

Controlled Environment Horticulture



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Executive Summary

This proposal presents updates to controlled environment horticulture (CEH) requirements for consideration in the 2028 California Energy Code (Title 24, Part 6 or Energy Code). The Statewide Codes and Standards Enhancement (CASE) Team developed these measures to improve energy performance in greenhouse and indoor growing facilities while strengthening compliance and supporting California’s long-term energy efficiency and greenhouse gas (GHG) reduction goals. The measures focus on increasing horticultural lighting efficacy, reducing unnecessary greenhouse lighting through daylight-responsive controls, and improving space conditioning system sizing, controls, and equipment performance for indoor CEH spaces. Collectively, these measures address some of the largest energy end uses in CEH facilities and reflect commercially available technologies and practices that are increasingly common across the industry. Combined, the measures would deliver more than 90 GWh of annual electricity savings, significant peak demand reductions, and approximately \$600 million in Long-term System Cost (LSC) savings for buildings permitted during the first year the 2028 code is in effect.

The Statewide CASE Team developed these proposed measures for consideration by the California Energy Commission (CEC) as part of the 2028 Title 24, Part 6 update process. Consistent with California’s code development framework, each measure was evaluated for technical feasibility, cost effectiveness, and enforceability. All three measures exceed the cost-effectiveness threshold, with benefit-to-cost ratios¹ greater than 1.0 across all climate zones.

Development of the proposal included extensive stakeholder engagement with growers, equipment manufacturers, designers, contractors, technicians, utility incentive program managers, Title 24 energy analysts, and other participants in the code compliance process. The Statewide CASE Team held public stakeholder workshops on September 24, 2025, December 12, 2025, and March 5, 2026, and incorporated stakeholder feedback throughout measure development and analysis.

The Statewide CASE Team recognizes ongoing systemic inequities in environmental and social justice (ESJ) communities and considered opportunities to minimize unintended consequences while advancing statewide energy and climate goals.

¹ The benefit-to-cost ratio (BCR) compares benefits or cost savings to costs over the 30-year period of analysis. Proposed code changes with a BCR of 1.0 or greater are cost effective.

Horticultural Lighting Efficacy

Proposed Code Change

The proposed code change would increase the minimum required photosynthetic photon efficacy (PPE) for horticultural lighting used in controlled environment horticulture facilities from 2.3 $\mu\text{mol}/\text{J}$ to 2.5 $\mu\text{mol}/\text{J}$. The requirement would be based on luminaire photosynthetic photon efficacy, ensuring that performance reflects the optical and thermal characteristics of the complete lighting system. The proposal would apply to nonresidential greenhouse and indoor CEH facilities with an aggregate horticultural lighting load of 40 kW or greater and would apply to new construction, additions, and alterations. The proposal would also clarify existing dimmability requirements and revise the definition of PPE to improve consistency in interpretation and enforcement.

Benefits of Proposed Change

CEH is a rapidly growing and energy-intensive sector, with lighting representing the largest share of electrical load in many facilities. Increasing the minimum lighting efficacy from 2.3 $\mu\text{mol}/\text{J}$ to 2.5 $\mu\text{mol}/\text{J}$ would align code requirements with current market performance and widely available high-efficiency technologies. The measure would deliver energy savings with minimal incremental cost while supporting California's long-term energy efficiency, decarbonization, and grid reliability goals.

Compliance and Enforcement

The proposed measure modifies an existing mandatory requirement by increasing the minimum efficacy threshold and clarifying the definition of PPE. As a result, compliance processes remain largely unchanged. Designers must specify compliant luminaires, and enforcement agencies would continue to verify compliance through existing forms, including NRCC-PRC-E (Nonresidential Certificate of Compliance – Process Systems) and NRCI-PRC-E (Nonresidential Certificate of Installation – Process Systems). The proposal does not introduce new acceptance testing or third-party verification requirements, and compliance can be demonstrated using manufacturer-reported performance data based on established test procedures (ANSI/ASABE S640).

Market Assessment

The market for horticultural lighting has largely transitioned to LED technology, with a substantial portion of available products already meeting or exceeding the proposed 2.5 $\mu\text{mol}/\text{J}$ threshold. Major manufacturers offer a wide range of compliant luminaires, and hundreds of products are listed on the DesignLights Consortium Qualified Products List. Manufacturers and other stakeholders confirmed that the proposed efficacy level is

technically feasible and consistent with current industry practice, and economic impacts are expected to be minimal.

Cost Effectiveness

The proposed code change is cost effective across all applicable California climate zones. Benefit-to-cost ratios range from 11 to 130, depending on climate zone, prototypical crop type, and prototypical building type. For some crop types, particularly leafy greens, the market baseline already meets or exceeds the proposed requirement, resulting in zero incremental cost and non-applicable benefit-to-cost ratios in those cases.

