70	70	70	70
	Crop Rotation (4 days)	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Horticulture Flowering CEH Setpoint Schedule (Humidity, %RH)	Initial & Early Stages (14 days)	65	65	65	65	65	65	67	67	67	67	67	67	67	67	67	67	67	67	65	65	65	65	65	65
	Mid Stage (35 days)	54	54	54	54	54	54	57	57	57	57	57	57	57	57	57	57	57	57	54	54	54	54	54	54
	Late Stage (14 days)	46	46	46	46	46	46	48	48	48	48	48	48	48	48	48	48	48	48	46	46	46	46	46	46
	Crop Rotation (4 days)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Schedule	Day	Hour																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Horticulture Flowering CEH Lighting - Dimming schedule	Initial Stage (7 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0
	Early Stage (7 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	Mid Stage (35 days)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	Late Stage (14 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	Crop Rotation (4 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[TBD](#)

#### **4.6.7 Compliance Forms**

As discussed in Section 4.1.4.5, the existing Process System Certificate of Compliance form (NRCC-PRC-E, Section P: Controlled Environment Horticulture) and Process System Certificate of Installation form (NRCI-PRC-E, Space Conditioning for Plant Production section) would both need new input fields added to ensure that CEH facilities meet sizing requirements and space conditioning system requirements. A new form, (NRCA-PRC-XX-F, Nonresidential Certificates of Acceptance), would need to be created to demonstrate compliance with new field technician acceptance testing requirements for CEH facilities.

To support accurate completion of the Process System Certificate of Compliance form, the Statewide CASE team has developed an Excel-based tool that mechanical designers and Title 24 consultants can use to calculate loads and verify compliance with mandatory sizing requirements, as well as prescriptive requirements for the primary space conditioning system. The sizing and load calculations are described in detail in Section 4.6.4.

The tool includes formulas and checks to simplify the process of verifying that a space conditioning system is sized to meet projected loads throughout the grow cycle, and that equipment meets the key performance specifications outlined in the prescriptive requirements.

The first step in using the load calculation, sizing, and equipment performance tool would require the designer to provide ambient design conditions based on the facilities location and describe the plant canopy area and planned daytime operating conditions, as shown in Figure 2.

Facility Ambient Design Conditions			
			Key
ASHRAE WMO Station:			User Input Value
Summer Design (0.4%)	DB (°F)		Default no value
	MCWB (°F)		Calculated Value
Winter Design (99%):	DB (°F)		

Facility Room Details																									
Fill out the following for each room/CEH Space																									
Room Name:	(Can be multiple rooms of the same size)																								
Canopy Square Feet:																									
Provide the Design Space Conditions for the four CEH environment operating conditions:																									
	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="2">Week 1 of Grow Cycle</th> <th colspan="2">Early/Mid Plant Life</th> <th colspan="2">Late Plant Life</th> </tr> <tr> <th>Day</th> <th>Night</th> <th>Day</th> <th>Night</th> <th>Day</th> <th>Night</th> </tr> </thead> <tbody> <tr> <td>Daytime Room Conditions (Lights On)</td> <td>DB (°F)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>WB (°F)</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life		Day	Night	Day	Night	Day	Night	Daytime Room Conditions (Lights On)	DB (°F)						WB (°F)				
Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life																					
Day	Night	Day	Night	Day	Night																				
Daytime Room Conditions (Lights On)	DB (°F)																								
	WB (°F)																								

**Figure 2: Facility Ambient Design Conditions and Room Details**

The next step would require the designer to provide loads from lighting, circulation fans, and transpiration at each of three phases in the grow cycle to calculate sensible and evapotranspiration load, as shown in Figure 3.

CEH Room Load Calc																																																																			
Provide the CEH Environmental Load Requirements for each space at the 6 prescribed conditions:																																																																			
	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="2">Week 1 of Grow Cycle</th> <th colspan="2">Early/Mid Plant Life</th> <th colspan="2">Late Plant Life</th> </tr> <tr> <th>Day</th> <th>Night</th> <th>Day</th> <th>Night</th> <th>Day</th> <th>Night</th> </tr> </thead> <tbody> <tr> <td>Horticultural Lighting</td> <td>(kW)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Motor Heat (Fan Power)</td> <td>(kW)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Standalone Dehu Load</td> <td>(BTU/hr)</td> <td>-</td> <td>-</td> <td></td> <td></td> </tr> <tr> <td>Envelope Load (Optional)</td> <td>(BTU/hr)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Plant Irrigation</td> <td>(gal/day)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>% of Total Irrigation Transpired</td> <td>%</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Hours (Day/Night)</td> <td>(hrs)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Sensible Space Load</td> <td>(BTU/hr)</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> </tr> <tr> <td>Evapotranspiration Load</td> <td>(BTU/hr)</td> <td>#DIV/0!</td> <td>#DIV/0!</td> <td>#DIV/0!</td> <td>#DIV/0!</td> </tr> </tbody> </table>	Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life		Day	Night	Day	Night	Day	Night	Horticultural Lighting	(kW)					Motor Heat (Fan Power)	(kW)					Standalone Dehu Load	(BTU/hr)	-	-			Envelope Load (Optional)	(BTU/hr)					Plant Irrigation	(gal/day)					% of Total Irrigation Transpired	%					Hours (Day/Night)	(hrs)					Sensible Space Load	(BTU/hr)	-	-	-	-	Evapotranspiration Load	(BTU/hr)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life																																																															
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Evapotranspiration Load	(BTU/hr)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!																																																														

**Figure 3: CEH Room Load Inputs and Calculations**

Subsequently, the designer would input operating airflows, capacities, and reheat load for each of the three phases in the grow cycle, as shown in Figure 4.

Prescriptive Compliance and Cooling System Operating Performance Information							
Cooling/Integrated System Equipment Specification							
Input the Primary System Performance Information <b>that corresponds to the ambient and CEH space operating conditions and loads above:</b>							
		Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life	
		Day	Night	Day	Night	Day	Night
System Operating Air Flow	(CFM)						
Total Cooling Operating Capacity	(BTU/hr)						
Latent Removal Operating Capacity	(BTU/hr)						
Operating Sensible Heat Ratio		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Reheat Operating Load	(BTU/hr)						
Recovered Heat Operating Capacity	(BTU/hr)						
Source of Recovered heat:		Text or Selection					
Cooling Stages:		#					
Cooling Stage # Type:		Variable or Constant					

**Figure 4: Prescriptive Compliance and Operating Performance**

Finally, the designer would describe any additional dehumidification or heating equipment, as shown in Figure 5.

Additional Equipment Specification							
		Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life	
		Day	Night	Day	Night	Day	Night
Quantity of Standalone Dehumidifiers	(#)						
Moisture Removal Capacity (At operating conditions)	(pints/day)						
Standalone Dehumidifier Moisture Removal Efficiency	(L/kWh)						
Standalone Dehumidifier Motor Power	(kW/ea)						
Total Hourly Moisture Removal Capacity	(lbm/hr)	0.00	0.00	0.00	0.00	0.00	0.00
Supplemental Heating Capacity	(BTU/hr)						
Supplemental Heating Capacity		Text or Selection					

**Figure 5: Additional Equipment Specification**

The tool would provide a summary of the combined cooling and latent removal capacity for all space conditioning equipment, helping to verify that the system is sized to meet the design conditions for the facility, as shown in Figure 6.

Mandatory Sizing Requirements - All System Types							
System Summary (including Standalone and Supplemental Heat)							
		Week 1 of Grow Cycle		Early/Mid Plant Life		Late Plant Life	
		Day	Night	Day	Night	Day	Night
Total System Cooling Capacity	(BTU/hr)	-	-	-	-	-	-
Total Latent Removal Capacity	(BTU/hr)	-	-	-	-	-	-

**Figure 6: System Summary**

The Statewide CASE Team can support the CEC in implementing these updates and tools if the proposed change is adopted.

## 5. Bibliography

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# Appendix A: Assumptions for Cost-effectiveness Analysis

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## A.1 Lighting Efficacy

### Key Assumptions for Energy Savings Analysis

Assumptions utilized for the proposed increase to minimum PPE are based on data, market research, and stakeholder input from the 2025 CEH CASE Report (California Energy Commission 2023). The Statewide CASE Team met with and will continue to meet with luminaire manufacturers, academic researchers, agricultural lighting consultants, and CEH facility operators to review and refine the key assumptions.

For the proposed increase to the minimum lighting efficacy requirement (PPE), the baseline case assumes minimally compliant 2025 Title 24, Part 6 CEH luminaires with PPE of 2.3  $\mu\text{mol}/\text{J}$ , while the proposed case assumes a minimum PPE of 2.5  $\mu\text{mol}/\text{J}$ . All other key assumptions used in the energy savings analysis for each crop-type building configuration are kept constant between the baseline and proposed cases.

#### A.1.1 Climate Zones

The Statewide CASE Team determined energy impacts to be climate-sensitive for both indoor CEH facilities and greenhouse facilities.

The indoor (warehouse) energy savings analysis includes interactive HVAC effects, which are impacted by outdoor air temperature variability. Savings vary slightly by climate zone due to variations in regional Typical Meteorological Year (TMY) weather by climate zone.

Greenhouses use daylight as a primary light source and operate supplemental lighting when daylight is insufficient to meet crop light targets. TMY data for each climate zone captures differences in daily and hourly solar radiation, including Global Horizontal Irradiance (GHI) in watts per square meter ( $\text{W}/\text{m}^2$ ), cloud cover, and haze patterns via Diffuse Horizontal Irradiance (DHI,  $\text{W}/\text{m}^2$ ), and day length. These conditions determine the number of hours that supplemental lighting must operate. Climate zones with higher annual daylight require fewer supplemental lighting hours, while coastal and northern zones tend to have less intense daylight or more persistent cloud cover. TMY data are used to estimate supplemental lighting operation, and results are reported on a per-square-foot basis for all 16 climate zones individually.

TMY data were sourced from 2028 CEC weather files.

## A.1.2 Prototypical Building Types

Prototypical models were developed for the six scenarios, including two facilities and three crop types shown in Table 64, consistent with prior CEH CASE efforts. The energy impacts for each prototype were modeled independently in the custom spreadsheet-based simulation tool developed by the 2025 CASE Team and evaluated on a per-square-foot basis. Crops (i.e., cannabis, leafy greens, and tomatoes) were selected based on previous CEH CASE work to represent high, medium, and low light intensity crops (Energy Solutions, 2023).

**Table 64: Building Prototype Models**

Prototype	Crop Type
Indoor (Warehouse)	Cannabis (83% flowering, 15% vegetative, 2% clone breakdown by canopy area)
	Leafy greens
	Tomatoes
Greenhouse	Cannabis (65% flowering, 33% vegetative, 2% clone breakdown by canopy area)
	Leafy greens
	Tomatoes

Note: The canopy area breakdown for CEH is based on the 2025 CASE Report and will be updated with stakeholder input data.

The baseline case assumes minimally compliant 2025 Title 24, Part 6 CEH luminaires with PPE of 2.3  $\mu\text{mol}/\text{J}$ , while the proposed case assumes a minimum PPE of 2.5  $\mu\text{mol}/\text{J}$ . All other key assumptions used in the energy savings analysis for each crop-type building configuration are kept constant between the baseline and proposed cases.

Indoor (Warehouse)

Indoor (warehouse) facilities used the following lighting assumptions:

- **Photoperiod:** The crop-specific number of hours per day that plants require light. For indoor facilities, the entire photoperiod is supplied exclusively by artificial light.
- **PPFD ( $\mu\text{mol}/\text{m}^2/\text{s}$ ):** The crop-specific required light intensity for each crop.
- **Canopy Area per Luminaire ( $\text{ft}^2$ ):** Calculated using the required PPFD for each crop and the performance of the baseline (2.3  $\mu\text{mol}/\text{J}$ ) luminaires.
- **HVAC System:** Cooling energy savings are calculated using a minimum code-level 11- to 20-ton rooftop unit with an Energy Efficiency Ratio (EER) of 10.0 and an Integrated Energy Efficiency Ratio (IEER) of 13.2.

The indoor lighting assumptions are detailed by crop type in Table 65.

**Table 65: Indoor CEH Lighting Assumptions**

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft <sup>2</sup> )	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μMol/m <sup>2</sup> /s)	1,000	600	200	200	350
Baseline PPE (μMol/J)	2.3	2.3	2.3	2.3	2.3
Proposed PPE (μMol/J)	2.5	2.5	2.5	2.5	2.5
Mounting Height Above Canopy (in)	24"	24"	24"	24"	24"

\* Assumptions based on historical CEH CASE reports are undergoing validation for the final CASE Report

## Greenhouse

Greenhouse facilities used the following lighting assumptions:

- **Photoperiod:** The number of hours per day the crop requires light. In greenhouses, the photoperiod does not necessarily correlate to daily operating hours of artificial light due to available daylight, which varies by climate zone.
- **PPFD (μmol/m<sup>2</sup>/s):** The required supplemental light intensity for each crop. Assumed to be lower than in indoor facilities due to the seasonal availability of sunlight for plant growth.
- **Canopy Area per Luminaire (ft<sup>2</sup>):** Calculated using the required PPFD for each crop and the performance of the baseline (2.3 μmol/J) luminaires.

The greenhouse lighting assumptions are detailed by crop type in Table 66.

Greenhouses use supplemental lighting in three distinct ways, unlike indoor facilities. These strategies are as follows:

1. **Photoperiod Extension:** Adds hours of light to achieve a target daylength or photoperiod.
2. **DLI Supplementation:** Adds photons to meet a cumulative DLI target.
3. **PPFD Supplementation:** Boosts light intensity to maintain a target PPFD setpoint.

For purposes of estimating operational hours, each strategy has been incorporated into the calculation methodology differently. Photoperiod extension runs for the fixed number of hours required to bridge the gap between natural daylength and the target photoperiod hours. DLI supplementation operates until the daily light target is met; its run-time varies based on seasonal and daily sunlight availability and fixture output. Further, PPFD supplementation operates during the photoperiod and cycles on only when natural light intensity falls below the target setpoint.

Interactive cooling effects were not accounted for in the greenhouse model since greenhouses typically use venting as the primary or first stage of cooling.

**Table 66: Greenhouse CEH Lighting Assumptions**

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft <sup>2</sup> )	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μMol/m <sup>2</sup> /s)	600	400	200	200	350
Baseline PPE (μMol/J)	2.3	2.3	2.3	2.3	2.3
Proposed PPE (μMol/J)	2.5	2.5	2.5	2.5	2.5
Mounting Height Above Canopy (in)	24	24	24	24	24

\* Assumptions based on historical CEH CASE Reports are undergoing validation for the Final CASE Report

Pending stakeholder input, the Statewide CASE Team has adopted the assumptions from the 2025 CEH CASE Report (Energy Solutions, 2023). The Statewide CASE Team will revise these assumptions and the analysis before releasing the Draft CASE Report and will update them again for the Final CASE Report.

### **A.1.3 Energy Savings Methodology per Prototypical Building**

The Statewide CASE Team estimated per-unit energy savings from the proposed PPE increase using the same methodology developed for the 2025 CASE Report. The approach utilizes a custom, spreadsheet-based hourly tool that models indoor and greenhouse prototypes to estimate energy impacts per square foot for each prototype. This analysis uses the assumptions outlined in the previous section.

The Statewide CASE Team’s spreadsheet tool calculates lighting energy consumption for every hour of the year measured in kWh/yr.

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types.

Because the mounting heights and PPFD values are constant between the baseline case and the proposed case for all prototypes, the LPD reduction for the proposed measure reduces lighting energy consumption by eight percent for all prototypes, before accounting for HVAC interactions.

#### Indoor (Warehouse)

The installed wattage of CEH lighting per square foot, or LPD, is calculated as follows:

$$LPD = PPFD/PPE \times (0.0929 \text{ m}^2/\text{ft}^2)$$

The annual energy savings (ES) per square foot is calculated by applying the photoperiod as follows:

$$ES = (LPD_b - LPD_p) \times (\text{photoperiod per day}) \times (\text{operating days per year})$$

Where  $LPD_b$  is the baseline lighting power density for the prototype and  $LPD_p$  is the proposed lighting power density for the prototype.

For indoor CEH facilities, the Statewide CASE Team modeled interactive cooling energy impacts where reduced lighting heat output from LEDs decreases cooling loads using a spreadsheet model. Energy savings for indoor (warehouse) facilities also include interactive HVAC energy impacts. This analysis determines the HVAC energy savings from the decreased cooling loads due to the reduced heat output of more efficient lighting. The model uses the generic DX cooling system performance curve used in the 2025 CASE Report analysis and hourly outside air temperatures sourced from 2025 CEC weather files. This analysis will be updated to use the 2028 weather files when they become available.

#### Greenhouse

The installed wattage of CEH lighting per square foot, or LPD, is calculated as follows:

$$LPD = PPFD/PPE \times (0.0929 \text{ m}^2/\text{ft}^2) \times (\text{mounting height derate factor})$$

where the mounting height derate factor is 1.05 and calculated using the inverse square law for lighting (Voudoukis, 2017). The mounting height derate factor was based on the change in PPFD change over the luminaire mounting height distance from the plant canopy and calculated as follows:

$$\text{Mounting Height derate factor} = 1/(PPFD \%) + ((1 - PPFD \%) * \text{Diffuse Light Factor})$$

where diffuse factor is the percentage of diffuse light reaching the canopy surface and PPFd% is the percentage of the PPFd that is reaching the canopy at a given mounting height. At the prototype mounting height of 24 inches, the PPFd% is 49.5 percent and the diffuse light factor is 90 percent.