First-Year Statewide Impacts

Table 1: Summary of Statewide Impacts — Horticultural Lighting Efficacy

Metric	Total Statewide Impacts ^a
Annual Electricity Savings (GWh)	5.08
Peak Demand Reduction (MW)	0.45
Annual Natural Gas Savings (Million Therms)	N/A
Annual Source Energy Savings (Million kBtu)	5.82
30-Year Long-term System Cost Savings (Million 2029 PV\$)	\$37.42
Annual Avoided GHG (Metric Tons CO ₂ e/yr)	308

a. Values represent impacts from buildings permitted during the first year the code is in effect. Positive values indicate savings or reductions.

Greenhouse Daylight Responsive Controls

Proposed Code Change

The proposed code change would introduce a new mandatory requirement for daylight-responsive lighting controls in greenhouses with supplemental horticultural lighting. The requirement would apply to nonresidential greenhouse CEH facilities with more than 40 kW of connected lighting load and would apply to new construction, additions, and alterations. Greenhouse lighting systems would be required to automatically adjust lighting output based on available daylight using either (1) timeclock scheduling combined with photosynthetically active radiation (PAR) sensor-based dimming controls or (2) daily light integral (DLI)-based controls. The proposal would also clarify existing lighting control requirements for indoor growing spaces.

Benefits of Proposed Change

The proposed measure addresses a common source of energy waste in greenhouse operations: operating supplemental lighting without adjusting output based on available daylight. By requiring lighting systems to respond to available daylight, the measure eliminates unnecessary energy use while maintaining the light levels needed to support plant growth. The measure is expected to deliver substantial and persistent savings, including reduced greenhouse lighting energy use, peak demand reduction, and avoided GHG emissions.

Compliance and Enforcement

The proposed measure would fit within the existing Title 24 compliance framework while minimizing additional burden on designers, consultants, installers, and facility operators. Designers and energy consultants would document compliance with standard Title 24 forms, with additional fields for lighting control systems and a new acceptance test form to verify functionality. The installing field technician would perform acceptance testing. This approach would minimize compliance costs and administrative complexity while ensuring that controls are properly installed and functional.

Market Assessment

Daylight-responsive lighting controls, including PAR sensor-based systems and DLI control platforms, are widely available from multiple manufacturers and are already in use in portions of the CEH market. Major control system providers offer integrated solutions that combine lighting, environmental controls, and automation. Market adoption is growing but remains uneven, with larger and newer greenhouse facilities more likely to use advanced controls than smaller or retrofit facilities. Analysis indicates that economic impacts would be modest.

Cost Effectiveness

The measure is cost effective across all applicable California climate zones. When evaluated against the existing code baseline, benefit-to-cost ratios range from 50 to 146, depending on climate zone and prototypical crop type. The strong benefit-to-cost ratios reflect the relatively low cost of controls compared with the substantial energy savings achieved by reducing unnecessary lighting operation throughout the day.

First-Year Statewide Impacts

Table 2: Summary of Statewide Impacts — Greenhouse Daylight Responsive Controls

Metric	Total Statewide Impacts ^a
Annual Electricity Savings (GWh)	57.69
Peak Demand Reduction (MW)	2.83
Annual Natural Gas Savings (Million Therms)	N/A
Annual Source Energy Savings (Million kBtu)	21.26
30-Year Long-term System Cost Savings (Million 2029 PV\$)	\$353.43
Annual Avoided GHG (Metric Tons CO ₂ e/yr)	1,125

a. Values represent impacts from buildings permitted during the first year the code is in effect. Positive values indicate savings or reductions.

Indoor CEH Space Conditioning Systems

Proposed Code Change

This proposal would establish mandatory requirements for space conditioning systems serving indoor controlled environment horticulture spaces. The requirements would address system sizing, equipment performance, and integrated control functionality for systems providing cooling, heating, and dehumidification to support plant growth. The new space conditioning requirements apply primarily to larger high-intensity indoor growing spaces. The proposal would introduce new definitions, revise and clarify applicability of existing HVAC and other nonresidential provisions, and add new requirements within the CEH section of Title 24, Part 6. The proposal would also establish a new compliance framework for commercial dehumidifiers, including qualification, testing, and certification requirements through a new reference appendix. In addition, it would update and clarify ventilation requirements for CO₂-enriched indoor growing spaces while aligning energy-code ventilation provisions with existing fire-code safety requirements.