The annual energy saving (ES) per square foot is calculated by applying the average hours of supplemental lighting as follows:

$$ES = (LPD_b - LPD_p) \times (\text{average hours of supplemental lighting per day}) \\ \times (\text{operating days per year})$$

where  $LPD_b$  is the baseline lighting power density for the prototype and  $LPD_p$  is the proposed lighting power density for the prototype.

The model determines the number of hours per day that supplemental lighting was used through calculations. The model uses TMY hourly solar irradiance data (GHI), weather data, and a greenhouse light transmittance factor to determine when available daylight is insufficient and supplemental lighting must operate to meet crop-specific daily lighting targets. Greenhouse glazing material/age, structure, and shade curtains are assumed to reduce canopy-level light by about 50 percent compared with outdoor (Torres & Lopez, Measuring Daily Light Integral in a Greenhouse, 2012). The hours of supplemental light required are calculated daily as photoperiod minus the daylight contribution needed to meet each crop's DLI.

For greenhouse CEH facilities, the calculations assume venting as the primary cooling mechanism, and interactive effects were excluded. The proposed model is identical to the baseline model except for lighting efficacy changes reflecting the proposed code update.

#### Stakeholder Input on Energy Savings Methodology

The Statewide CASE Team is gathering stakeholder input to inform the energy savings analysis and plans to update the results for the final report. The Statewide CASE Team will continue to meet with luminaire manufacturers, agricultural lighting consultants, and CEH facility operators to review the proposed savings methodology, key assumptions, and analytical framework.

Importantly, stakeholder engagement identified a technical challenge in accurately modeling lighting control practices in horticultural environments. Dimming is commonly used to manage plant stress and optimize crop traits by adjusting PPFd throughout growth cycles, such as during vegetative and flowering stages for cannabis or for leafy greens like lettuce. However, the current energy model assumes static PPFd levels. To resolve this, the Statewide CASE Team plans to document real-world dimming strategies through stakeholder outreach and adjusting energy and cost models to simulate realistic dimming strategies.

### A.1.4 Cost Effectiveness by Climate Zone and Prototype

The energy impacts of the proposed code change vary by climate zone. The variations for indoor are relatively small because they are only caused by the interactive HVAC effects. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

**Table 67: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Indoor (Warehouse) Cannabis**

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$111.50	\$2.66	42
2	\$111.77	\$2.66	42
3	\$111.58	\$2.66	42
4	\$111.74	\$2.66	42
5	\$112.24	\$2.66	42
6	\$111.38	\$2.66	42
7	\$111.36	\$2.66	42
8	\$110.68	\$2.66	42
9	\$113.55	\$2.66	43
10	\$111.29	\$2.66	42
11	\$111.34	\$2.66	42
12	\$112.57	\$2.66	42
13	\$111.89	\$2.66	42
14	\$109.09	\$2.66	41
15	\$116.09	\$2.66	44
16	\$108.64	\$2.66	41

**Table 68: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Indoor (Warehouse) Cannabis**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$111.50	\$2.66	42
<b>2</b>	\$111.77	\$2.66	42
<b>3</b>	\$111.58	\$2.66	42
<b>4</b>	\$111.74	\$2.66	42
<b>5</b>	\$112.24	\$2.66	42
<b>6</b>	\$111.38	\$2.66	42
<b>7</b>	\$111.36	\$2.66	42
<b>8</b>	\$110.68	\$2.66	42
<b>9</b>	\$113.55	\$2.66	43
<b>10</b>	\$111.29	\$2.66	42
<b>11</b>	\$111.34	\$2.66	42
<b>12</b>	\$112.57	\$2.66	42
<b>13</b>	\$111.89	\$2.66	42
<b>14</b>	\$109.09	\$2.66	41
<b>15</b>	\$116.09	\$2.66	44
<b>16</b>	\$108.64	\$2.66	41

**Table 69: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Indoor (Warehouse) Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$39.28	\$0.00	infinite
<b>2</b>	\$39.70	\$0.00	infinite
<b>3</b>	\$39.61	\$0.00	infinite
<b>4</b>	\$40.01	\$0.00	infinite
<b>5</b>	\$39.70	\$0.00	infinite
<b>6</b>	\$39.97	\$0.00	infinite
<b>7</b>	\$40.04	\$0.00	infinite
<b>8</b>	\$40.86	\$0.00	infinite
<b>9</b>	\$40.91	\$0.00	infinite
<b>10</b>	\$40.97	\$0.00	infinite
<b>11</b>	\$40.28	\$0.00	infinite
<b>12</b>	\$40.06	\$0.00	infinite
<b>13</b>	\$40.50	\$0.00	infinite
<b>14</b>	\$40.66	\$0.00	infinite
<b>15</b>	\$41.19	\$0.00	infinite
<b>16</b>	\$39.91	\$0.00	infinite

**Table 70: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Indoor (Warehouse) Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$39.28	\$0.00	infinite
2	\$39.70	\$0.00	infinite
3	\$39.61	\$0.00	infinite
4	\$40.01	\$0.00	infinite
5	\$39.70	\$0.00	infinite
6	\$39.97	\$0.00	infinite
7	\$40.04	\$0.00	infinite
8	\$40.86	\$0.00	infinite
9	\$40.91	\$0.00	infinite
10	\$40.97	\$0.00	infinite
11	\$40.28	\$0.00	infinite
12	\$40.06	\$0.00	infinite
13	\$40.50	\$0.00	infinite
14	\$40.66	\$0.00	infinite
15	\$41.19	\$0.00	infinite
16	\$39.91	\$0.00	infinite

**Table 71: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Indoor (Warehouse) Tomatoes**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$39.15	\$0.50	78
2	\$39.18	\$0.50	78
3	\$39.11	\$0.50	77
4	\$39.10	\$0.50	77
5	\$39.38	\$0.50	78
6	\$38.95	\$0.50	77
7	\$38.93	\$0.50	77
8	\$38.49	\$0.50	76
9	\$39.70	\$0.50	79
10	\$38.72	\$0.50	77
11	\$38.88	\$0.50	77
12	\$39.44	\$0.50	78
13	\$39.07	\$0.50	77
14	\$37.86	\$0.50	75
15	\$40.70	\$0.50	81
16	\$37.82	\$0.50	75

**Table 72: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Indoor (Warehouse) Tomatoes**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$39.15	\$0.50	78
2	\$39.18	\$0.50	78
3	\$39.11	\$0.50	77
4	\$39.10	\$0.50	77
5	\$39.38	\$0.50	78
6	\$38.95	\$0.50	77
7	\$38.93	\$0.50	77
8	\$38.49	\$0.50	76
9	\$39.70	\$0.50	79
10	\$38.72	\$0.50	77
11	\$38.88	\$0.50	77
12	\$39.44	\$0.50	78
13	\$39.07	\$0.50	77
14	\$37.86	\$0.50	75
15	\$40.70	\$0.50	81
16	\$37.82	\$0.50	75

**Table 73: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Cannabis**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$29.20	\$0.77	38
<b>2</b>	\$23.66	\$0.77	31
<b>3</b>	\$23.04	\$0.77	30
<b>4</b>	\$18.44	\$0.77	24
<b>5</b>	\$18.20	\$0.77	24
<b>6</b>	\$17.80	\$0.77	23
<b>7</b>	\$17.67	\$0.77	23
<b>8</b>	\$17.04	\$0.77	22
<b>9</b>	\$16.58	\$0.77	22
<b>10</b>	\$16.47	\$0.77	22
<b>11</b>	\$23.41	\$0.77	31
<b>12</b>	\$21.45	\$0.77	28
<b>13</b>	\$19.38	\$0.77	25
<b>14</b>	\$15.62	\$0.77	20
<b>15</b>	\$15.65	\$0.77	20
<b>16</b>	\$21.91	\$0.77	29

**Table 74: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Cannabis**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$29.20	\$0.77	38
<b>2</b>	\$23.66	\$0.77	31
<b>3</b>	\$23.04	\$0.77	30
<b>4</b>	\$18.44	\$0.77	24
<b>5</b>	\$18.20	\$0.77	24
<b>6</b>	\$17.80	\$0.77	23
<b>7</b>	\$17.67	\$0.77	23
<b>8</b>	\$17.04	\$0.77	22
<b>9</b>	\$16.58	\$0.77	22
<b>10</b>	\$16.47	\$0.77	22
<b>11</b>	\$23.41	\$0.77	31
<b>12</b>	\$21.45	\$0.77	28
<b>13</b>	\$19.38	\$0.77	25
<b>14</b>	\$15.62	\$0.77	20
<b>15</b>	\$15.65	\$0.77	20
<b>16</b>	\$21.91	\$0.77	29

**Table 75: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$9.11	\$0.00	infinite
<b>2</b>	\$6.95	\$0.00	infinite
<b>3</b>	\$6.67	\$0.00	infinite
<b>4</b>	\$4.04	\$0.00	infinite
<b>5</b>	\$3.50	\$0.00	infinite
<b>6</b>	\$3.07	\$0.00	infinite
<b>7</b>	\$2.67	\$0.00	infinite
<b>8</b>	\$2.89	\$0.00	infinite
<b>9</b>	\$2.89	\$0.00	infinite
<b>10</b>	\$2.83	\$0.00	infinite
<b>11</b>	\$7.27	\$0.00	infinite
<b>12</b>	\$5.99	\$0.00	infinite
<b>13</b>	\$4.91	\$0.00	infinite
<b>14</b>	\$2.45	\$0.00	infinite
<b>15</b>	\$2.28	\$0.00	infinite
<b>16</b>	\$6.23	\$0.00	infinite

**Table 76: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$9.11	\$0.00	infinite
<b>2</b>	\$6.95	\$0.00	infinite
<b>3</b>	\$6.67	\$0.00	infinite
<b>4</b>	\$4.04	\$0.00	infinite
<b>5</b>	\$3.50	\$0.00	infinite
<b>6</b>	\$3.07	\$0.00	infinite
<b>7</b>	\$2.67	\$0.00	infinite
<b>8</b>	\$2.89	\$0.00	infinite
<b>9</b>	\$2.89	\$0.00	infinite
<b>10</b>	\$2.83	\$0.00	infinite
<b>11</b>	\$7.27	\$0.00	infinite
<b>12</b>	\$5.99	\$0.00	infinite
<b>13</b>	\$4.91	\$0.00	infinite
<b>14</b>	\$2.45	\$0.00	infinite
<b>15</b>	\$2.28	\$0.00	infinite
<b>16</b>	\$6.23	\$0.00	infinite

**Table 77: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Tomatoes**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$11.08	\$0.50	22
2	\$8.53	\$0.50	17
3	\$8.14	\$0.50	16
4	\$5.51	\$0.50	11
5	\$5.02	\$0.50	10
6	\$4.46	\$0.50	9
7	\$4.11	\$0.50	8
8	\$4.24	\$0.50	8
9	\$4.23	\$0.50	8
10	\$4.15	\$0.50	8
11	\$8.74	\$0.50	17
12	\$7.54	\$0.50	15
13	\$6.33	\$0.50	13
14	\$3.70	\$0.50	7
15	\$3.55	\$0.50	7
16	\$7.80	\$0.50	15

**Table 78: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Tomatoes**

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$11.08	\$0.50	22
2	\$8.53	\$0.50	17
3	\$8.14	\$0.50	16
4	\$5.51	\$0.50	11
5	\$5.02	\$0.50	10
6	\$4.46	\$0.50	9
7	\$4.11	\$0.50	8
8	\$4.24	\$0.50	8
9	\$4.23	\$0.50	8
10	\$4.15	\$0.50	8
11	\$8.74	\$0.50	17
12	\$7.54	\$0.50	15
13	\$6.33	\$0.50	13
14	\$3.70	\$0.50	7
15	\$3.55	\$0.50	7
16	\$7.80	\$0.50	15

## A.2 Daylight Responsive Controls

### Key Assumptions for Energy Savings Analysis

Assumptions utilized for the proposed Daylighting Responsive Controls energy savings analysis are based Greenhouse Lighting Efficacy assumptions from 2025 CEH CASE Report (Energy Solutions, 2023), market research, and stakeholder input. The Statewide CASE Team plans to continue to meet with manufacturers, academic researchers, agricultural lighting consultants, and CEH facility operators to review and refine the methodology, key assumptions, and analytical framework.

The baseline case assumes CEH luminaires with the proposed 2028 PPE requirement of 2.5  $\mu\text{mol}/\text{J}$  and astronomical timeclock scheduling with automatic on/off control based on the specified crop photoperiod. All other key assumptions used in the energy savings analysis for each crop-type building configuration are kept constant between the baseline and proposed cases.

## A.2.1 Climate Zones

The Statewide CASE Team determined energy impacts to be climate-sensitive due to daily and hourly sunlight availability and intensity or solar irradiance (GHI,  $W/m^2$ ). Greenhouses use daylight as a primary light source and operate supplemental lighting when daylight is insufficient to meet crop light targets. TMY data for each climate zone captures differences in daily and hourly solar radiation, including GHI ( $W/m^2$ ), cloud cover, and haze patterns via DHI ( $W/m^2$ ), and day length. These conditions determine the number of hours that supplemental lighting must operate. Climate zones with higher annual daylight hours require fewer supplemental lighting hours, while coastal and northern zones tend to have less intense daylight or more persistent cloud cover. TMY data are used to estimate supplemental lighting operation, and results are reported on a per-square-foot basis for all 16 climate zones individually.

TMY data were sourced from 2028 CEC weather files.

Prototypical models were developed for the six scenarios, including two facilities and three crop types shown in Table 64, consistent with prior CEH CASE Reports. The energy impacts for each prototype were modeled independently in the custom spreadsheet-based simulation tool developed by the Statewide CASE Team and evaluated on a per-square-foot basis. Crops (cannabis, leafy greens, and tomatoes) were selected based on previous CEH CASE work to represent high, medium, and low light intensity crops (Energy Solutions, 2023).

Inputs and assumption used for both the baseline scenario (timeclock only, lights on full photoperiod) and the proposed scenario (Option 1 Timeclock + PAR sensor with LED dimming capability, dimming adjusted based on calculated canopy PPFD):

- **Photoperiod:** The number of hours per day the crop requires light. In greenhouses, the photoperiod does not necessarily correlate to daily operating hours of artificial light due to available daylight, which varies by climate zone.
- **PPFD ( $\mu mol/m^2/s$ ):** The required supplemental light intensity for each crop.
- **Canopy Area per Luminaire ( $ft^2$ ):** Calculated using the required PPFD for each crop and the performance of the baseline ( $2.5 \mu mol/J$ ) luminaires.
- **Hourly solar/PAR:** Hourly GHI ( $W/m^2$ ) converted to PAR and then to PPFD
- **Greenhouse transmittance to canopy:** 50 percent factor accounting for glazing transmission, framing/shading, soiling, curtain state, and canopy interception.
- **Canopy PPFD setpoint:** Target PPFD during the crop's photoperiod.
- **LED fixture PPE:** Photosynthetic Photon Efficacy (PPE,  $\mu mol/J$ ), driver efficiency, and minimum dimming output (assumed 10 percent)

Table 79 details assumptions by crop type. For purposes of this analysis, the Statewide CASE Team conservatively assumed that only cannabis flower would be impacted by the measure.

**Table 79: Greenhouse CEH Lighting Assumptions**

Parameter	Cannabis - Flower	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft <sup>2</sup> )	20	58	56
Photoperiod (hours/day)	12	18	12
PPFD (μMol/m <sup>2</sup> /s)	600	200	350
Baseline PPE (μMol/J)	2.5	2.5	2.5
Proposed PPE (μMol/J)	2.5	2.5	2.5
Mounting Height Above Canopy (in)	24	24	24

\* Assumptions based on historical CEH CASE Reports are undergoing validation via stakeholder outreach engagement for the final CASE Report

Pending stakeholder input, the Statewide CASE Team has adopted the assumptions from the 2025 CEH CASE Report (Energy Solutions, 2023). The Statewide CASE Team will revise these assumptions based on ongoing stakeholder outreach and data collection, will update and the analysis before releasing the Draft CASE Report, and will update them again for the Final CASE Report.

### Energy Savings Methodology per Prototypical Building

The modeling approach utilizes a custom, spreadsheet-based hourly tool that models indoor and greenhouse prototypes to estimate energy impacts per square foot for each prototype. This analysis uses the assumptions outlined in the previous section. The Statewide CASE Team’s spreadsheet tool calculates lighting energy consumption for every hour of the year, measured in kWh.

The baseline model reflects code baseline with fixed output 2.5 PPE LEDs with a timeclock only control. The proposed case includes the PAR sensor, dimming LEDs, and on/off logic.

- **Baseline (Greenhouse – No Daylight Control):** Fixtures operate at a fixed schedule to meet the canopy PPFD/DLI target without credit for daylight (or with crude step control that does not track PAR. The lights are on at 100% power (not dimmed) for the full photoperiod.

- **Proposed (Greenhouse – PAR Sensor with Dimming + On/Off):** Fixtures track real-time daylight at the canopy to maintain the PPFD setpoint with continuous dimming, an explicit minimum output, and off capability. The dimming is adjusted to maintain the PPFD target every 15 minutes throughout the photoperiod. When the dimming would be below 10% power, the lights are turned off.