Benefits of Proposed Change

Indoor CEH facilities are among the most energy-intensive building types in California, with space conditioning systems accounting for a substantial portion of total energy use. Current code language does not comprehensively address the performance of HVAC and dehumidification systems in these spaces. This proposal would address that gap by establishing enforceable requirements for system sizing, controls, and equipment performance tailored to CEH applications. The proposed requirements are expected to

reduce HVAC and dehumidification energy use in affected spaces and improve environmental control and operational efficiency.

Compliance and Enforcement

The proposal would establish clear requirements for design documentation, system sizing, equipment rating, and field verification to support consistent enforcement. Compliance would require documentation of system sizing calculations, equipment specifications, and control sequences demonstrating the ability to meet both sensible and latent loads across the grow cycle. A new reference appendix would provide a standardized methodology for verifying load calculations and system sizing to improve consistency in design and plan review. Installing field technicians would verify compliance through acceptance testing. The proposal does not introduce third-party verification requirements.

Market Assessment

The market for CEH space conditioning systems includes multiple manufacturers offering compliant technologies, including integrated HVAC/dehumidification systems, commercial dehumidifiers, and advanced environmental control systems. Equipment capable of meeting the proposed requirements is commercially available, including integrated direct expansion systems, chilled water systems with heat recovery, and coordinated systems using commercial HVAC and dehumidification equipment with centralized controls. Although advanced systems are commercially available, adoption remains limited across much of the indoor cultivation industry. Analysis indicates that economic impacts would be modest and concentrated in existing job categories.

Cost Effectiveness

The proposal is cost effective across all applicable California climate zones. Benefit-to-cost ratios range from 62 to 71, depending on climate zone. The measure achieves strong cost effectiveness by combining significant energy savings with relatively low incremental first costs and reduced maintenance and replacement costs over time.

First-Year Statewide Impacts

Table 3: Summary of Statewide Impacts — Indoor CEH Space Conditioning Systems

Metric	Total Statewide Impacts ^a
Annual Electricity Savings (GWh)	30.2
Peak Demand Reduction (MW)	1.8
Annual Natural Gas Savings (Million Therms)	N/A
Annual Source Energy Savings (Million kBtu)	26.4
30-Year Long-term System Cost Savings (Million 2029 PV\$)	\$211.43
Annual Avoided GHG (Metric Tons CO ₂ e/yr)	1,395

- a. Values represent impacts from buildings permitted during the first year the code is in effect. Positive values indicate savings or reductions.

Acronyms

Table 4 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a [glossary of terms](#).

Table 4: List of Acronyms

Acronym	Definition
AC	Air Conditioning
ACM	Alternative Calculation Method
AESAP	Agriculture Energy Savings Action Plan
AHJ	Authorities Having Jurisdiction
AHRI	Air Conditioning, Heating, and Refrigeration Institute
ASABE	American Society of Agricultural and Biological Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
BCR	Benefit-Cost Ratio
Btu	British Thermal Units
Btu/h	British Thermal Units per hour
Btuh/sqft	British Thermal Units per Hour per square foot
CaIBEM	California Building Energy Modeling
CALGreen	California Green Building Standards Code
CaINEXT	California's Statewide Electric Emerging Technologies Program
Cal/OSHA	California Division of Occupational Safety and Health
CASE	Codes and Standards Enhancement
CAV	Constant Air Volume
CBECC	California Building Energy Code Compliance Software
CBO	Community-Based Organization
CEC	California Energy Commission
CEDARS	California Energy Data and Reporting System
CEH	Controlled Environment Horticulture
CEQA	California Environmental Quality Act
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CIEF	Commercial Integrated Energy Factor
CMR	Code of Massachusetts Regulations
CO₂	Carbon Dioxide
CO₂e	Carbon Dioxide Equivalent

Acronym	Definition
COP	Coefficient of Performance
CPUC	California Public Utilities Commission
CZ	Climate Zone
DAC	Disadvantaged Community
DCC	Department of Cannabis Control
DEER	Database for Energy Efficient Resources
DHI	Diffuse Horizontal Irradiance
DLC	DesignLights Consortium
DLI	Daily Light Integral
DOAS	Dedicated Outdoor Air System
DOE	Department of Energy
DOSH	Division of Occupational Safety and Health
DX	Direct Expansion
ECC	Energy Code Compliance
EER	Energy Efficiency Ratio
EPA	Environmental Protection Agency
ESJ	Environmental and Social Justice
EUI	Energy Use Intensity
EUL	Estimated Useful Life
F	Fahrenheit
ft²	Square Feet
GHG	Greenhouse Gas
GWh	Gigawatt-Hours
GHI	Global Horizontal Irradiance
HID	High Intensity Discharge
HP	Heat Pump
HPS	High Pressure Sodium
HVAC	Heating, Ventilation, and Air Conditioning
HVAC/D	Heating, Ventilation, Air Conditioning, and Dehumidification
IEER	Integrated Energy Efficiency Ratio
IOU	Investor-Owned Utility
IPLV	Integrated Part Load Value
ISMRE	Integrated Seasonal Moisture Removal Efficiency
IVEC	Integrated Ventilation, Economizer, and Cooling
IVHE	Integrated Ventilation and Heating Efficiency
JA	Joint Appendix