For each prototype, climate zone, and crop type, energy savings estimates were calculated and reported per square foot on an hourly basis.

**Determine daylight at the canopy:** For each time step inside the photoperiod, the model would start with the available sunlight at the canopy. This assumption comes from the site’s outdoor light level adjusted by the greenhouse’s overall transmittance (glazing, structure, curtains, soiling, and typical shading). The result is the sunlight-only PPFD at the canopy.

Available sunlight at the canopy was calculated per hour per climate zone by converting GHI ( $\text{W}/\text{m}^2$ ) to PPFD within the PAR band using the following assumptions:

- All-sky GHI (broadband sunlight across the range of 285 to 2,800 nm) is reduced because only 46 percent of that broadband energy is in the PAR band (400–700 nm) (Monteith 1972; Szeicz 1974). This value is further reduced by applying a 50 percent adjustment for the greenhouse’s overall light transmittance.
- The PAR watts are converted to PPFD using the standard daylight quantum conversion of  $4.57 \mu\text{mol}/\text{J}$ , which is the radiant-to-quantum factor for sunlight (Thimijan & Heins, 1983). The result is the sunlight-only PPFD at the canopy after.
- The fraction of broadband GHI (285–2,800 nm) that is PAR (400 to 700 nm) is estimated at  $\sim 0.46$  for daylight, per guidance

**Compare daylight with the PPFD threshold:** The canopy PPFD setpoint (e.g.,  $600 \mu\text{mol}/\text{m}^2/\text{s}$ ) defines the minimum light level the crop should receive during the photoperiod. If daylight alone meets or exceeds that threshold, the supplemental electric lights would be turned off for that hour. If daylight falls short, the control system would turn on the lights and must provide only the missing amount of light.

**Translate the shortfall into a dimming command:** The modeled controller would convert that gap to a dimming level for the fixtures. If the gap is small, the required dim level might be very low. If the required output is below the driver’s minimum of 10 percent, the fixture would hold at its minimum output instead of going lower. If the required output is above the minimum but below full power, the fixture would dim proportionally to maintain the setpoint. If the gap is very high, the fixture would cap at full output.

**Determine fixture output and power:** Once the command is set (i.e., to off, to minimum, or at a given dim level), the model calculates how much electric PPFd the fixtures deliver and the corresponding input power per square foot based on fixture PPE and LPD. LPD is calculated as follows:

- $LPD = PPFd/PPE \times (0.0929 m^2/ft^2) \times (\text{mounting height derate factor})$   
where the mounting height derate factor used is 1.05 and accounts for light uniformity and loss. This value is based on the change in PPFd over the luminaire mounting height distance from the plant canopy, and calculated as follows:

$$\text{Mounting Height derate factor} = 1/(\text{PPFD \%}) + ((1 - \text{PPFD \%}) * \text{Diffuse Light Factor})$$

Where PPFd% is the percentage of the PPFd that is reaching the canopy at a given mounting height. At the prototype mounting height of 24 inches, the PPFd% is 49.5 percent and the diffuse light factor is the percentage of diffuse light reaching the canopy surface. A diffuse light factor of 90 percent was used in these calculations.

The power per square foot for each hour of the year is calculated from the lighting power density and is assumed to be constant over each hour to provide hourly energy consumption through the year.

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types.

## **A.2.2 Cost Effectiveness by Climate Zone and Prototype**

The energy impacts of the proposed code change vary by climate zone. The variations for indoor are relatively small because they are only caused by the interactive HVAC effects. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts. Table 80 shows the 30-year cost effectiveness summary per square foot of canopy for new construction for greenhouse cannabis. Table 81 shows the 30-year cost effectiveness summary per square foot of canopy for new construction for greenhouse leafy greens.

**Table 80: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Cannabis**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$186.59	\$4.16	45
2	\$218.19	\$4.16	52
3	\$221.88	\$4.16	53
4	\$243.99	\$4.16	59
5	\$243.60	\$4.16	59
6	\$244.52	\$4.16	59
7	\$242.21	\$4.16	58
8	\$239.84	\$4.16	58
9	\$250.70	\$4.16	60
10	\$243.57	\$4.16	59
11	\$216.57	\$4.16	52
12	\$233.12	\$4.16	56
13	\$237.29	\$4.16	57
14	\$252.46	\$4.16	61
15	\$258.54	\$4.16	62
16	\$224.62	\$4.16	54

**Table 81: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$156.30	\$0.83	188
<b>2</b>	\$168.36	\$0.83	202
<b>3</b>	\$169.68	\$0.83	204
<b>4</b>	\$178.51	\$0.83	215
<b>5</b>	\$180.07	\$0.83	216
<b>6</b>	\$176.06	\$0.83	212
<b>7</b>	\$175.47	\$0.83	211
<b>8</b>	\$173.61	\$0.83	209
<b>9</b>	\$182.09	\$0.83	219
<b>10</b>	\$175.11	\$0.83	210
<b>11</b>	\$166.11	\$0.83	200
<b>12</b>	\$176.42	\$0.83	212
<b>13</b>	\$174.73	\$0.83	210
<b>14</b>	\$175.68	\$0.83	211
<b>15</b>	\$182.98	\$0.83	220
<b>16</b>	\$173.73	\$0.83	209

**Table 82: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Tomatoes**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
<b>1</b>	\$220.84	\$1.46	152
<b>2</b>	\$245.48	\$1.46	169
<b>3</b>	\$249.45	\$1.46	171
<b>4</b>	\$268.54	\$1.46	184
<b>5</b>	\$270.00	\$1.46	185
<b>6</b>	\$268.41	\$1.46	184
<b>7</b>	\$267.73	\$1.46	184
<b>8</b>	\$263.86	\$1.46	181
<b>9</b>	\$275.69	\$1.46	189
<b>10</b>	\$266.43	\$1.46	183
<b>11</b>	\$243.44	\$1.46	167
<b>12</b>	\$260.91	\$1.46	179
<b>13</b>	\$262.45	\$1.46	180
<b>14</b>	\$272.68	\$1.46	187
<b>15</b>	\$282.41	\$1.46	194
<b>16</b>	\$253.36	\$1.46	174

**Table 83: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Cannabis**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$186.59	\$4.16	45
2	\$218.19	\$4.16	52
3	\$221.88	\$4.16	53
4	\$243.99	\$4.16	59
5	\$243.60	\$4.16	59
6	\$244.52	\$4.16	59
7	\$242.21	\$4.16	58
8	\$239.84	\$4.16	58
9	\$250.70	\$4.16	60
10	\$243.57	\$4.16	59
11	\$216.57	\$4.16	52
12	\$233.12	\$4.16	56
13	\$237.29	\$4.16	57
14	\$252.46	\$4.16	61
15	\$258.54	\$4.16	62
16	\$224.62	\$4.16	54

**Table 84: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Leafy Greens**

<b>Climate Zone</b>	<b>Benefits LSC Savings + Other PV Savings (2029 PV\$)</b>	<b>Costs Total Incremental PV Costs (2029 PV\$)</b>	<b>Benefit-to-Cost Ratio</b>
1	\$156.30	\$0.83	188
2	\$168.36	\$0.83	202
3	\$169.68	\$0.83	204
4	\$178.51	\$0.83	215
5	\$180.07	\$0.83	216
6	\$176.06	\$0.83	212
7	\$175.47	\$0.83	211
8	\$173.61	\$0.83	209
9	\$182.09	\$0.83	219
10	\$175.11	\$0.83	210
11	\$166.11	\$0.83	200
12	\$176.42	\$0.83	212
13	\$174.73	\$0.83	210
14	\$175.68	\$0.83	211
15	\$182.98	\$0.83	220
16	\$173.73	\$0.83	209

**Table 85: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Tomatoes**

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$220.84	\$1.46	152
2	\$245.48	\$1.46	169
3	\$249.45	\$1.46	171
4	\$268.54	\$1.46	184
5	\$270.00	\$1.46	185
6	\$268.41	\$1.46	184
7	\$267.73	\$1.46	184
8	\$263.86	\$1.46	181
9	\$275.69	\$1.46	189
10	\$266.43	\$1.46	183
11	\$243.44	\$1.46	167
12	\$260.91	\$1.46	179
13	\$262.45	\$1.46	180
14	\$272.68	\$1.46	187
15	\$282.41	\$1.46	194
16	\$253.36	\$1.46	174

### A.3 Space Conditioning

#### Key Assumptions for Energy Savings Analysis

Assumptions for the proposed space conditioning measure are based on data, market research, and stakeholder input. The Statewide CASE Team will continue to meet with HVAC manufacturers/distributors, academic researchers, design professionals, and CEH facility operators to review and refine the methodology, key assumptions, and analytical framework.

The baseline system is thermostat-controlled, single-stage packaged DX cooling sized to the sensible load with electric resistance reheat, and constant-volume fans, used in conjunction with humidistat-controlled standalone DX dehumidifiers meeting federal minimum efficiency sized for latent load. The measure case system is a packaged variable-capacity DX unit sized for both sensible and latent loads, modulating hot gas

reheat capable of recovering up to 90 percent of waste heat with no electric reheat, and variable air volume fans.

All other key assumptions used in the energy savings analysis for each crop-type building configuration are kept constant between the baseline and proposed cases.

### A.3.1 Climate Zones

Although the loads in CEH facilities are primarily process loads, the Statewide CASE Team determined energy impacts to be climate-sensitive because HVAC systems are impacted by outdoor air temperature variability. Therefore, savings vary slightly by climate zone due to variations in regional Typical TMY weather by climate zone. TMY data were sourced from the 2028 CEC weather files for all 16 climate zones.

### Energy Savings Methodology per Prototypical Building

A prototypical model was developed for an indoor CEH facility with high-intensity lighting, representing a cannabis facility with flower rooms of approximately 1,400 canopy square feet per room and a maximum lighting intensity of 48.5 W per canopy square feet. The energy impacts were modeled for one room using an EnergyPlus model developed by the Statewide CASE Team and evaluated on a per-square-foot basis. For each climate zone, three simulations starting three weeks apart were averaged to obtain energy savings per square foot representing multiple flower rooms on staggered schedules, as SMEs suggested is most common in cannabis growing facilities. Cannabis flower was selected based on the assumption that high-intensity lighting (greater than 30 W per canopy ft<sup>2</sup>) likely applies only to cannabis flower rooms. Section 4.6.6 (Appendix 5.4B Schedules) provides a detailed schedule of assumed evapotranspiration rates, room target setpoints (temperature and relative humidity), and light dimming schedule for each stage of growth throughout the 63-day flower cycle.

Inputs and assumptions for both Standard and Proposed scenarios used the assumptions in Table 86.

**Table 86: Prototype Flower Room Used for Energy, Demand, Cost and Environmental Impacts Analysis**

Prototype Variables		Assumptions
<b>Building</b>	Type	Indoor (Warehouse)
	Envelope	One exterior wall (North) without windows and three adiabatic interior walls
	Insulation	R-26 (roof), R-19 (walls)
	Material	Metal
	Plenum	Above ceiling
	Room Floor Area	2,000 square foot per room

Prototype Variables		Assumptions
<b>Crop</b>	Type	Cannabis: 100% flower, 0% veg, 0% clone
	Room Canopy Area	1,400 canopy square foot, single level (70% of room area)
	Maximum evapotranspiration latent cooling load	80 Btuh/ft <sup>2</sup> max load (room square foot)
	Maximum evapotranspiration sensible heating load	-80 Btuh/ft <sup>2</sup> max load (room square foot)
	Grow cycle duration	63 days
	Downtime between cycles	4 days
<b>Lighting</b>	Photoperiod	12 hours/day
	Fixture Coverage Area	20 square feet per fixture
	Maximum Lighting Intensity	48.5 W/canopy square foot
	Photosynthetic Photon Efficacy	2.3 μMol/J
	Photosynthetic Photon Flux Density	1,200 μMol/m <sup>2</sup> /s with dimming

a) British Thermal Units per Hour per square foot

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 87 presents the system specifications used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume variable-capacity DX equipment with modulating hot gas reheat and adjustable sensible heat ratio.

**Table 87: Space Conditioning Equipment Specifications Used for Energy, Demand, Cost, and Environmental Impacts Analysis**

Equipment Component	Standard Design	Proposed Design
<b>Cooling</b>	Thermostat-controlled, single-stage packaged DX sized to sensible load (11.9 EER, 31.5 tons/room)	Packaged variable-capacity DX sized to both sensible and latent loads (12.23 EER, 39.2 tons/room)
<b>Dehumidification</b>	Humidistat-controlled standalone DX dehumidifiers (0.64 gallons per kWh) sized for latent load	Integrated with DX system (variable sensible heat ratio)
<b>Reheat</b>	Electric resistance (no hot gas reheat)	Modulating hot gas reheat (90 percent) No electric reheat
<b>Fan Control</b>	Constant volume fans	Variable air volume fans

The energy impacts of the proposed code change vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

## Whole Building Prototype

For the Final CASE Report, the Statewide CASE Team plan to use a whole-building EnergyPlus Prototype. Current assumptions for this prototype are laid out in tables below.

Table 88 shows high-level prototype assumptions.

**Table 88. CEH Indoor Prototype High Level Assumptions.**

Characteristic	Value	Data Sources
<b>Building Type</b>	Indoor Controlled Environmental Horticulture - Cannabis	Over 90% of Indoor CEH was estimated to be cannabis in the T24 2025 cycle
<b>Building Category</b>	Nonresidential	
<b>Shape</b>	Rectangle	Previous CEH Floor plans. Previous T24 CASE work.
<b>Total Floor Area (ft<sup>2</sup>)</b>	25515 (243 ft x 105 ft)	Based Department of Cannabis License data by size.
<b>Aspect Ratio</b>	2.3	Based Department of Cannabis License data by size.
<b>Number of Floors</b>	1	Based on 2050 CEH Prototype and Existing Warehouse Prototype. 2050 CEH Prototype assumption was based on CEH SME input.
<b>Roof type</b>	Flat	Based on 2050 CEH Prototype and Existing Warehouse Prototype. 2050 CEH Prototype assumption was based on CEH SME input.
<b>Window-to-Wall Ratio (WWR)</b>	0.00%	When included, assuming high security feature in addition to T24 compliant windows, still researching this topic.
<b>Shading Geometry</b>	No Shades	Based on typical indoor horticulture buildings
<b>Floor to floor height (ft)</b>	18	Based on input from SME Kelly Energy Management, confirmed to be typical by other CEH SMEs.

Characteristic	Value	Data Sources
Floor to ceiling height (ft)	14	Based on input from SME Kelly Energy Management, confirmed to be typical by other CEH SMEs.
Glazing sill height (ft)	n/a	Assuming high security feature in addition to T24 compliant windows, still researching this topic. For the time being assuming there 0 windows in this building for security reasons. Practically speaking the office areas would likely have a WWR similar to the small or medium office prototype and the corresponding sill height only in that office area not in the other parts of the building of the CEH prototype.

The zones are shown in Figure 7 and are described in Table 89.

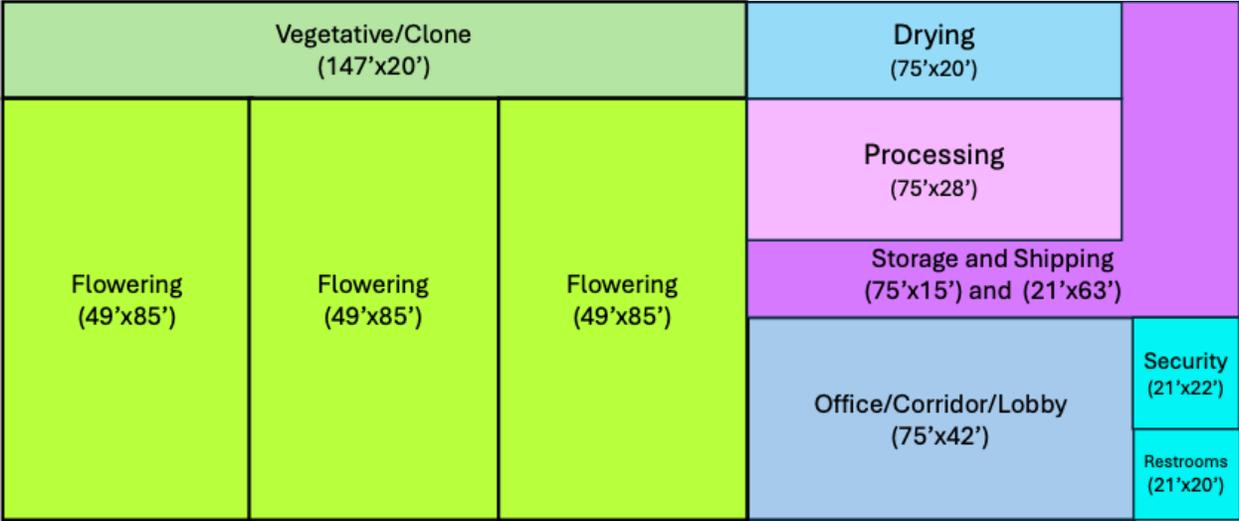


Figure 7. Indoor CEH Whole Building Prototype Zones.

**Table 89. Indoor CEH Whole Building Prototype Zone Description**

Space Type	Space/ Thermal Zone	Condition- ed (Y/N)	HVAC zone	Area Fraction	Area (ft <sup>2</sup> )	Length (ft)	Width (ft)	Volume (ft <sup>3</sup> )	Number of People	People (Persons/ 1,000 ft <sup>2</sup> ) [T24, 2025, Table 120.1-A]	Canopy Area (ft <sup>2</sup> )	Notes
<b>Horticulture_ Vegetative</b>	Horticulture_ Vegetative	Y	Horticulture_ Vegetative	11.5%	2,940	20	147	41,160	0	-	4,116	The veg/clone room has two tiers for growing, thus double the canopy are per room square foot.
<b>Horticulture_ Flowering</b>	Horticulture_ Flowering 3 zones	Y	Horticulture_ Flowering 3 HVAC zones	49.0%	12,495	85	147	174,930	0	-	8,747	The flowering space type needs to be split into 3 flowering rooms, with shifted schedules (a 9-week grow cycle starting every 3 weeks), each a separate

Space Type	Space/ Thermal Zone	Condition- ed (Y/N)	HVAC zone	Area Fraction	Area (ft <sup>2</sup> )	Length (ft)	Width (ft)	Volume (ft <sup>3</sup> )	Number of People	People (Persons/ 1,000 ft <sup>2</sup> ) [T24, 2025, Table 120.1-A]	Canopy Area (ft <sup>2</sup> )	Notes
												HVAC zone.
<b>Processing Area</b>	Processing Area	Y	Processing	8.2%	2,100	28	75	29,400	3	1	N/A	The processing area includes trimming, which generates a lot of dust and pollen
<b>Horticulture_Drying</b>	Drying room	Y	Horticulture_Drying	5.9%	1,500	20	75	21,000	0	0	N/A	
<b>Storage</b>	Storage and Shipping	Y	Storage	9.6%	2,448	15.0	75.0	34,272	0	0	N/A	
		Y				63.0	21.0				N/A	
<b>Office</b>	Office	Y	Office_Area	12.3%	3,150	42	75	44,100	16	5	N/A	Low density occupancy relative to office buildings.
<b>Restrooms</b>	Restrooms	Y	Office_Area	1.6%	420	20	21	5,880	1	-	N/A	
<b>Security office</b>	Security office	Y	Office_Area	1.8%	462	22	21	6,468	1	5	N/A	

Space Type	Space/ Thermal Zone	Condition- ed (Y/N)	HVAC zone	Area Fraction	Area (ft <sup>2</sup> )	Length (ft)	Width (ft)	Volume (ft <sup>3</sup> )	Number of People	People (Persons/ 1,000 ft <sup>2</sup> ) [T24, 2025, Table 120.1-A]	Canopy Area (ft <sup>2</sup> )	Notes
<b>Total (10 Spaces, 8 space types)</b>	Total (10 Thermal Zones)		Total (8 HVAC Zones)	100%	25,515			357,210			12,863	

Prototype envelope assumptions are shown in Table 90 and Table 91.

**Table 90. Indoor CEH Whole Building Prototype Envelope Assumption Information**

Element	Prototype	Assembly Type	Construction	Thermal properties	Vintage	Selected T24	Note
External Wall	CEH	Metal Building	Metal surface + Continuous Insulation + Gypsum board	U-factor IP	Pre 2022	2001	ASHRAE 90.1, 2022 Table A3.4.3.1, 3.5", R-0
					2022+	2025	Table 140.3-B
Roof	CEH	Metal Roof	Roof Membrane + Continuous Insulation + Metal Decking	U-factor IP	Pre 2022	2001	Table 1-H
					2022+	2025	Table 140.3-B
Windows	Windows	Fixed Windows	Single Pane (CBECS 2018, ~ 50 % of warehouse conversions that were built before 2000 are single pane)	U-factor IP	Pre 2022	2001	Table 1-H
			Double Pane		2022+	2025	From Medium Office scorecard. Assumed windows only in office areas. This u-factor does not yet include security feature.
	Windows	Fixed Windows	Single Pane (CBECS 2018, ~ 50 % of warehouse conversion that were built before 2000 are single pane)	SHGC	Pre 2022	2001	Table 1-H
			Double Pane		2022+	2025	From Medium Office scorecard. Assumed windows only in office areas. This u-factor does not yet include security feature.

**Table 91. Indoor CEH Whole Building Prototype Envelope Assumptions by Climate Zone**

Element	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
External Wall	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292
	0.098	0.053	0.098	0.053	0.053	0.098	0.098	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
Roof	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
Windows	0.49	0.49	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.49	0.49	0.49	0.49	0.49	0.49	0.49
	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.34	0.36	0.34	0.34	0.34	0.34	0.34	0.36
	0.49	0.47	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.47	0.47	0.47	0.47	0.46	0.46	0.49
	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.22	0.22	0.22	0.22	0.22	0.25

The HVAC Systems are described in Table 92 and Table 93.

**Table 92. Indoor CEH Whole Building Prototype HVAC Systems**

Space/ Thermal Zone	Heating	Cooling	Air Distribution	Other Systems	Source
Security office	Furnace (Gas)	DX (RTU)	CAV	Airside economizers (Integrated)	
Horticulture_Vegetative	Heat Pump	DX (RTU)	CAV	Dehumidifier 2.41L/kWh	
Horticulture_Flowering	Recovered Heat	VAV 12.23 EER	VAV	N/A	
Processing Area	Heat Pump	DX (RTU)	CAV	Dehumidifier 2.41L/kWh	
Horticulture_Drying	None	DX (RTU)	CAV	Dehumidifier 2.41L/kWh	Dry rooms typically use standalone dehumidifiers to remove moisture and then trim the temperature.
Storage and Shipping	Heat Pump	DX (RTU)	CAV	Airside economizers (Integrated)	
Office	Heat Pump	DX (RTU)	CAV	Airside economizers (Integrated)	
Restrooms	Heat Pump	DX (RTU)	CAV	Airside economizers (Integrated)	T24, 2025
Security office	Heat Pump	DX (RTU)	CAV	Airside economizers (Integrated)	

**Table 93. Indoor CEH Prototype Flower Room HVAC Equipment.**

	Parameter	Value	Notes
RTU Coil	Design Supply Air Temperature [F]	50	
	Design Supply Air Humidity Ratio [-]	0.0072	
RTU System	Type of Load to Size On	Latent	
	Cooling Supply Air Flow Rate per Unit Cooling Capacity [m <sup>3</sup> /s/W]	3.89E-05	
	Cooling Design Capacity [W]	140674	
	Cooling Design Capacity [tons]	40	
	Central Cooling Capacity Control Method	VAV	
RTU Cooling Coil	Compressor Speeds	8	
	Low Speed COP	3.233	Dehumidification mode: low fan & high compressor
	Low Speed SHR	0.6943	
	Low Speed Capacity [tons]	7.82528467	
	High Speed COP	3.586	Sensible mode: high fan & high compressor
	High Speed SHR	0.6703	
	High Speed Capacity [tons]	40	
RTU Heating Coil	Coil Type	Hot Gas Reheat	
	Efficiency	0.9	Max possible heat reclaim effectiveness for AIO when cooling coil operates

Ventilation information is in Table 94.

**Table 94. Indoor CEH Prototype Outdoor Airflow Rate.**

Space/ Thermal Zone	Occupancy Category [T24, 2025, Table 120.1-A]	General Area Required cfm/ft <sup>2</sup>	Required Exhaust Rate cfm/unit	Units	Total cfm by area	Total Ventilation	Total Exhaust CFM	Total cfm	Notes
<b>Horticulture_ Vegetative</b>	Indoor CEH	0	0	0	0	0	0	0	
<b>Horticulture_ Flowering</b>	Indoor CEH	0	0	0	0	0	0	0	
<b>Horticulture_ Drying</b>	Indoor CEH	0	0	0	0	0	0	0	
<b>Processing Area</b>	Dry Flower Trimming and/or Packaging	0.15	0	0	315	315	0	315	In lieu of ventilation, the room may be permanently fit with filtration and dust collection systems capable of at least 12 air changes per hour with minimum MERV 15 filters.
<b>Storage</b>	Warehouse	0.15	0	0	367.2	367.2	0	367.2	
<b>Office</b>	Office	0.15	0	0	472.5	472.5	0	472.5	
<b>Restrooms</b>	All Others	0.15	25	6	63	63	150	0	Transfer Air allowed
<b>Security office</b>	Office / All Others	0.15	0	0	69.3	69.3	0	69.3	

Process lighting is covered in Table 95 and ventilation fan information is shown in Table 96.

**Table 95. Indoor CEH Prototype Horticultural Lighting Information**

Space	Horticulture Lighting (W/ft <sup>2</sup> canopy)	Max Dimming %	Source
Horticulture Vegetative	24.24	100	T24 2025 - Revised CEH Lighting Cannabis Calculations ( lighting power density and dimming on analysis of 6 California facilities provided by Dr. Greenhouse) Note that with LEDs, flower room dimming varies from 60% to 100% over the plant grow cycle.
Horticulture_Flowering	48.47	60	
Horticulture_Drying	0.00	100	
Processing Area	4.42	100	
Storage	0.0	100	
Office	0	100	
Restrooms	0	100	
Security office	0	100	

**Table 96. Indoor CEH Prototype Ventilation Fan Information**

<b>Space</b>	<b>Circulation Fan (W/ft<sup>2</sup>)</b>	<b>Fan Efficiency</b>
<b>Horticulture Vegetative</b>	1.00	0.85
<b>Horticulture_Flowering</b>	1.00	0.85
<b>Horticulture_Drying</b>	1.00	0.85
<b>Processing Area</b>	0	N/A
<b>Storage</b>	0	N/A
<b>Office</b>	0	N/A
<b>Restrooms</b>	0	N/A
<b>Security office</b>	0	N/A

Hourly schedules for non-growing areas are in Table 97

**Table 97. Indoor CEH Prototype Schedules for Non-Growing Spaces**

Schedule	Day	Hour																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Office Areas Occupancy	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.95	0.95	0.95	0.95	0.50	0.95	0.95	0.95	0.95	0.30	0.10	0.10	0.10	0.10	0.05	0.05
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.00	0.00	0.00
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Office Areas Lighting	Weekday	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.35	0.30	0.30	0.20	0.20	0.10	0.05
	Saturday	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Sunday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Office Areas HVAC Availability	Weekday	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Saturday	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
	Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Office Areas Infiltration	Weekday	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Saturday	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
	Sunday	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Storage and Process Areas Occupancy	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.70	0.90	0.90	0.90	0.50	0.85	0.85	0.85	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Schedule	Day	Hour																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storage and Process Areas Lighting	Weekday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.25	0.45	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.30	0.05	0.05	0.05	0.05	0.05	0.05
	Saturday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.24	0.24	0.24	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Sunday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Horticulture Drying Area Occupancy	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.70	0.90	0.90	0.90	0.50	0.85	0.85	0.85	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horticulture Drying Area Lighting	Weekday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.25	0.45	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.30	0.05	0.05	0.05	0.05	0.05	0.05
	Saturday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.24	0.24	0.24	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Sunday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

**Table 98. Indoor CEH Prototype Horticultural Lighting Dimming and Grow Space Occupancy Schedules.**

Schedule	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
<b>Horticulture Vegetative Horticultural Lighting</b>	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
<b>Horticulture Vegetative Occupancy</b>	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.95	0.95	0.95	0.95	0.50	0.95	0.95	0.95	0.95	0.30	0.10	0.10	0.10	0.10	0.05	0.05	
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.00	
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	
<b>Horticulture Flowering Occupancy</b>	Weekday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.95	0.95	0.95	0.95	0.50	0.95	0.95	0.95	0.95	0.30	0.10	0.10	0.10	0.10	0.05	0.05	
	Saturday	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.00	
	Sunday	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	
<b>Horticulture Flowering Horticultural Lighting - Dimming schedule</b>	Initial Stage (7 days)	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	
	Early Stage (7 days)	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.00	0.00	0.00	0.00	0.00	0.00	
	Mid Stage (35 days)	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Late Stage (14 days)	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.00	0.00	0.00	0.00	0.00	0.00
	Crop Rotation (4 days)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

**Table 99. Indoor CEH Prototype Flower Room Evapotranspiration, Temperature Setpoint, Humidity Setpoint, and Dimming Schedule**

Schedule	Day	Hour																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Horticulture Flowering CEH Evapotranspiration Schedule (% of peak latent load)	Initial Stage (7 days)	12	12	12	12	12	12	30	40	45	50	50	50	50	50	50	50	50	50	35	25	20	18	16	14
	Early Stage (7 days)	14	14	14	14	14	14	60	70	75	80	80	80	80	80	80	80	80	80	60	43	34	26	22	18
	Mid Stage (35 days)	18	18	18	18	18	18	73	82	91	100	100	100	100	100	100	100	100	100	75	54	41	31	26	21
	Late Stage (14 days)	25	25	25	25	25	25	68	75	83	90	90	90	90	90	90	90	90	90	70	55	40	35	30	28
	Crop Rotation (4 days)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Horticulture Flowering CEH Setpoint Schedule (Cooling, °F)	Initial & Early Stages (14 days)	79	79	79	79	79	79	82	82	82	82	82	82	82	82	82	82	82	82	79	79	79	79	79	79
	Mid Stage (35 days)	75	75	75	75	75	75	79	79	79	79	79	79	79	79	79	79	79	79	75	75	75	75	75	75
	Late Stage (14 days)	70	70	70	70	70	70	73	73	73	73	73	73	73	73	73	73	73	73	70	70	70	70	70	70
	Crop Rotation (4 days)	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Horticulture Flowering Setpoint Schedule (Humidity, %RH)	Initial & Early Stages (14 days)	65	65	65	65	65	65	67	67	67	67	67	67	67	67	67	67	67	67	65	65	65	65	65	65
	Mid Stage (35 days)	54	54	54	54	54	54	57	57	57	57	57	57	57	57	57	57	57	57	54	54	54	54	54	54
	Late Stage (14 days)	46	46	46	46	46	46	48	48	48	48	48	48	48	48	48	48	48	48	46	46	46	46	46	46
	Crop Rotation (4 days)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Horticulture Flowering Horticultural Lighting - Dimming schedule	Initial Stage (7 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0
	Early Stage (7 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	Mid Stage (35 days)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	Late Stage (14 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	Crop Rotation (4 days)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Thermostat setpoints do not vary by climate zone for this process load. They are outlined in Table 100.

**Table 100. Indoor CEH Whole Building Prototype Thermostat Setpoints by Zone**

Space/Thermal Zone	Setpoint	CZ1-16	Source and Notes
Office	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	
	Cooling Setpoint (F)	75	
	Cooling Setback (F)	80	
Security	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	
	Cooling Setpoint (F)	75	
	Cooling Setback (F)	85	
Restrooms	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	
	Cooling Setpoint (F)	75	
	Cooling Setback (F)	85	
Storage and Shipping	Heating Setpoint (F)	60	Storage is typically cool and dry to preserve product.
	Heating Setback (F)	60	
	Cooling Setpoint (F)	65	
	Cooling Setback (F)	75	
Processing	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B. RH is kept below 50% to avoid rehydrating product during trimming and packaging.
	Heating Setback (F)	60	
	Cooling Setpoint (F)	70	
	Cooling Setback (F)	80	
Horticulture_Drying	Heating Setpoint (F)	60	Drying room is not typically occupied, kept at 60F and 60%RH to dry plants.
	Heating Setback (F)	60	
	Cooling Setpoint (F)	60	
	Cooling Setback (F)	60	
Horticulture_Vegetative	Heating Setpoint (F)	n/a	Assume no heating
	Heating Setback (F)	n/a	
	Cooling Setpoint (F)	82	
	Cooling Setback (F)	n/a	
Horticulture_Flowering	Heating Setpoint (F)	n/a	See Latent Load and Setpoint table.
	Heating Setback (F)	n/a	
	Cooling Setpoint (F)	Variable	
	Cooling Setback (F)	n/a	

# Appendix B: Purpose and Necessity of Proposed Code Changes

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## 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.

Section 2.6 of this report provides marked-up code language.

## Lighting Efficacy

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

The Statewide CASE Team proposes no changes to Title 24, Part 1.

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

Section: 100.1

**Purpose:** The purpose of this change is to aid in the interpretation and implementation of lighting efficacy requirements for CEH facilities in Title 24, Part 6, Section 120.6(h) by modifying the definition of Photosynthetic Photon Efficacy (PPE).

**Necessity:** This change changes the definition of Photosynthetic Photon Efficacy (PPE) to be a definition of Luminaire Photosynthetic Photon Efficacy (PPE). It also restricts the definition to a range of light wavelengths. These changes ensure clarity of the proposed lighting efficacy requirements.

Section: 120.6(h)

**Purpose:** The purpose of this change is to strengthen existing CEH lighting efficacy requirements. It would require horticultural lighting to achieve a luminaire PPE of 2.5 micromoles per Joule.

**Necessity:** These proposed changes are intended to reduce the energy consumption of CEH facilities. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

## Daylight Adaptive Controls for Greenhouses

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

There are no proposed changes to Title 24, Part 1.

## **Purpose and Necessity of Changes to Title 24, Part 6**

Section: 100.1

**Purpose:** The purpose of this change is to aid in the interpretation and implementation of new daylight adaptive lighting control requirements for CEH facilities in Title 24, Part 6, Section 120.6(h) by adding new definitions.