Acronym	Definition
kBtu	Thousand British Thermal Units
kW	Kilowatts
kW/ft²	Kilowatts Per Square Foot
kWh	Kilowatt-Hours
kWh/yr	Kilowatt-Hours Per Year
LED	Light-Emitting Diode
LPD	Lighting Power Density
LSC	Long-term System Cost
MRE	Moisture Removal Efficiency
MW	Megawatts
NA	Nonresidential Appendix
nm	Nanometers
NPDI	Net Private Domestic Investment
NRCA	Nonresidential Certificates of Acceptance
NRCC	Nonresidential Certificate of Compliance
NRCI	Nonresidential Certificate of Installation
NRCS	Natural Resources Conservation Service
PAR	Photosynthetically Active Radiation
PG&E	Pacific Gas and Electric
PPE	Photosynthetic Photon Efficacy
PPFD	Photosynthetic Photon Flux Density
ppm	Parts per Million
PV	Present Value
QPL	Qualified Products List
RH	Relative Humidity
RTU	Rooftop Unit
SEER	Seasonal Energy Efficiency Ratio
SHR	Sensible Heat Ratio
SME	Subject Matter Expert
SSPC	Standing Standards Project Committee
TMY	Typical Meteorological Year
UL	Underwriters Laboratories
UMLH	Unmet Load Hours
USDA	United States Department of Agriculture
VAV	Variable Air Volume
VPD	Vapor Pressure Deficit

Acronym	Definition
VRF	Variable Refrigerant Flow
W	Watts
W/ft ²	Watts Per Square Foot
W/m ²	Watts Per Square Meter
μmol/J	Micromoles Per Joule
μmol/m ² /s	Micromoles Per Square Meter Per Second

1. Introduction

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 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 jointly sponsored this effort. Where the term “Statewide CASE Team” is used in this report, it refers to the authors and State Building Codes Advocacy activities supported through the Codes and Standards program.

1.3 Stakeholder Engagement to Inform Proposal

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, 2025,² December 12, 2025,³ and March 5, 2026.⁴

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

1.4 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in environmental and social justice (ESJ) communities.⁵ These issues persist today. To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences on ESJ communities.

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

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

² <https://title24stakeholders.com/event/nonresidential-covered-processes-lighting-utility-sponsored-stakeholder-meeting/>

³ <https://title24stakeholders.com/event/controlled-environment-horticulture-prototype-workshop/>

⁴ <https://title24stakeholders.com/event/controlled-environment-horticulture-and-solar-pool-heating-utility-sponsored-stakeholder-meeting/>

⁵ 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).

2. Horticultural Lighting Efficacy

2.1 Horticultural 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), ensuring fair comparison for all products. The rating of all products will account for the optical efficiency of the luminaire and the thermal impacts of its 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 also includes 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 Subchapter 9 [Section 120.6] (Process Systems and Equipment) of Title 24, Part 6.

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 908.1.5.3 [Section 120.6(h)5C], which requires luminaires to adhere to the multilevel lighting controls requirements in Section 601.2.2.2 [Section 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 5 summarizes the scope and applicability of the proposed change.

Table 5: 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	Part 6, Section 201 Part 6, Section 908.1	NRCC-PRC-E NRCI-PRC-E	N/A

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 6.6 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 industry performance criteria (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/ft²/yr for indoor cannabis (Mills, 2012; New Frontier Data, 2018; Sabeh, Miner, & Perman, 2022), about 700 kBtu/ft²/yr for vertical farms (Resource Innovation Institute, 2023) to about 400-450 kBtu/ft²/yr for greenhouse cannabis (New Frontier Data, 2018; Sabeh, Miner, & Perman, 2022) and about 250 kBtu/ft²/yr for other greenhouse crops (Resource Innovation Institute, 2023). For comparison, California office building energy use intensity is about 50 kBtu/ft²/yr (California Energy Commission, 2024) and California data center energy use intensity ranges from 340 kBtu/ft²/yr (25th percentile) to 1127 kBtu/ft²/yr (75th 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 percent of full power. Section 3 of this report describes a code change proposal for dimming controls, which leverages 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 201 – 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 908.1.5 by having a single luminaire PPE requirement rather than separate requirements for integrated luminaires and for luminaires with removable lamps.