**Necessity:** This change adds definitions for Daily Light Integral (DLI), Daily Light Integral (DLI) Control, Photosynthetic Active Radiation (PAR), Photosynthetic Photon Flux Density (PPFD), and PAR Sensor. This change also modifies existing definitions for Photosynthetic Photon Efficacy (PPE) and Photosynthetic Photon Flux (PPF). These definitions ensure clarity of the proposed lighting control requirements.

Section: 120.6(h)

**Purpose:** The purpose of this change is to replace existing CEH lighting requirements with more comprehensive efficiency and controls requirements. Requiring advanced controls to prevent over-lighting horticultural spaces when already sufficiently lit by daylight will reduce energy consumption.

**Necessity:** These proposed changes are intended to reduce the energy consumption of CEH facilities. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

## **Purpose and Necessity of Changes to the Reference Appendices**

Section: NA7.X

**Purpose:** The purpose of these changes is to establish acceptance test requirements for the proposed daylight adaptive lighting control requirements.

**Necessity:** This change is necessary to enforce the proposed new requirement for CEH facilities.

## **Space Conditioning**

### **Purpose and Necessity of Changes to Title 24, Part 1**

There are no proposed changes to Title 24, Part 1.

### **Purpose and Necessity of Changes to Title 24, Part 6**

Section: 100.1

**Purpose:** The purpose of this change is to aid in the interpretation and implementation of new space conditioning requirements for CEH facilities in Title 24, Part 6, Section 120.6(h) by adding new definitions.

**Necessity:** This change adds definitions for Plant Canopy Area and CEH Space Conditioning System. This change also modifies existing definitions for Conditioned Space, Directly and Controlled Environment Horticulture. These definitions ensure clarity of the proposed space conditioning requirements.

Section: 120.6(h)

**Purpose:** The purpose of this change is to replace CEH dehumidification requirements with more comprehensive space conditioning requirements. Improving the sizing and controls of products used for CEH space conditioning will reduce the amount of energy consumed by these facilities.

**Necessity:** These proposed changes are intended to reduce the energy consumption of CEH facilities. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

Section: 140.9(d)

**Purpose:** The purpose of this change is to prescriptively require performance characteristics for CEH space conditioning systems. CEH space conditioning systems meeting these requirements will reduce the amount of energy consumed by these facilities.

**Necessity:** These proposed changes are intended to reduce the energy consumption of CEH facilities. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

## **Purpose and Necessity of Changes to the Reference Appendices**

Section: NA7.X

**Purpose:** The purpose of these changes is to establish field verification requirements for the proposed CEH space conditioning requirements.

**Necessity:** This change is necessary to enforce the proposed new requirement for CEH facilities.

Section: NA9

**Purpose:** The purpose of these changes is to establish a method for load and sizing calculations for CEH space conditioning systems.

**Necessity:** This change is necessary to enforce the proposed new requirement for CEH facilities.

# Appendix C: Assumptions for Statewide Savings Estimates

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The Statewide CASE Team is anticipating updated construction forecasts to be released by the California Energy Commission in February 2026. This will impact statewide energy savings but not the cost effectiveness of the proposal. The final CASE Report will present the updated savings based on the new forecasts.

## C.1 Lighting Efficacy

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by 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.

California has an estimated 40.2 million square feet of existing CEH facilities, with an additional 2.1 million square feet of annual new construction projected by the 2029 Statewide Construction Forecast (California Energy Commission, 2025). The Statewide Construction Forecast does not distinguish between greenhouse and indoor CEH floor area. The proportions from the 2022 CEH Final CASE Report were applied, assuming 68 percent of statewide CEH square footage is greenhouse, and 32 percent is indoor grow (Energy Solutions, 2023).

The Statewide CASE Team assumed that only 70 percent of the existing and projected square footage would have at least 40 kW connected lighting load and therefore be subject to this measure. The same value was used for greenhouse and indoor CEH facilities.

For indoor grow facilities, the Statewide CASE Team assumed that 70 percent of the building square footage is utilized as canopy area, which would be the area equipped with horticulture lighting. The assumption for greenhouses is that 100 percent of the building square footage is utilized as canopy area.

The Statewide CASE Team estimated that the portion of existing square footage that would be upgraded each year is the inverse of the EUL of the light fixture for each crop type. For example, the EUL of light fixtures used to grow cannabis is calculated to be ten years, so ten percent of impacted facilities would be replacing their fixtures each year. In this scenario, the portion of statewide existing CEH square footage that would be impacted annually is 68 percent (portion of statewide CEH square footage that is greenhouse) x 70 percent (portion of existing and projected square footage that would have at least 40 kW connected light load) x 10 percent (portion of impacted facilities replacing their fixtures each year) for greenhouses, and 32 percent x 70 percent x 70

percent (for indoor grow facilities, the portion of building square footage that is utilized as canopy area) x 10 percent for indoor grow facilities.

Additionally, the statewide savings and cost estimates take the current market share rate into account. For the lighting efficacy measure, the Statewide CASE Team estimated that the current market share rate is 62 percent for both new construction and alterations based on preliminary feedback from the first stakeholder meeting, as well as results from an industry-funded survey (Cannabis Business Times, 2024).

Combining all prototypes, the Statewide CASE Team assumed 12.96 percent of the new construction forecast and 0.54 percent of the facility stock are impacted annually by the proposed code change. The assumptions used to estimate the impacted square footage will be updated for the Final CASE Report based on ongoing stakeholder outreach and analysis of the 2022 USDA Census of Agriculture.

Simulations were run with cannabis, tomatoes, and leafy greens as representative crops in each building type for all 16 climate zones. Microgreens and herbs are represented by leafy greens and tomatoes represent vine crops, fruiting crops, and flowering crops due to similar light and temperature requirements. The results were then weighted to represent the proportion of statewide CEH facilities dedicated to growing each crop. The percent of facility stock is based on those used in the 2025 CASE Report, and the percent of statewide floorspace impacted by the proposed measure was adapted based on subject matter expertise. These values will be updated based on stakeholder input. These assumptions and calculations are shown in Table 80 for new construction and additions, and Table 80 for alterations.

**Table 101: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – New Construction & Additions**

Building Type	Crop Type	Percent of building type square footage used for crop type (%)	Percent of CEH Statewide New Construction Impacted (%)
<b>Indoor – 32%</b>	Cannabis	92	14.43
	Leafy greens / Microgreens / Herbs	5	0.78
	Tomatoes / Flowers / Vine Plants	3	0.47
<b>Greenhouse – 68%</b>	Cannabis	30	14.28
	Leafy greens / Microgreens / Herbs	30	14.28
	Tomatoes / Flowers / Vine Plants	40	19.04

a. Note: These values do not account for the market adoption.

**Table 102: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – Alterations**

Building Type	Crop Type	Percent of building type square footage used for crop type (%)	Percent of CEH Building Stock Impacted Annually (%)
Indoor	Cannabis	92	1.87
	Leafy greens/Microgreens/Herbs	5	0.14
	Tomatoes/Flowers/Vine Plants	3	0.05
Greenhouse	Cannabis	30	1.70
	Leafy greens/Microgreens/Herbs	30	2.55
	Tomatoes/Flowers/Vine Plants	40	2.09

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 103 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that none of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. Table 104 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

Table 106 represents the assumed percentage of affected floorspace by climate zone.

**Table 103: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
<b>CEH Indoor Cannabis</b>	0.0051	0.0042	0.0175	0.0022	0.0111	0.0141	0.0001	0.0013	0.0014	0.0152	0.0166	0.0167	0.0049	0.0006	0.0026	0.0003	0.1140
<b>CEH Indoor Leafy Greens</b>	0.0003	0.0002	0.0010	0.0001	0.0006	0.0008	0.0000	0.0001	0.0001	0.0008	0.0009	0.0009	0.0003	0.0003	0.0001	0.0001	0.0063
<b>CEH Indoor Tomatoes</b>	0.0002	0.0001	0.0006	0.0001	0.0004	0.0005	0.0000	0.0000	0.0000	0.0005	0.0005	0.0006	0.0002	0.0002	0.0001	0.0001	0.0038
<b>CEH Greenhouse Cannabis</b>	0.0051	0.0043	0.0176	0.0022	0.0111	0.0142	0.0001	0.0013	0.0014	0.0153	0.0166	0.0168	0.0050	0.0006	0.0026	0.0003	0.1144
<b>CEH Greenhouse Leafy Greens</b>	0.0051	0.0043	0.0176	0.0022	0.0111	0.0142	0.0001	0.0013	0.0014	0.0153	0.0166	0.0168	0.0050	0.0006	0.0026	0.0003	0.1144
<b>CEH Greenhouse Tomatoes</b>	0.0068	0.0057	0.0234	0.0029	0.0148	0.0189	0.0001	0.0017	0.0019	0.0204	0.0222	0.0224	0.0066	0.0008	0.0035	0.0003	0.1525
<b>TOTAL</b>	<b>0.0225</b>	<b>0.0188</b>	<b>0.0777</b>	<b>0.0097</b>	<b>0.0491</b>	<b>0.0626</b>	<b>0.0004</b>	<b>0.0057</b>	<b>0.0063</b>	<b>0.0675</b>	<b>0.0735</b>	<b>0.0742</b>	<b>0.0219</b>	<b>0.0026</b>	<b>0.0116</b>	<b>0.0011</b>	<b>0.5052</b>

**Table 104: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
CEH Indoor Cannabis	0.0050	0.0033	0.0187	0.0076	0.0450	0.0588	0.0076	0.0053	0.0114	0.0257	0.0179	0.0323	0.0382	0.0033	0.0046	0.0007	0.2863
CEH Indoor Leafy Greens	0.0004	0.0002	0.0014	0.0006	0.0034	0.0044	0.0006	0.0004	0.0009	0.0019	0.0014	0.0024	0.0029	0.0003	0.0003	0.0001	0.0216
CEH Indoor Tomatoes	0.0001	0.0001	0.0005	0.0002	0.0013	0.0016	0.0002	0.0001	0.0003	0.0007	0.0005	0.0009	0.0011	0.0001	0.0001	0.0005	0.0080
CEH Greenhouse Cannabis	0.0046	0.0030	0.0171	0.0070	0.0414	0.0541	0.0070	0.0049	0.0105	0.0236	0.0164	0.0297	0.0351	0.0031	0.0042	0.0005	0.2632
CEH Greenhouse Leafy Greens	0.0069	0.0045	0.0257	0.0105	0.0621	0.0811	0.0105	0.0073	0.0157	0.0354	0.0247	0.0445	0.0526	0.0046	0.0063	0.0003	0.3948
CEH Greenhouse Tomatoes	0.0056	0.0037	0.0211	0.0086	0.0510	0.0666	0.0086	0.0060	0.0129	0.0291	0.0202	0.0365	0.0432	0.0038	0.0052	0.0009	0.3239
<b>TOTAL</b>	<b>0.0226</b>	<b>0.0147</b>	<b>0.0846</b>	<b>0.0346</b>	<b>0.2042</b>	<b>0.2667</b>	<b>0.0346</b>	<b>0.0239</b>	<b>0.0516</b>	<b>0.1165</b>	<b>0.0811</b>	<b>0.1463</b>	<b>0.1730</b>	<b>0.0151</b>	<b>0.0208</b>	<b>0.00076</b>	<b>1.2978</b>

**Table 105: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type**

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Indoor (Warehouse) Cannabis	2.93%	0.11%
CEH Indoor (Warehouse) Leafy Greens	0.16%	0.01%
CEH Indoor (Warehouse) Tomatoes	0.10%	0.02%
CEH Greenhouse Cannabis	2.93%	0.10%
CEH Greenhouse Leafy Greens	2.93%	0.15%
CEH Greenhouse Tomatoes	3.91%	0.12%
<b>TOTAL</b>	<b>12.96%</b>	<b>0.51%</b>

**Table 106: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone, for All Prototypes**

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	3.993%	0.066%
2	0.529%	0.008%
3	0.373%	0.009%
4	0.085%	0.006%
5	2.864%	0.215%
6	0.386%	0.036%
7	0.004%	0.007%
8	0.029%	0.003%
9	0.023%	0.004%
10	0.558%	0.013%
11	2.427%	0.043%
12	0.459%	0.016%
13	0.413%	0.048%
14	0.088%	0.008%
15	0.621%	0.017%
16	<b>0.111%</b>	<b>0.011%</b>

**Table 107: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00508	0.0783	0.0060	N/A	0.073	\$0.57
2	0.00425	0.0663	0.0051	N/A	0.061	\$0.47
3	0.01753	0.2728	0.0208	N/A	0.252	\$1.96
4	0.00219	0.0344	0.0026	N/A	0.031	\$0.24
5	0.01108	0.1731	0.0132	N/A	0.160	\$1.24
6	0.01413	0.2220	0.0169	N/A	0.205	\$1.57
7	0.00008	0.0013	0.0001	N/A	0.001	\$0.01
8	0.00128	0.0204	0.0015	N/A	0.019	\$0.14
9	0.00143	0.0227	0.0017	N/A	0.021	\$0.16
10	0.01524	0.2424	0.0184	N/A	0.222	\$1.70
11	0.01659	0.2624	0.0199	N/A	0.240	\$1.85
12	0.01674	0.2634	0.0200	N/A	0.242	\$1.88
13	0.00494	0.0784	0.0059	N/A	0.072	\$0.55
14	0.00059	0.0094	0.0007	N/A	0.009	\$0.06
15	0.00263	0.0427	0.0032	N/A	0.039	\$0.31
16	0.00026	0.0039	0.0003	N/A	0.004	\$0.03
<b>Total</b>	<b>0.11402</b>	<b>1.7939</b>	<b>0.1363</b>	<b>N/A</b>	<b>1.649</b>	<b>\$12.75</b>

**Table 108: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0002789	0.001324	0.000131	N/A	0.00187	0.0110
2	0.0002333	0.001120	0.000111	N/A	0.00157	0.0093
3	0.0009625	0.004615	0.000457	N/A	0.00650	0.0381
4	0.0001200	0.000581	0.000057	N/A	0.00081	0.0048
5	0.0006084	0.002922	0.000288	N/A	0.00410	0.0242
6	0.0007761	0.003756	0.000371	N/A	0.00529	0.0310
7	0.0000044	0.000021	0.000002	N/A	0.00003	0.0002
8	0.0000705	0.000344	0.000034	N/A	0.00048	0.0029
9	0.0000785	0.000383	0.000038	N/A	0.00054	0.0032
10	0.0008369	0.004091	0.000403	N/A	0.00572	0.0343
11	0.0009113	0.004432	0.000437	N/A	0.00619	0.0367
12	0.0009191	0.004447	0.000440	N/A	0.00622	0.0368
13	0.0002713	0.001326	0.000131	N/A	0.00185	0.0110
14	0.0000325	0.000158	0.000015	N/A	0.00022	0.0013
15	0.0001444	0.000722	0.000070	N/A	0.00100	0.0059
16	0.0000140	0.000067	0.000007	N/A	0.00009	0.0006
<b>Total</b>	<b>0.0062622</b>	<b>0.030309</b>	<b>0.002992</b>	<b>N/A</b>	<b>0.04249</b>	<b>0.2512</b>

**Table 109: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.000167	0.00093	0.000067	N/A	0.00078	\$0.0066
2	0.000140	0.00079	0.000057	N/A	0.00066	\$0.0055
3	0.000577	0.00324	0.000234	N/A	0.00272	\$0.0226
4	0.000072	0.00041	0.000029	N/A	0.00034	\$0.0028
5	0.000365	0.00206	0.000148	N/A	0.00172	\$0.0144
6	0.000466	0.00264	0.000190	N/A	0.00221	\$0.0181
7	0.000003	0.00002	0.000001	N/A	0.00001	\$0.0001
8	0.000042	0.00024	0.000017	N/A	0.00020	\$0.0016
9	0.000047	0.00027	0.000019	N/A	0.00022	\$0.0019
10	0.000502	0.00288	0.000206	N/A	0.00239	\$0.0194
11	0.000547	0.00312	0.000224	N/A	0.00258	\$0.0213
12	0.000551	0.00313	0.000225	N/A	0.00260	\$0.0218
13	0.000163	0.00093	0.000067	N/A	0.00077	\$0.0064
14	0.000019	0.00011	0.000008	N/A	0.00009	\$0.0007
15	0.000087	0.00051	0.000036	N/A	0.00042	\$0.0035
16	0.000008	0.00005	0.000003	N/A	0.00004	\$0.0003
<b>Total</b>	<b>0.003757</b>	<b>0.02130</b>	<b>0.001532</b>	<b>N/A</b>	<b>0.01775</b>	<b>\$0.1470</b>

**Table 110: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00509	0.0179	0.00193	N/A	0.0280	\$0.149
2	0.00426	0.0119	0.00144	N/A	0.0210	\$0.101
3	0.01758	0.0465	0.00570	N/A	0.0840	\$0.405
4	0.00219	0.0047	0.00069	N/A	0.0093	\$0.040
5	0.01111	0.0239	0.00339	N/A	0.0461	\$0.202
6	0.01417	0.0292	0.00420	N/A	0.0567	\$0.252
7	0.00008	0.0002	0.00002	N/A	0.0003	\$0.001
8	0.00129	0.0027	0.00038	N/A	0.0052	\$0.022
9	0.00143	0.0029	0.00042	N/A	0.0057	\$0.024
10	0.01528	0.0305	0.00445	N/A	0.0616	\$0.252
11	0.01664	0.0481	0.00620	N/A	0.0834	\$0.390
12	0.01678	0.0442	0.00561	N/A	0.0796	\$0.360
13	0.00495	0.0115	0.00166	N/A	0.0226	\$0.096
14	0.00059	0.0011	0.00018	N/A	0.0023	\$0.009
15	0.00264	0.0048	0.00075	N/A	0.0102	\$0.041
16	0.00026	0.0007	0.00009	N/A	0.0012	\$0.006
<b>Total</b>	<b>0.11436</b>	<b>0.2809</b>	<b>0.03710</b>	<b>N/A</b>	<b>0.5173</b>	<b>\$2.350</b>

**Table 111: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00509	0.00493	0.00069	N/A	0.0115	\$0.0464
2	0.00426	0.00309	0.00044	N/A	0.0079	\$0.0296
3	0.01758	0.01169	0.00151	N/A	0.0305	\$0.1173
4	0.00219	0.00093	0.00016	N/A	0.0027	\$0.0089
5	0.01111	0.00412	0.00068	N/A	0.0122	\$0.0389
6	0.01417	0.00423	0.00081	N/A	0.0139	\$0.0435
7	0.00008	0.00002	0.00000	N/A	0.0001	\$0.0002
8	0.00129	0.00039	0.00007	N/A	0.0013	\$0.0037
9	0.00143	0.00045	0.00008	N/A	0.0014	\$0.0041
10	0.01528	0.00457	0.00080	N/A	0.0154	\$0.0433
11	0.01664	0.01355	0.00194	N/A	0.0332	\$0.1210
12	0.01678	0.01114	0.00160	N/A	0.0290	\$0.1006
13	0.00495	0.00257	0.00047	N/A	0.0078	\$0.0243
14	0.00059	0.00015	0.00003	N/A	0.0005	\$0.0015
15	0.00264	0.00059	0.00012	N/A	0.0022	\$0.0060
16	0.00026	0.00019	0.00003	N/A	0.0004	\$0.0016
<b>Total</b>	<b>0.11436</b>	<b>0.06262</b>	<b>0.00945</b>	<b>N/A</b>	<b>0.1700</b>	<b>\$0.5909</b>

**Table 112: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00679	0.0089	0.00100	N/A	0.0143	\$0.0753
2	0.00568	0.0056	0.00063	N/A	0.0104	\$0.0484
3	0.02344	0.0216	0.00230	N/A	0.0409	\$0.1907
4	0.00292	0.0018	0.00026	N/A	0.0040	\$0.0161
5	0.01481	0.0085	0.00125	N/A	0.0189	\$0.0743
6	0.01890	0.0092	0.00143	N/A	0.0223	\$0.0843
7	0.00011	0.0001	0.00001	N/A	0.0001	\$0.0004
8	0.00172	0.0009	0.00013	N/A	0.0020	\$0.0073
9	0.00191	0.0009	0.00014	N/A	0.0022	\$0.0081
10	0.02038	0.0097	0.00143	N/A	0.0244	\$0.0846
11	0.02219	0.0240	0.00280	N/A	0.0422	\$0.1940
12	0.02238	0.0206	0.00237	N/A	0.0386	\$0.1687
13	0.00661	0.0049	0.00072	N/A	0.0109	\$0.0418
14	0.00079	0.0003	0.00006	N/A	0.0009	\$0.0029
15	0.00352	0.0013	0.00023	N/A	0.0038	\$0.0125
16	0.00034	0.0003	0.00004	N/A	0.0006	\$0.0027
<b>Total</b>	<b>0.15248</b>	<b>0.1187</b>	<b>0.01480</b>	<b>N/A</b>	<b>0.2365</b>	<b>\$1.0121</b>

**Table 113: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0050	0.08	0.006	N/A	0.07	\$0.55
2	0.0033	0.05	0.004	N/A	0.05	\$0.36
3	0.0187	0.29	0.022	N/A	0.27	\$2.08
4	0.0076	0.12	0.009	N/A	0.11	\$0.85
5	0.0450	0.70	0.054	N/A	0.65	\$5.06
6	0.0588	0.92	0.070	N/A	0.86	\$6.55
7	0.0076	0.12	0.009	N/A	0.11	\$0.85
8	0.0053	0.08	0.006	N/A	0.08	\$0.58
9	0.0114	0.18	0.014	N/A	0.17	\$1.29
10	0.0257	0.41	0.031	N/A	0.37	\$2.86
11	0.0179	0.28	0.021	N/A	0.26	\$1.99
12	0.0323	0.51	0.039	N/A	0.47	\$3.63
13	0.0382	0.61	0.046	N/A	0.55	\$4.27
14	0.0033	0.05	0.004	N/A	0.05	\$0.36
15	0.0046	0.07	0.006	N/A	0.07	\$0.53
16	0.0017	0.03	0.002	N/A	0.02	\$0.18
<b>Total</b>	<b>0.2863</b>	<b>4.51</b>	<b>0.343</b>	<b>N/A</b>	<b>4.15</b>	<b>\$32.02</b>

**Table 114: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00038	0.0018	0.0002	N/A	0.003	\$0.01
2	0.00025	0.0012	0.0001	N/A	0.002	\$0.01
3	0.00141	0.0068	0.0007	N/A	0.010	\$0.06
4	0.00058	0.0028	0.0003	N/A	0.004	\$0.02
5	0.00340	0.0163	0.0016	N/A	0.023	\$0.14
6	0.00444	0.0215	0.0021	N/A	0.030	\$0.18
7	0.00058	0.0028	0.0003	N/A	0.004	\$0.02
8	0.00040	0.0019	0.0002	N/A	0.003	\$0.02
9	0.00086	0.0042	0.0004	N/A	0.006	\$0.04
10	0.00194	0.0095	0.0009	N/A	0.013	\$0.08
11	0.00135	0.0066	0.0006	N/A	0.009	\$0.05
12	0.00244	0.0118	0.0012	N/A	0.016	\$0.10
13	0.00288	0.0141	0.0014	N/A	0.020	\$0.12
14	0.00025	0.0012	0.0001	N/A	0.002	\$0.01
15	0.00035	0.0017	0.0002	N/A	0.002	\$0.01
16	0.00013	0.0006	0.0001	N/A	0.001	\$0.01
<b>Total</b>	<b>0.02162</b>	<b>0.1048</b>	<b>0.0103</b>	<b>N/A</b>	<b>0.147</b>	<b>\$0.87</b>

Table 115: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00014	0.0008	0.00006	N/A	0.0006	\$0.005
2	0.00009	0.0005	0.00004	N/A	0.0004	\$0.004
3	0.00052	0.0029	0.00021	N/A	0.0024	\$0.020
4	0.00021	0.0012	0.00009	N/A	0.0010	\$0.008
5	0.00126	0.0071	0.00051	N/A	0.0059	\$0.049
6	0.00164	0.0093	0.00067	N/A	0.0078	\$0.064
7	0.00021	0.0012	0.00009	N/A	0.0010	\$0.008
8	0.00015	0.0008	0.00006	N/A	0.0007	\$0.006
9	0.00032	0.0018	0.00013	N/A	0.0015	\$0.013
10	0.00072	0.0041	0.00029	N/A	0.0034	\$0.028
11	0.00050	0.0028	0.00020	N/A	0.0024	\$0.019
12	0.00090	0.0051	0.00037	N/A	0.0042	\$0.035
13	0.00106	0.0061	0.00044	N/A	0.0050	\$0.042
14	0.00009	0.0005	0.00004	N/A	0.0004	\$0.004
15	0.00013	0.0007	0.00005	N/A	0.0006	\$0.005
16	0.00005	0.0003	0.00002	N/A	0.0002	\$0.002
<b>Total</b>	<b>0.00798</b>	<b>0.0453</b>	<b>0.00326</b>	<b>N/A</b>	<b>0.0378</b>	<b>\$0.312</b>

**Table 116: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0046	0.016	0.002	N/A	0.03	\$0.13
2	0.0030	0.008	0.001	N/A	0.01	\$0.07
3	0.0171	0.045	0.006	N/A	0.08	\$0.40
4	0.0070	0.015	0.002	N/A	0.03	\$0.13
5	0.0414	0.089	0.013	N/A	0.17	\$0.75
6	0.0541	0.112	0.016	N/A	0.22	\$0.96
7	0.0070	0.015	0.002	N/A	0.03	\$0.12
8	0.0049	0.010	0.001	N/A	0.02	\$0.08
9	0.0105	0.021	0.003	N/A	0.04	\$0.17
10	0.0236	0.047	0.007	N/A	0.10	\$0.39
11	0.0164	0.048	0.006	N/A	0.08	\$0.39
12	0.0297	0.078	0.010	N/A	0.14	\$0.64
13	0.0351	0.081	0.012	N/A	0.16	\$0.68
14	0.0031	0.006	0.001	N/A	0.01	\$0.05
15	0.0042	0.008	0.001	N/A	0.02	\$0.07
16	0.0015	0.004	0.001	N/A	0.01	\$0.03
<b>Total</b>	<b>0.2632</b>	<b>0.604</b>	<b>0.083</b>	<b>N/A</b>	<b>1.14</b>	<b>\$5.06</b>

**Table 117: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00686	0.0066	0.0009	N/A	0.016	\$0.06
2	0.00449	0.0033	0.0005	N/A	0.008	\$0.03
3	0.02572	0.0171	0.0022	N/A	0.045	\$0.17
4	0.01052	0.0044	0.0008	N/A	0.013	\$0.04
5	0.06212	0.0231	0.0038	N/A	0.068	\$0.22
6	0.08113	0.0242	0.0046	N/A	0.079	\$0.25
7	0.01052	0.0029	0.0005	N/A	0.009	\$0.03
8	0.00728	0.0022	0.0004	N/A	0.007	\$0.02
9	0.01570	0.0049	0.0009	N/A	0.015	\$0.05
10	0.03543	0.0106	0.0019	N/A	0.036	\$0.10
11	0.02467	0.0201	0.0029	N/A	0.049	\$0.18
12	0.04450	0.0295	0.0043	N/A	0.077	\$0.27
13	0.05262	0.0273	0.0050	N/A	0.083	\$0.26
14	0.00460	0.0011	0.0003	N/A	0.004	\$0.01
15	0.00633	0.0014	0.0003	N/A	0.005	\$0.01
16	0.00231	0.0017	0.0002	N/A	0.004	\$0.01
<b>Total</b>	<b>0.39479</b>	<b>0.1806</b>	<b>0.0294</b>	<b>N/A</b>	<b>0.519</b>	<b>\$1.71</b>

**Table 118: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0056	0.0074	0.0008	N/A	0.012	\$0.06
2	0.0037	0.0037	0.0004	N/A	0.007	\$0.03
3	0.0211	0.0195	0.0021	N/A	0.037	\$0.17
4	0.0086	0.0054	0.0008	N/A	0.012	\$0.05
5	0.0510	0.0294	0.0043	N/A	0.065	\$0.26
6	0.0666	0.0323	0.0050	N/A	0.078	\$0.30
7	0.0086	0.0040	0.0006	N/A	0.009	\$0.04
8	0.0060	0.0030	0.0004	N/A	0.007	\$0.03
9	0.0129	0.0064	0.0009	N/A	0.015	\$0.05
10	0.0291	0.0139	0.0020	N/A	0.035	\$0.12
11	0.0202	0.0219	0.0026	N/A	0.039	\$0.18
12	0.0365	0.0336	0.0039	N/A	0.063	\$0.28
13	0.0432	0.0318	0.0047	N/A	0.071	\$0.27
14	0.0038	0.0016	0.0003	N/A	0.004	\$0.01
15	0.0052	0.0020	0.0003	N/A	0.006	\$0.02
16	0.0019	0.0019	0.0002	N/A	0.003	\$0.01
<b>Total</b>	<b>0.3239</b>	<b>0.2176</b>	<b>0.0294</b>	<b>N/A</b>	<b>0.463</b>	<b>\$1.87</b>

## C.2 Daylight Responsive Controls for Greenhouses

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by 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.

California has an estimated 40.2 million square feet of existing CEH facilities, with an additional 2.1 million square feet of annual new construction projected by the 2029 Statewide Construction Forecast (California Energy Commission, 2025). The Statewide Construction Forecast does not distinguish between greenhouse and indoor CEH floor area. The proportions from the 2022 CEH Final CASE Report were applied, assuming 68 percent of statewide CEH square footage is greenhouse (Energy Solutions, 2023).

The Statewide CASE Team assumed that only 70 percent of the existing and projected square footage would have at least 40 kW connected lighting load and therefore be subject to this measure. The same value was used for greenhouse and indoor CEH facilities.

The Statewide CASE Team estimated that the portion of existing square footage that would be upgraded each year is the inverse of the EUL of the controls component for each crop type. For example, the EUL of time clocks and PAR sensors is estimated to be eight years, meaning 12.5% of time clocks and PAR sensors are expected to be replaced each year. In this scenario, the affected square footage in the first year after the standards take place is 70 percent (portion of existing and projected square footage that would have at least 40 kW connected lighting load) x 12.5 percent (portion of time clocks and PAR sensors replaced each year), or 8.75 percent.

Additionally, the statewide savings and cost estimates take the current market share rate into account. For daylight responsive controls, the Statewide CASE Team estimated that the current market share rate is 62 percent based on preliminary feedback from the first stakeholder meeting, which aligned with findings from a recent CalNEXT study on Smart Controls for Data-Driven Indoor Agriculture Field Evaluation (Schimelpfenig, 2025) .

The Statewide CASE Team modeled the greenhouse prototype for cannabis, tomatoes, and leafy greens as representative crops in all 16 climate zones. Microgreens and herbs are represented by leafy greens, and tomatoes represent vine crops, fruiting crops, and flowering crops due to similar light and temperature requirements. The percent of facility stock is based on those used in the 2025 CASE Report, and the percent of statewide floorspace impacted by the proposed measure was adapted based on subject matter expert opinion and will be updated with stakeholder feedback. For purposes of the statewide energy savings analysis, the Statewide CASE Team conservatively assumed

that in cannabis greenhouses, only cannabis flower rooms (not vegetative or clone rooms) would be impacted by the measure. This assumption reflects greenhouse canopy area breakdown, where cannabis is typically 65% flowering, 33% vegetative, and 2% clone by canopy area; therefore, 65% of cannabis canopy square footage was used in the calculations. The CASE Team is continuing to seek stakeholder feedback, and this assumption may be updated in the final CASE report. These assumptions are shown in Table 119 for new construction and additions, and Table 120 for alterations.

**Table 119: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – New Construction & Additions**

<b>Greenhouse Prototype</b>	<b>Percent of building type square footage used for crop type (%)</b>	<b>Percent of CEH Statewide New Construction Impacted (%)</b>
<b>Cannabis</b>	30	14.28
<b>Cannabis Flower Only</b>	19.5	9.28
<b>Leafy greens / Microgreens / Herbs</b>	30	14.28
<b>Tomatoes / Flowers / Vine Plants</b>	40	16.00

**Table 120: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – Alterations**

<b>Greenhouse Prototype</b>	<b>Percent of building type square footage used for crop type (%)</b>	<b>Percent of CEH Building Stock Impacted Annually (%)</b>
<b>Cannabis</b>	30	2.55
<b>Cannabis Flower Only</b>	19.5	1.66
<b>Leafy greens / Microgreens / Herbs</b>	30	2.55
<b>Tomatoes/Flowers/ Vine Plants</b>	40	16.00

Table 121 presents the projected nonresidential new construction that the proposed code change will impact in 2026. Table 122 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 123 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that none of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. Table 124 represents the assumed percentage of affected floorspace by climate zone.