SUBCHAPTER 9 PROCESS SYSTEMS AND EQUIPMENT

Subsection 908.1.5 [Section 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.

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/ft²) 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 $\mu\text{mol}/\text{J}$ (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/ft² (and up to 50 W/ft² 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 Horticultural 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 stay 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 must understand that the luminaire's Photosynthetic Photon Flux must be tested in accordance with ASABE 640 with the lamps installed, and that 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 908.1.5 [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.

Construction Team. Installation contractors on the construction team 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 Section 908.1.5 [Section 120.6(h)5].

2.2.2 Impact on Market Actors

Table 6 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 6: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/Developer ^a	May experience modestly higher upfront fixture costs, offset by reduced energy bills.	Update Energy Code Ace Fact Sheet on Controlled Environment Horticulture and similar resources offered by other programs. Additional targeted outreach likely unnecessary.

Market Actor	Impact(s)	Suggested Outreach and Education
Design Professionals^b	Need to specify horticultural luminaires that meet the updated luminaire PPE requirement.	Marginal impact on needed ongoing training to stay current with changes to code. Update resources such as the Energy Code Ace Fact Sheet on Controlled Environment Horticulture.
Construction Team^c	Need to install horticultural luminaires consistent with approved plans and compliance documentation. No change to installation practice is anticipated.	Marginal impact on needed ongoing training to stay current with Energy Code updates.
Building Departments^d	Plan checkers and inspectors currently verify compliance with CEH horticultural lighting efficacy requirements. This proposal would update the required efficacy value and clarify that compliance is based on luminaire PPE.	Additional outreach and education may be helpful to ensure building departments are aware of CEH requirements, particularly smaller AHJs and AHJs with a higher concentration of CEH facilities.
Manufacturers and Distributors	Need to be aware of the updated luminaire PPE threshold. Sales of luminaires meeting or exceeding 2.5 µmol/J may increase, while sales of lower-efficacy products for covered California projects may decrease.	Include the updated PPE threshold in outreach related to Title 24 and Title 20 regulatory updates.

- a. Owner/Developer is funding the project and is the primary decision-maker.
- b. Design professionals include architects, 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 third-party plan review and inspection.

The [2028 CASE Methodology Report](#) presents a quantitative assessment of how changes to the California building code impact builders, design professionals, energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on owner/developer, design professionals, construction team, building departments, manufacturers, and distributors, since these market actors are expected to experience the most direct impacts from changes in horticultural lighting

efficacy requirements. 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.

Construction Team. The proposed change would likely affect commercial builders involved in the construction or alteration of CEH facilities. The construction team would need to ensure that installed horticultural luminaires meet the updated luminaire PPE requirement. Because the proposal updates an existing mandatory requirement and does not change installation methods, construction sequencing, or compliance documentation processes, impacts on builders are expected to be minimal. 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.

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

Table 7 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 7: 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 \$)
Nonresidential Electrical Contractors	3,245	72,794	\$7.8
Other Nonresidential Equipment Contractors	580	9,749	\$1.1
All Other Nonresidential Trade Contractors	948	17,084	\$1.7

Source: (State of California, n.d.)

*An establishment is a single economic unit, typically at one physical location, which 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 and Distributors. Major manufacturers already offer horticultural luminaires that meet or exceed the proposed 2.5 μmol/J PPE requirement. The proposed standard is therefore not expected to create compliance challenges or supply constraints. Instead, it is expected to reinforce ongoing market trends toward higher-efficacy horticultural lighting by shifting produce selection toward luminaries that meet or exceed the updated threshold.

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.

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.

The 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, and 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 turnover 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.

Plan review function would consist of reviewing the NRCC-PRC-E form and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing the NRCI-PRC-E form and ensuring that the information on the forms is consistent with the approved NRCC-PRC-E forms and with what is actually installed.

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 percent of the luminaires are dimmable from 10 percent to 100 percent 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.

To directly evaluate this concern, the Statewide CASE Team analyzed the spectra of the 2,286 luminaires listed in Version 4 of the DesignLights Consortium (DLC) horticultural lighting database from December 2025 that reported both PPE and spectral flux. Table 8 groups luminaires into PPE bins and reports the average percentage contribution of four light categories: blue (400-500nm), green (500-600nm), red (600-700nm), and far red (700-800 nm).