**Table 121: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
CEH Greenhouse Cannabis	0.003	0.003	0.011	0.001	0.007	0.009	0.000	0.001	0.001	0.010	0.011	0.011	0.003	0.000	0.002	0.000	0.074
CEH Greenhouse Leafy Greens	0.005	0.004	0.018	0.002	0.011	0.014	0.000	0.001	0.001	0.015	0.017	0.017	0.005	0.001	0.003	0.000	0.114
CEH Greenhouse Tomatoes	0.007	0.006	0.023	0.003	0.015	0.019	0.000	0.002	0.002	0.020	0.022	0.022	0.007	0.001	0.004	0.000	0.152
<b>TOTAL</b>	<b>0.015</b>	<b>0.013</b>	<b>0.052</b>	<b>0.007</b>	<b>0.033</b>	<b>0.042</b>	<b>0.000</b>	<b>0.004</b>	<b>0.004</b>	<b>0.046</b>	<b>0.050</b>	<b>0.050</b>	<b>0.015</b>	<b>0.002</b>	<b>0.008</b>	<b>0.001</b>	<b>0.341</b>

**Table 122: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
CEH Greenhouse Cannabis	0.004	0.003	0.017	0.007	0.040	0.053	0.007	0.005	0.010	0.023	0.016	0.029	0.034	0.003	0.004	0.001	0.257
CEH Greenhouse Leafy Greens	0.007	0.004	0.026	0.011	0.062	0.081	0.011	0.007	0.016	0.035	0.025	0.045	0.053	0.005	0.006	0.002	0.395
CEH Greenhouse Tomatoes	0.009	0.006	0.034	0.014	0.083	0.108	0.014	0.010	0.021	0.047	0.033	0.059	0.070	0.006	0.008	0.003	0.526
<b>TOTAL</b>	<b>0.020</b>	<b>0.013</b>	<b>0.077</b>	<b>0.031</b>	<b>0.185</b>	<b>0.242</b>	<b>0.031</b>	<b>0.022</b>	<b>0.047</b>	<b>0.106</b>	<b>0.074</b>	<b>0.133</b>	<b>0.157</b>	<b>0.014</b>	<b>0.019</b>	<b>0.007</b>	<b>1.178</b>

**Table 123: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type**

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Greenhouse Cannabis	1.91%	0.10%
CEH Greenhouse Leafy Greens	2.93%	0.15%
CEH Greenhouse Tomatoes	3.91%	0.20%
<b>TOTAL</b>	<b>8.75%</b>	<b>0.45%</b>

**Table 124: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone**

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	2.70%	0.06%
2	0.36%	0.01%
3	0.25%	0.01%
4	0.06%	0.01%
5	1.93%	0.19%
6	0.26%	0.03%
7	0.00%	0.01%
8	0.02%	0.00%
9	0.02%	0.00%
10	0.38%	0.01%
11	1.64%	0.04%
12	0.31%	0.01%
13	0.28%	0.04%
14	0.06%	0.01%
15	0.42%	0.01%
16	<b>0.07%</b>	<b>0.01%</b>

**Table 125: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00331	0.104	0.0049	N/A	0.0284	\$0.62
2	0.00277	0.101	0.0049	N/A	0.0273	\$0.60
3	0.01142	0.427	0.0212	N/A	0.1171	\$2.53
4	0.00142	0.058	0.0026	N/A	0.0167	\$0.35
5	0.00722	0.293	0.0130	N/A	0.0868	\$1.76
6	0.00921	0.379	0.0170	N/A	0.1156	\$2.25
7	0.00005	0.002	0.0001	N/A	0.0007	\$0.01
8	0.00084	0.034	0.0015	N/A	0.0104	\$0.20
9	0.00093	0.039	0.0017	N/A	0.0117	\$0.23
10	0.00993	0.414	0.0182	N/A	0.1210	\$2.42
11	0.01082	0.396	0.0173	N/A	0.1072	\$2.34
12	0.01091	0.420	0.0192	N/A	0.1161	\$2.54
13	0.00322	0.130	0.0054	N/A	0.0336	\$0.76
14	0.00039	0.017	0.0007	N/A	0.0050	\$0.10
15	0.00171	0.074	0.0032	N/A	0.0225	\$0.44
16	0.00017	0.006	0.0003	N/A	0.0019	\$0.04
<b>Total</b>	<b>0.07433</b>	<b>2.894</b>	<b>0.1313</b>	<b>N/A</b>	<b>0.8220</b>	<b>\$17.21</b>

**Table 126: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.00509	0.126	0.0070	N/A	0.051	\$0.80
2	0.00426	0.112	0.0064	N/A	0.048	\$0.72
3	0.01758	0.469	0.0269	N/A	0.203	\$2.98
4	0.00219	0.061	0.0033	N/A	0.028	\$0.39
5	0.01111	0.308	0.0166	N/A	0.143	\$2.00
6	0.01417	0.394	0.0209	N/A	0.185	\$2.50
7	0.00008	0.002	0.0001	N/A	0.001	\$0.01
8	0.00129	0.036	0.0019	N/A	0.017	\$0.22
9	0.00143	0.040	0.0021	N/A	0.019	\$0.26
10	0.01528	0.426	0.0223	N/A	0.199	\$2.68
11	0.01664	0.436	0.0236	N/A	0.182	\$2.76
12	0.01678	0.454	0.0252	N/A	0.199	\$2.96
13	0.00495	0.136	0.0072	N/A	0.058	\$0.87
14	0.00059	0.017	0.0009	N/A	0.008	\$0.10
15	0.00264	0.075	0.0040	N/A	0.036	\$0.48
16	0.00026	0.007	0.0004	N/A	0.003	\$0.04
<b>Total</b>	<b>0.11436</b>	<b>3.098</b>	<b>0.1687</b>	<b>N/A</b>	<b>1.380</b>	<b>\$19.78</b>

**Table 127: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0068	0.247	0.0126	N/A	0.080	\$1.50
2	0.0057	0.228	0.0121	N/A	0.075	\$1.39
3	0.0234	0.958	0.0520	N/A	0.323	\$5.85
4	0.0029	0.128	0.0063	N/A	0.046	\$0.78
5	0.0148	0.644	0.0315	N/A	0.237	\$4.00
6	0.0189	0.828	0.0409	N/A	0.312	\$5.07
7	0.0001	0.005	0.0002	N/A	0.002	\$0.03
8	0.0017	0.075	0.0037	N/A	0.028	\$0.45
9	0.0019	0.084	0.0041	N/A	0.032	\$0.53
10	0.0204	0.899	0.0435	N/A	0.332	\$5.43
11	0.0222	0.890	0.0443	N/A	0.293	\$5.40
12	0.0224	0.936	0.0480	N/A	0.320	\$5.84
13	0.0066	0.285	0.0135	N/A	0.093	\$1.73
14	0.0008	0.036	0.0017	N/A	0.014	\$0.22
15	0.0035	0.159	0.0077	N/A	0.061	\$0.99
16	0.0003	0.014	0.0007	N/A	0.005	\$0.09
<b>Total</b>	<b>0.1525</b>	<b>6.416</b>	<b>0.3231</b>	<b>N/A</b>	<b>2.253</b>	<b>\$39.30</b>

**Table 128: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Cannabis**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0045	0.14	0.007	N/A	0.04	\$0.83
2	0.0029	0.11	0.005	N/A	0.03	\$0.64
3	0.0167	0.62	0.031	N/A	0.17	\$3.71
4	0.0068	0.28	0.012	N/A	0.08	\$1.67
5	0.0404	1.64	0.073	N/A	0.49	\$9.84
6	0.0527	2.17	0.098	N/A	0.66	\$12.89
7	0.0068	0.28	0.013	N/A	0.09	\$1.66
8	0.0047	0.19	0.009	N/A	0.06	\$1.13
9	0.0102	0.43	0.019	N/A	0.13	\$2.56
10	0.0230	0.96	0.042	N/A	0.28	\$5.61
11	0.0160	0.59	0.026	N/A	0.16	\$3.47
12	0.0289	1.11	0.051	N/A	0.31	\$6.74
13	0.0342	1.38	0.058	N/A	0.36	\$8.12
14	0.0030	0.13	0.006	N/A	0.04	\$0.75
15	0.0041	0.18	0.008	N/A	0.05	\$1.06
16	0.0015	0.06	0.002	N/A	0.02	\$0.34
<b>Total</b>	<b>0.2566</b>	<b>10.25</b>	<b>0.457</b>	<b>N/A</b>	<b>2.95</b>	<b>\$61.02</b>

**Table 129: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Leafy Greens**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0069	0.17	0.009	N/A	0.07	\$1.07
2	0.0045	0.12	0.007	N/A	0.05	\$0.76
3	0.0257	0.69	0.039	N/A	0.30	\$4.36
4	0.0105	0.29	0.016	N/A	0.13	\$1.88
5	0.0621	1.72	0.093	N/A	0.80	\$11.19
6	0.0811	2.26	0.120	N/A	1.06	\$14.28
7	0.0105	0.29	0.016	N/A	0.14	\$1.85
8	0.0073	0.20	0.011	N/A	0.09	\$1.26
9	0.0157	0.44	0.023	N/A	0.21	\$2.86
10	0.0354	0.99	0.052	N/A	0.46	\$6.20
11	0.0247	0.65	0.035	N/A	0.27	\$4.10
12	0.0445	1.20	0.067	N/A	0.53	\$7.85
13	0.0526	1.45	0.076	N/A	0.62	\$9.19
14	0.0046	0.13	0.007	N/A	0.06	\$0.81
15	0.0063	0.18	0.010	N/A	0.09	\$1.16
16	0.0023	0.06	0.003	N/A	0.03	\$0.40
<b>Total</b>	<b>0.3948</b>	<b>10.83</b>	<b>0.583</b>	<b>N/A</b>	<b>4.91</b>	<b>\$69.22</b>

**Table 130: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Tomatoes**

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	0.0091	0.33	0.02	N/A	0.11	\$2.02
2	0.0060	0.24	0.01	N/A	0.08	\$1.47
3	0.0343	1.40	0.08	N/A	0.47	\$8.56
4	0.0140	0.61	0.03	N/A	0.22	\$3.77
5	0.0828	3.60	0.18	N/A	1.33	\$22.36
6	0.1082	4.74	0.23	N/A	1.78	\$29.04
7	0.0140	0.61	0.03	N/A	0.24	\$3.76
8	0.0097	0.42	0.02	N/A	0.16	\$2.56
9	0.0209	0.93	0.05	N/A	0.35	\$5.77
10	0.0472	2.08	0.10	N/A	0.77	\$12.59
11	0.0329	1.32	0.07	N/A	0.43	\$8.01
12	0.0593	2.48	0.13	N/A	0.85	\$15.48
13	0.0702	3.03	0.14	N/A	0.99	\$18.41
14	0.0061	0.28	0.01	N/A	0.11	\$1.67
15	0.0084	0.38	0.02	N/A	0.15	\$2.38
16	0.0031	0.13	0.01	N/A	0.05	\$0.78
<b>Total</b>	<b>0.5264</b>	<b>22.58</b>	<b>1.12</b>	<b>N/A</b>	<b>8.08</b>	<b>\$138.62</b>

### C.3 Space Conditioning

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by 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.

California has an estimated 40.2 million square feet of existing CEH facilities, with an additional 2.1 million square feet projected by the 2029 Statewide Construction Forecast (California Energy Commission, 2025). The Statewide Construction Forecast does not distinguish between greenhouse and indoor CEH floor area. Therefore, the proportions from the 2022 CEH Final CASE Report were applied, assuming 32 percent of statewide CEH square footage is indoor (Energy Solutions, 2023).

The Statewide CASE Team assumed that 92 percent of the indoor facilities are cannabis (Energy Solutions, 2023), 87 percent of the statewide canopy square footage is over 5,000 square feet (California Department of Cannabis Control, n.d.), 47 percent of the building square footage is cannabis flower (40 percent two-tier and 60 percent single-tier) (Gillespie, 2025; Stober & Weitze, 2024). In the scenario of New Construction, the affected square footage in the first year after the standards take place is 32 percent (portion of statewide CEH square footage that is indoor) x 92 percent (indoor facilities that are for cannabis) x 87 percent (portion of statewide canopy square footage that is over 5,000 square feet) x 47 percent (portion of the building square footage that is cannabis flow) = 12.0 percent.

For alterations, the Statewide CASE Team assumed that only a portion of existing square footage would be upgraded each year. The Statewide CASE Team assumed that CEH HVAC/D equipment would be upgraded or replaced roughly every 12 years, due to replacing the full system (not repairing or replacing components) or expanding the canopy square footage and requiring additional capacity. In this scenario, the affected square footage in the first year after the standards take place would then be 12.0 percent x 1/12 (portion of CEH HVAC/D equipment replaced each year) = 1 percent.

Additionally, the statewide energy and cost savings estimates take the current market share rate into account. The Statewide CASE Team estimates the current market share rate is 25 percent based on a weighted average from a poll response from the Utility-Sponsored Stakeholder Meeting 1 on September 24, 2025. The current market share rate will be updated based on interviews with well-informed stakeholders.

The Statewide CASE Team modeled the prototype for cannabis flower as representative crops in all 16 climate zones. The percent of facility stock is based on those used in the 2025 CASE Report, and the percent of statewide floorspace impacted

by the proposed measure was adapted based on subject matter expert opinion and will be updated with stakeholder feedback. These assumptions are shown in Table 131 for new construction and additions, and Table 132 for alterations.

**Table 131: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – New Construction & Additions**

Indoor (Warehouse) Prototype	Percent of Facility Stock (%)	Percent of Total Floorspace Impacted (%)	Percent of Statewide New Construction Impacted (%)
Cannabis	92	13.08	12.04

**Table 132: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – Alterations**

Indoor (Warehouse) Prototype	Percent of Facility Stock (%)	Percent of Total Floorspace Impacted (%)	Percent of Statewide New Construction Impacted (%)
Cannabis	92	1.09	1.00

**Table 133: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
CEH Indoor Cannabis	0.0084	0.0070	0.0289	0.0036	0.0182	0.0233	0.0001	0.0021	0.0024	0.0251	0.0273	0.0276	0.0081	0.0010	0.0043	0.0004	0.1878
<b>TOTAL</b>	<b>0.0084</b>	<b>0.0070</b>	<b>0.0289</b>	<b>0.0036</b>	<b>0.0182</b>	<b>0.0233</b>	<b>0.0001</b>	<b>0.0021</b>	<b>0.0024</b>	<b>0.0251</b>	<b>0.0273</b>	<b>0.0276</b>	<b>0.0081</b>	<b>0.0010</b>	<b>0.0043</b>	<b>0.0004</b>	<b>0.1878</b>

**Table 134: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)**

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
CEH Indoor Cannabis	0.0053	0.0034	0.0197	0.0081	0.0476	0.0622	0.0081	0.0056	0.0120	0.0272	0.0189	0.0341	0.0403	0.0035	0.0048	0.0018	0.3026
<b>TOTAL</b>	<b>0.0053</b>	<b>0.0034</b>	<b>0.0197</b>	<b>0.0081</b>	<b>0.0476</b>	<b>0.0622</b>	<b>0.0081</b>	<b>0.0056</b>	<b>0.0120</b>	<b>0.0272</b>	<b>0.0189</b>	<b>0.0341</b>	<b>0.0403</b>	<b>0.0035</b>	<b>0.0048</b>	<b>0.0018</b>	<b>0.3026</b>

**Table 135: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type**

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Indoor Cannabis	4.82	0.12
<b>TOTAL</b>	<b>4.82</b>	<b>0.12</b>

**Table 136: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone**

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	1.48	0.015
2	0.20	0.0017
3	0.14	0.0020
4	0.031	0.0014
5	1.06	0.050
6	0.14	0.008
7	0.0015	0.0015
8	0.011	0.0005
9	0.0086	0.0007
10	0.21	0.0028
11	0.90	0.010
12	0.17	0.003
13	0.15	0.011
14	0.033	0.0015
15	0.23	0.0037
16	<b>0.041</b>	<b>0.0023</b>

# Appendix D: Environmental Analysis

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## Horticultural Lighting Efficacy

### 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 will not result in a significant effect on the environment.

### Direct Environmental Impacts

#### *Direct Environmental Benefits*

Increasing the required lighting efficacy for horticultural lighting will reduce the total amount of energy that CEH facilities consume. This practice in turn will reduce GHG emissions due to the reduced need to generate electricity.

Section 2.5.1 discusses the data demonstrating energy benefits. Section 2.5.2 discusses the data demonstrating GHG benefits.

#### *Direct Adverse Environmental Impacts*

The Statewide CASE Team has not identified any direct adverse environmental impacts.

### Indirect Environmental Impacts

#### *Indirect Environmental Benefits*

The Statewide CASE Team has not identified any indirect environmental benefits.

#### *Indirect Adverse Environmental Impacts*

The Statewide CASE Team has not identified any indirect adverse environmental impacts.

### 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.

## **Reasonable Alternatives to Proposal**

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternate proposals would achieve the same impact of reduced horticultural lighting energy consumption.

## **Water Use and Water Quality Impacts Methodology**

The Statewide CASE Team determined the proposal comes with no impacts to water quality or water use.

## **Daylight Responsive Controls for Greenhouses**

### **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 will not result in a significant effect on the environment.

### **Direct Environmental Impacts**

#### ***Direct Environmental Benefits***

Using daylight responsive controls prevents the use of horticultural lighting when daylight is already sufficiently illuminating the plants. Using horticultural lighting at these times provides no added benefit and simply wastes energy. This measure will therefore reduce energy consumption as well as reduce GHG emissions by reducing the need to generate electricity.

Section 3.5 discusses the data demonstrating energy benefits. Section 3.5.2 discusses the data demonstrating GHG benefits.

#### ***Direct Adverse Environmental Impacts***

The Statewide CASE Team has not identified any direct adverse environmental impacts.

### **Indirect Environmental Impacts**

#### ***Indirect Environmental Benefits***

The Statewide CASE Team has not identified any indirect environmental benefits.

#### ***Indirect Adverse Environmental Impacts***

The Statewide CASE Team has not identified any indirect adverse environmental impacts.

## **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.

## **Reasonable Alternatives to Proposal**

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternate proposals would achieve the same impact of reduced boiler energy consumption.

## **Water Use and Water Quality Impacts Methodology**

The Statewide CASE Team determined the proposal comes with no impacts to water quality or water use.

## **Space Conditioning Systems**

### **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 will not result in a significant effect on the environment.

### **Direct Environmental Impacts**

#### ***Direct Environmental Benefits***

CEH facilities have highly variable latent and sensible space conditioning loads. Traditional HVAC equipment is typically optimized for steady state applications and are poorly equipped to deal with typical CEH conditioning requirements. The proposed measure would require more efficient, integrated space conditioning and would therefore save energy. This effect would then in turn reduce GHG emissions through the reduced need to generate electricity.

Section 4.5.1 discusses the data demonstrating energy benefits. Section 4.5.2 discusses the data demonstrating GHG benefits.

#### ***Direct Adverse Environmental Impacts***

The Statewide CASE Team has not identified any direct adverse environmental impacts.

## **Indirect Environmental Impacts**

### ***Indirect Environmental Benefits***

The Statewide CASE Team has not identified any indirect environmental benefits.