Across PPE bins below 2.7 $\mu\text{mol}/\text{J}$, spectral composition remains relatively consistent. Red light represents approximately 43% of the photon flux, green light contributes approximately 36-38%, blue light contributes approximately 17%, and far-red light contributes 3-4%. More substantial shifts toward red-dominant spectra do not appear until PPE exceeds 2.9 $\mu\text{mol}/\text{J}$, where the contributions from green and blue wavelengths decline more noticeably. These results indicate that fixtures in the 2.5-2.7 $\mu\text{mol}/\text{J}$ range generally maintain spectral characteristics similar to fixtures in the 2.3-2.5 $\mu\text{mol}/\text{J}$ range, directly addressing the consultant concern that balanced-spectrum products may be unavailable efficacies above the proposed threshold.

Table 8: Average Spectral Composition by PPE Bin Showing the Percentage Contribution from Blue, Green, Red, and Far-red Light Across Six PPE Ranges

PPE Bin	n	Average % of photon flux in blue band (400-500nm)	Average % of photon flux in green band (500-600nm)	Average % of photon flux in red band (600-700nm)	Average % of photon flux in far red band (700-800nm)
<2.3	86	17.4%	35.5%	43.2%	3.9%
2.3 - <2.5	381	16.5%	38.2%	42.5%	2.8%
2.5 - <2.7	544	17.2%	36.2%	43.7%	2.9%
2.7 - <2.9	515	16.9%	33.4%	46.6%	3.1%
2.9 - <3.1	333	14.8%	23.9%	58.2%	3.1%
≥ 3.1	427	8.5%	9.0%	80.6%	1.9%

The Statewide CASE Team also evaluated whether certain spectral distributions available below 2.5 $\mu\text{mol}/\text{J}$ were unavailable above the proposed threshold. The analysis normalized each luminaire’s blue, green, red, and far-red photon flux into percentage shares, and grouped fixtures into rounded spectrum “signatures” to identify spectra unique to specific PPE ranges. Results showed that the most-difficult-to-

substitute spectra below 2.5 $\mu\text{mol}/\text{J}$ were disproportionately blue-heavy, with 5 of 30 below-only signatures containing more than 30% blue photon flux.

Because blue-heavy spectra appeared to represent the primary area of potential constraint, the Statewide CASE Team further analyzed the availability of fixtures with elevated blue-light content across PPE bins, looking at different thresholds (>30%, >35%, >40%, and >45% blue). The results, shown in Table 9, indicate that high blue spectra are available at PPEs from 2.5 to 2.9 at a similar rate as they are at PPEs from 2.3 to 2.5.

Table 9: Counts of Valid Spectra by PPE Bin Exceeding Blue-share Thresholds From >30% to >45%

PPE Bin	n	Number of fixtures with blue >30% of photon flux	Number of fixtures with blue >35% of photon flux	Number of fixtures with blue >40% of photon flux	Number of fixtures with blue >45% of photon flux
<2.3	86	4	1	0	0
2.3–<2.5	381	5	0	0	0
2.5–<2.7	544	3	1	1	1
2.7–<2.9	515	7	1	1	1
2.9–<3.1	333	3	0	0	0
≥ 3.1	427	0	0	0	0
Total	2,286	22	3	2	2

Fixtures with higher red-light ratios are cost-effective and contribute to increased PPE, but may reduce full-spectrum output, potentially impacting crop quality. The Statewide CASE Team solicited feedback on this issue during stakeholder meetings and conducted follow-up outreach with respondents. Feedback indicated that limitations in achieving desired spectral characteristics at or above 2.5 $\mu\text{mol}/\text{J}$ are infrequent and generally occur only at higher efficacy levels beyond the proposed threshold.

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 percent 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 6 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

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

The Statewide CASE Team determined that this measure is unlikely to have significant impact on ESJ Communities. Minor impacts identified to date include the following:

- **Cost and Affordability:** Market assessment findings indicate that the incremental cost between the proposed and baseline technologies is small.
- **Health and Safety and Comfort:** Improved lighting efficacy standards may reduce waste heat, providing a slight improvement in worker health, safety, and comfort.
- **Resilience:** More efficient lighting can reduce total load but is not expected to have a significant impact on ESJ Communities.

2.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders. Because this measure only requires selection of LED fixtures with higher efficacy than those previously required, no impacts are anticipated for designers, energy consultants, or building inspectors. Table 10 outlines the statewide implications for commercial builders. For more information on the Statewide CASE Team's economic impacts methodology, see the [2028 CASE Methodology Report](#).

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

Because both the baseline and proposed case are LED fixtures, there are not changes in installation or maintenance with this proposed code change.

Table 10: Estimated Impact that Adoption of the Proposed Measure Would Have on the California Nonresidential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	1.7	\$0.134	\$0.202	\$0.436
Indirect Effect (Additional spending by firms supporting Commercial Builders)	1.0	\$0.077	\$0.133	\$0.233
Total Economic Impacts	2.7	\$0211	\$0.335	\$0.669

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.⁶

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

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

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team’s IMPLAN modeling resulted in an estimated \$46,059 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.⁸

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm’s capital stock (referred to

⁶ IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

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

⁸ 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 11.

as net private domestic investment, or NPDI).⁹ As Table 11 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

Table 11: Net Domestic Private Investment and Corporate Profits, U.S.

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a \$10,812 increase in net private investment by California businesses.

2.3.5 Economic and Fiscal Impacts

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

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

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

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

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

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals. Public universities in the UC/CSU system operate greenhouses for teaching and research, some of which include controlled lighting experiments or supplemental lighting setups. All greenhouses with at least 40kW connected lighting are subject to the requirements of this measure, and will impose slightly higher upfront costs, resulting in energy savings over time, as the proposed changes have been found to be cost-effective.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 2.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

2.3.5.2 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because local agencies and schools do not typically operate controlled environment horticulture facilities.

2.3.5.3 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts because local agencies and schools do not typically operate controlled environment horticulture facilities.

2.3.5.4 Costs or Savings to Any State Agency

Public universities in the UC/CSU system operate greenhouses for teaching and research, some of which include controlled lighting experiments or supplemental lighting setups. All greenhouses with at least 40kW connected lighting are subject to the requirements of this measure, and will impose slightly higher upfront costs, resulting in energy savings over time.

2.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies because local agencies and schools do not typically operate controlled environment horticulture facilities.

2.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state because federal funding to California for agriculture is not driven by specific Title 24 thresholds like horticultural lighting efficacy.

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. Because both the baseline and proposed case are LEDs, there is no incremental design cost, and because there is no acceptance testing requirement, there are no 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 modeling of CEH-specific space types, lighting systems, crop production schedules, or greenhouse operating characteristics 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 12 summarizes the prototype buildings used to evaluate energy, demand, cost, and environmental impacts.

Table 12: 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 (representing microgreens and herbs)
Indoor (Warehouse)	Tomatoes (representing vine crops and flowering crops)
Greenhouse	Cannabis (65% flowering, 33% vegetative, 2% clone breakdown by canopy area)
Greenhouse	Leafy greens (representing microgreens and herbs)
Greenhouse	Tomatoes (representing vine crops and flowering crops)

For each crop and prototype type, the analysis calculated lighting energy use based on canopy area per luminaire, photoperiod, required photosynthetic photon flux density (PPFD), and PPE, using either baseline or proposed PPE values. Baseline PPE values reflect the minimum efficiency required by the 2025 Energy Code, consistent with Title 24 CASE methodology, while proposed PPE values reflect the proposed 2028 Energy

Code updates presented in this report. Because crop lighting requirements, mounting heights, photoperiods, and operating schedules are held constant between the baseline and proposed cases, increases in PPE directly reduce lighting power density and associated energy use. Annual lighting energy savings are calculated by multiplying the difference between baseline and proposed lighting power density by the applicable lighting operating hours and annual operating days. Additional details are provided in Appendix A.

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.

1. For indoor CEH facilities, operating hours are based on the crop photoperiod, and reduced lighting heat output from more efficient LEDs is modeled as a reduction in cooling load.
2. For greenhouse facilities, supplemental lighting hours vary by climate zone and season based on available daylight, greenhouse light transmittance, crop daily light integral requirements, and photoperiod. Greenhouse simulations assume venting as the primary cooling mechanism, so HVAC interactive effects were excluded.

Greenhouse-specific modeling assumptions are further described below. Interactive effects in greenhouses were excluded because greenhouse thermal and moisture interactions vary substantially with facility design and operation and could not be consistently represented in a prototype-level model. Crop type, irrigation strategy, humidity control approach, ventilation operation, shade/thermal curtain use, and other crop production practices all impact this parameter. For example, changes in lighting heat gain could affect transpiration, latent load, and dehumidification needs, but these effects are highly site-specific and were not quantified in the prototype-level energy model. Excluding these effects is expected to be conservative, as reductions in lighting heat gain would generally reduce cooling and ventilation loads.