### ***Indirect Adverse Environmental Impacts***

The Statewide CASE Team has not identified any indirect adverse environmental impacts.

## **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.

## **Reasonable Alternatives to Proposal**

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternate proposals would achieve the same impact of reduced boiler energy consumption.

## **Water Use and Water Quality Impacts Methodology**

The Statewide CASE Team determined the proposal comes with no impacts to water quality or water use.

# Appendix E: Summary of Stakeholder Engagement

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## Introduction to Stakeholder Engagement

A core component of the Statewide CASE Team's process includes collaborating with stakeholders who may be affected by proposed code changes is. 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 in this Draft CASE Report that reflect broad support. 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, and potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations.

## E.1 Lighting Efficacy

### Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2028 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on the following:

- Proposed code changes;
- Draft code language;
- Draft assumptions and results of analyses;
- Data to support assumptions;
- Compliance and enforcement; and
- Technical and market feasibility.

The Statewide CASE Team hosted one stakeholder meeting for CEH Lighting Efficacy via webinar and plans to hold a second stakeholder meeting following publication of the draft CASE Report, as described in Table 137. The below table includes dates and links to event pages on [Title24Stakeholders.com](https://www.title24stakeholders.com). Materials from each meeting, such as slide

presentations (Hathaway, Controlled Environment Horticulture: Lighting Efficacy September 24 Stakeholder Meeting Slides, 2025), proposal summaries with code language, and meeting notes (California Energy Codes & Standards, 2025), are included in the bibliography section of this report.

**Table 137: Utility-Sponsored Stakeholder Meetings**

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
<p>First Round of Nonresidential Covered Processes, Lighting Utility-Sponsored Stakeholder Meeting</p> <p><a href="https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/">https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/</a></p>	<p>Wednesday September 24, 2025</p>	<ul style="list-style-type: none"> <li>• Impacts of lighting efficacy requirements on lighting spectrum, and whether the spectral needs of all crop types can be met at higher PPE.</li> <li>• Increase in lighting intensity with increasing PPE for some crop types.</li> <li>• Compliance verification for lighting efficacy.</li> <li>• Modeling of energy savings from lighting efficacy</li> <li>• Market adoption rates for CEH lighting with PPE of 2.5 and above.</li> </ul>
<p>Second Round of Utility-Sponsored Stakeholder Meeting</p>	<p>Thursday March 5, 2026</p>	<ul style="list-style-type: none"> <li>• Incremental first costs</li> <li>• Incremental maintenance costs</li> <li>• Market share</li> <li>• Assumptions used for per unit energy savings calculations</li> <li>• Per Unit Energy Savings</li> <li>• Assumptions used for Statewide Energy Savings calculations</li> <li>• Proposed code triggers for alterations</li> </ul>

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 included soliciting input on the scope of the 2025 code cycle proposals; requesting data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understanding potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings will be scheduled in early 2026 and will provide updated details on proposed code changes. These meetings will

introduce early results of energy, cost effectiveness, and incremental cost analyses, and they will also solicit feedback on refined draft code language.

Utility-sponsored stakeholder meetings are open to the public. For each stakeholder meeting, two promotional emails are distributed from [info@title24stakeholders.com](mailto:info@title24stakeholders.com). One email was sent to the full Title 24 Stakeholders listserv, which includes over 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 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 of 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.

## **Statewide CASE Team Communications**

The Statewide CASE Team conducted direct outreach through email, videoconference, and phone conversations with a range of stakeholders representing manufacturers, research institutions, trade associations, and technical experts. These discussions informed the development of the proposed lighting efficacy updates and provided valuable insights into product trends, control strategies, and implementation considerations.

Table 138 lists key organizations and individuals engaged during the proposal development process.

**Table 138: Engaged Stakeholders**

<b>Organization / Individual</b>	<b>Market Role</b>	<b>Referenced in CASE Report Sections</b>
<b>DesignLights Consortium (Kasey Holland)</b>	Qualified Product List Provider / Nonprofit	Technical specifications referenced; product trend data used for EUL and far-red analysis
<b>California Farm Bureau (Karen Mills)</b>	Agricultural Industry Association	Provided input on agricultural lighting market characteristics
<b>Matt Golden</b>	Energy Modeling Expert	Provided input on best practices for energy modeling
<b>Argus Controls (Justin Jacobs)</b>	Manufacturer – Horticultural Control Systems	Provided feedback on typical light fixtures specified with Argus controls, control system configurations, and capabilities
<b>University of California, Davis (Shamim Ahamed)</b>	Academic Research Institution	Contributed insights on controlled environment horticulture and lighting system design
<b>Autogrow (Kelley Nicholson)</b>	Manufacturer – Horticultural Control Systems	Discussed the integration of lighting systems and environmental control platforms
<b>University of Arizona (Gene Giacomelli)</b>	Academic Research Institution	Provided context on greenhouse lighting and plant response studies
<b>Energy Resources Integration (Gretchen Schimelpfenig)</b>	Energy Engineer / Technical Expert	Provided background on emerging control strategies, energy modeling inputs, and recent publications.

The Statewide CASE Team will continue to engage additional stakeholders, particularly grower representatives, lighting fixture manufacturers, and equity-focused organizations, as the proposal moves into future review and refinement phases. Examples of future stakeholders include California Lightworks, Philips Signify, Acuity Lithonia, Growers Choice, and Illuminar, all of which are representatives of the CEH Lighting manufacturer sector.

### **Engagement with ESJ communities**

The Statewide CASE Team plans to reach out to organizations representing and serving ESJ communities, particularly those affected by lighting quality, safety, and

affordability in CEH applications. Additional effort will be made to include underrepresented groups, such as agricultural worker housing organizations and smaller Central Valley municipalities. These stakeholders will be contacted through local energy partnership networks and program implementers active in those regions.

## **E.2 Daylight Responsive Controls for Greenhouses**

### **Utility-Sponsored Stakeholder Meetings**

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team’s role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2028 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on the following:

- Proposed code changes;
- Draft code language;
- Draft assumptions and results of analyses;
- Data to support assumptions;
- Compliance and enforcement; and
- Technical and market feasibility.

The Statewide CASE Team hosted one stakeholder meeting for the CEH Daylight Responsive Controls measure via webinar and plans to hold a second stakeholder meeting following publication of the draft CASE Report, as described in Table 137. Table 139 provides dates and links to event pages on [Title24Stakeholders.com](https://www.title24stakeholders.com). Materials from each meeting, such as slide presentations (Hathaway, Controlled Environment Horticulture: Daylight Responsive Controls for Greenhouses, 2025), proposal summaries with code language, and meeting notes (California Energy Codes & Standards, 2025), are included in the bibliography section of this report.

**Table 139: Utility-Sponsored Stakeholder Meetings**

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Nonresidential Covered Processes, Lighting Utility-Sponsored Stakeholder Meeting <a href="https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/">https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/</a>	Wednesday September 24, 2025	<ul style="list-style-type: none"> <li>• Scope and justification for the proposed code change for daylight responsive controls in greenhouse</li> <li>• Definition of two compliance pathways proposed</li> <li>• Estimated energy savings potential for the measure</li> <li>• Interaction of lighting controls with cooling loads and grid demand</li> </ul>
Second Round of Utility-Sponsored Stakeholder Meeting	Thursday March 5, 2026	<ul style="list-style-type: none"> <li>• Incremental first costs</li> <li>• Incremental maintenance costs</li> <li>• Market share</li> <li>• Assumptions used for per unit energy savings calculations</li> <li>• Energy Savings methodology</li> <li>• Assumptions used for Statewide Energy Savings calculations</li> <li>• Proposed code triggers for alterations</li> </ul>

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 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings are scheduled for early 2026 and will provide updated details on proposed code changes. These meetings will introduce early results of energy, cost effectiveness, and incremental cost analyses, and will solicit feedback on refined draft code language.

Utility-sponsored stakeholder meetings are open to the public. For each stakeholder meeting, two promotional emails were or will be distributed from [info@title24stakeholders.com](mailto:info@title24stakeholders.com). One email was sent to the full Title 24 Stakeholders listserv, which includes over 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 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 of 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.

### **Statewide CASE Team Communications**

The Statewide CASE Team conducted direct outreach through email, videoconference, and phone conversations with a range of stakeholders representing manufacturers, research institutions, trade associations, and technical experts. These discussions informed the development of the proposed daylight responsive controls updates and provided valuable insights into product trends, control strategies, and implementation considerations.

Table 140 lists key organizations and individuals engaged during the proposal development process.

**Table 140: Engaged Stakeholders**

Organization / Individual	Market Role	Referenced in CASE Report Sections
<b>DesignLights Consortium (Kasey Holland)</b>	Qualified Product List Provider / Nonprofit	Technical specifications referenced; product trend data used for EUL and far-red analysis
<b>California Farm Bureau (Karen Mills)</b>	Agricultural Industry Association	Provided input on agricultural lighting market characteristics
<b>Matt Golden</b>	Energy Modeling Expert	Provided input on best practices for energy modeling
<b>Argus Controls (Justin Jacobs)</b>	Manufacturer – Horticultural Control Systems	Provided feedback on typical light fixtures specified with Argus controls, control system configurations, and capabilities
<b>University of California, Davis (Shamim Ahamed)</b>	Academic Research Institution	Contributed insights on controlled environment horticulture and lighting system design
<b>Autogrow (Kelley Nicholson)</b>	Manufacturer – Horticultural Control Systems	Discussed the integration of lighting systems and environmental control platforms
<b>University of Arizona (Gene Giacomelli)</b>	Academic Research Institution	Provided context on greenhouse lighting and plant response studies
<b>Energy Resources Integration (Gretchen Schimelpfenig)</b>	Energy Engineer / Technical Expert	Provided background on emerging control strategies, energy modeling inputs, and recent publications.
<b>MicroGrow/AutoGrow Kelley Nicholson</b>	Manufacturer – Horticultural Control Systems	Provided feedback on crop assumptions, current automation and control system practices, lighting control products and technologies, and daylight responsive controls system design and commissioning.

The Statewide CASE Team will continue engaging additional stakeholders, including grower representatives, lighting control manufacturers, and equity focused organizations, as the proposal enters subsequent review and refinement. A brief survey has been prepared to collect cost data and insights on current daylight responsive control practices across crop types. The survey will be sent to stakeholders the Statewide CASE Team has already spoken with and to leading daylight responsive controls manufacturers such as Wadsworth Controls, Argus Controls, TrolMaster, Apogee, and Priva. Feedback from this outreach will help supplement and refine the Statewide CASE Team’s savings estimates, crop specific assumptions, and cost data.

## Engagement with ESJ communities

The Statewide CASE Team plans to reach out to organizations representing and serving ESJ communities, particularly those affected by lighting quality, safety, and affordability in CEH applications. Additional effort will be made to include underrepresented groups, such as agricultural worker housing organizations and smaller Central Valley municipalities. These stakeholders will be contacted through local energy partnership networks and program implementers active in those regions.

## E.3 Space Conditioning Systems

### Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on the following:

1. Proposed code changes;
2. Draft code language;
3. Draft assumptions and results of analyses;
4. Data to support assumptions;
5. Compliance and enforcement; and
6. Technical and market feasibility.

The Statewide CASE Team hosted one stakeholder meeting for CEH Space Conditioning via webinar and plans to hold a second stakeholder meeting following publication of the draft CASE report, as described in Table 141. This table displays dates and links to event pages on [Title24Stakeholders.com](https://www.title24stakeholders.com). Materials from each meeting, such as slide presentations (Torvestad, 2025), proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

**Table 141: Utility-Sponsored Stakeholder Meetings**

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Nonresidential Covered Processes, Lighting Utility-Sponsored Stakeholder Meeting <a href="https://title24stakeholders.com/wp-content/uploads/2025/10/Meeting-Notes-2028_T24_Utility-Sponsored-Stakeholder-Meeting-2-Sept-24-2025.pdf">https://title24stakeholders.com/wp-content/uploads/2025/10/Meeting-Notes-2028_T24_Utility-Sponsored-Stakeholder-Meeting-2-Sept-24-2025.pdf</a>	Wednesday September 24, 2025	<ul style="list-style-type: none"> <li>• Scope and justification for the proposed code change for daylight responsive controls in greenhouse</li> <li>• Market share for the measure</li> <li>• Estimated energy savings potential for the measure</li> <li>• Energy Savings Methodology</li> </ul>
Indoor CEH Prototype Workshop <a href="https://title24stakeholders.com/event/controlled-environment-horticulture-prototype-workshop/">https://title24stakeholders.com/event/controlled-environment-horticulture-prototype-workshop/</a>	Wednesday December 10, 2025	<ul style="list-style-type: none"> <li>• Assumptions in the indoor CEH prototype</li> <li>• Proposed user inputs vs. fixed assumptions</li> </ul>
Second Round of Utility-Sponsored Stakeholder Meeting	Thursday March 5, 2026	<ul style="list-style-type: none"> <li>• Measure updates based on stakeholder feedback</li> <li>• CEH prototype and savings methodology</li> <li>• Cost-effectiveness approach, assumptions, and results</li> <li>• Proposed compliance process (load/sizing calculations and prototype use)</li> </ul>

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 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings will be scheduled in early 2026 and will provide updated details on proposed code changes. These meetings will

introduce early results of energy, cost effectiveness, and incremental cost analyses, and they will also solicit feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from [info@title24stakeholders.com](mailto:info@title24stakeholders.com). One email was sent to the full Title 24 Stakeholders listserv, which includes over 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 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 of 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.

## **Statewide CASE Team Communications**

The Statewide CASE Team conducted direct outreach through email, videoconference, and phone conversations with a range of stakeholders representing manufacturers, research institutions, trade associations, and technical experts. These discussions informed the development of the proposed CEH Space Conditioning measure and provided valuable insights into product trends, control strategies, and implementation considerations.

The Statewide CASE Team has also presented the measure and solicited feedback at several ASHRAE SSPC 90.1 Mechanical Subcommittee Indoor Agriculture Working Group meetings.

Table 142 lists key organizations and individuals engaged during the proposal development process.

**Table 142: Engaged Stakeholders**

<b>Organization / Individual</b>	<b>Market Role</b>	<b>Referenced in CASE Report Sections</b>
<b>Anden / Randy Lenz</b>	Manufacturer, Standalone Dehumidifier	Staging of dehumidifiers
<b>DesertAire / Brian Kammers, Craig Burg, Chip Seidel</b>	Manufacturer, Integrated DX/DOAS	Incremental cost, Compliance and enforcement
<b>UCDavis/Shamim Ahamed</b>	Academic Researcher	Prototype assumptions
<b>InSpire/Adrian Giovenco</b>	Manufacturer/Designer, Integrated DX/DOAS	Integrated DX/DOAS equipment background
<b>Anvil Agrinomics / Jim Megerson</b>	Designer, Cannabis Space Conditioning Equipment	Incremental Cost
<b>Rhythm CSS / Cale Winters</b>	Manufacturer, CEH Controls	Integrated controls for HVAC and dehumidifiers
<b>Rupp Air / Rex Mustain</b>	Sales Representative, Cannabis Space Conditioning Equipment	Sizing and design approaches
<b>Agxano / Jim Doyle</b>	Manufacturer, CEH Controls	Integrated controls for HVAC and dehumidifiers
<b>University of Wyoming</b>	Academic Researcher, Modeling	Prototype assumptions
<b>Mojave / Zachary Jenkins</b>	Manufacturer, Liquid Desiccant Integrated system	Background
<b>Energy 350 / Meg Waltner, Justin Hovland</b>	Energy Policy	Background, Prototype feedback
<b>Matt Golden</b>	Efficiency Researcher	
<b>Resource Innovation Institute</b>	Industry Group	
<b>Harvest Integrated / Jesse Porter</b>	Cannabis Climate Control Service Provider	Incremental cost, prototype feedback
<b>Accelerated Growth Solutions / Conor Guckian</b>	Distributor/Designer, Cannabis Space Conditioning Equipment	Incremental cost, maintenance cost
<b>ERI/Gretchen Schimelpfenig, Eric Noller</b>	Programs	Prototype feedback
<b>Higher Yields Consulting</b>	Consultants	Incremental cost
<b>Cannabis Grower (anonymous)</b>	Grower	EULs, market share

The Statewide CASE Team will continue engaging additional stakeholders, including grower representatives, lighting control manufacturers, and equity focused organizations, as the proposal enters subsequent review and refinement. The Statewide CASE Team prepared a brief survey to collect cost data and insights on current daylight responsive control practices across crop types. The survey will be sent to stakeholders

the Statewide CASE Team has already spoken with and to additional stakeholders. Feedback from this outreach will help supplement and refine the Statewide CASE Team's savings estimates, crop specific assumptions, and cost data.

The Statewide CASE Team is also engaging with stakeholders to vet the prototype used for modeling used for energy savings estimates and recommended for inclusion in CBECC. The prototype assumptions were posted and a public meeting was held on December 10, 2025 to obtain feedback from the public.

### **Engagement with ESJ communities**

The Statewide CASE Team plans to reach out to organizations representing and serving ESJ communities, particularly those affected by lighting quality, safety, and affordability in indoor CEH facilities. Additional effort will be made to include underrepresented groups, such as agricultural worker housing organizations and smaller Central Valley municipalities. These stakeholders will be contacted through local energy partnership networks and program implementers active in those regions.