This analysis uses the assumptions from the 2025 CEH CASE Report unless otherwise noted (Energy Solutions, 2023). Table 13 highlights key assumptions for indoor growing and Table 14 summarizes key assumptions for greenhouse growing. The assumptions were confirmed via 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 13: Indoor CEH Lighting Assumptions

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens/ Microgreens /Herbs	Tomatoes/ Vine/ Flowering
Canopy Area per Luminaire (ft ²)	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μmol/m ² /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

Table 14: Greenhouse CEH Lighting Assumptions

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens/ Microgreens/Herbs	Tomatoes/ Vine/ Flowering
Canopy Area per Luminaire (ft ²)	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μmol/m ² /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

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 PPFD throughout growth cycles, such as during vegetative and flowering stages for cannabis or production stages for leafy greens such as lettuce. However, the current energy model assumes static PPFD levels. As discussed in Section 4.4.2, in CEH building energy models, the Statewide CASE Team performed sensitivity analysis for the use of a dimming schedule and found little impact on overall energy consumption when comparing a constant 1000 μmol/m²/s PPFD schedule to a cannabis grow-cycle dimming schedule with a peak PPFD of 1200 μmol/m²/s.

Energy savings and peak demand reductions per unit are presented in Table 15 through Table 18. First-year per-unit electricity savings are expected to range from 0.23 to 16.26

kilowatt-hours per year (kWh/yr) per canopy square foot (ft²), depending on climate zone, facility type, and crop type, and no natural gas savings are expected. Demand reductions are expected to range between 0.00005 kW and 0.001 kW/ft², depending on climate zone, facility type, and crop type. The per-unit energy savings do not vary between new construction and additions/alterations because the measure affects equipment performance rather than building geometry or system configuration. This proposal has no natural gas savings.

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 15: First Year Electricity Savings (kWh) Per Canopy Square Foot by Climate Zone (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	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
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	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
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	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
Greenhouse Cannabis	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
Greenhouse Leafy Greens/ Microgreens/ Herbs	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
Greenhouse Tomatoes/ Vine/ Flowering	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 16: 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/ Microgreens/ Herbs	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/ Vine/ Flowering	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/ Microgreens/ Herbs	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/ Vine/ Flowering	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 17: 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
Indoor (Warehouse) Cannabis	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
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	6.69	6.72	6.75	6.76	6.74	6.82	6.84	6.83	6.83	6.84	6.79	6.77	6.83	6.78	6.94	6.68
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	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
Greenhouse Cannabis	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
Greenhouse Leafy Greens/ Microgreens/ Herbs	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
Greenhouse Tomatoes/ Vine/ Flowering	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 18: Total 30-Year LSC Savings (2029 Present Value \$) 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	\$1111.50	\$1111.77	\$1111.58	\$1111.74	\$1112.24	\$1112.38	\$1111.36	\$110.68	\$113.55	\$111.29	\$111.34	\$112.57	\$111.89	\$109.09	\$116.09	\$108.64
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	\$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
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	\$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
Greenhouse Cannabis	\$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
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$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
Greenhouse Tomatoes/ Vine/ Flowering	\$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 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.

Incremental first costs were 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. Assumptions of equipment first costs and incremental costs per square foot of canopy are presented in Table 19.

Table 19: Equipment First Cost Per Canopy Square Foot– Lighting Efficacy

Building Type	Crop Type	Proposed Case Equipment First Cost (Dollar per Canopy Square Foot)	Incremental Equipment First Cost (Dollar per Canopy Square Foot)
Indoor (Warehouse)	Cannabis	\$38.70	\$1.23
	Leafy Greens/ Microgreens/ Herbs	\$11.27	\$0.00
	Tomatoes/ Vine/ Flowering	\$14.72	\$0.47
Greenhouse	Cannabis	\$21.96	\$0.70
	Leafy Greens/ Microgreens/ Herbs	\$11.27	\$0.00
	Tomatoes/ Vine/ Flowering	\$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 account for periodic downtime associated with crop turnover, sanitation and cleaning between production cycles, and maintenance of environmental and mechanical systems. This assumption is based on input from Statewide CASE Team subject matter

experts and reflects typical in CEH facilities. The use life by crop type area shown in Table 20.

Table 20: Estimated Useful Life by Crop Type

Parameter	Cannabis – Flower	Cannabis – Vegetative	Cannabis – Clone	Leafy Greens	Tomatoes
Photoperiod (hours/day)	12	18	24	18	12
Annual Operating Hours	4,161	6,242	8,322	6,242	4,161
EUL (years) Baseline	Indoor = 12 Greenhouse = 11	Indoor = 12 Greenhouse = 11	Indoor = 12 Greenhouse = 11	8	13
EUL (years) Proposed Case	Indoor = 12 Greenhouse = 12	Indoor = 12 Greenhouse = 12	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 20 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 residual value of the LED horticulture fixture is zero at the end of the 30-year analysis period.

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 were 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 proposed case (PPE \geq 2.5). Based on these lifetimes, the resulting EULs are 12 years for cannabis; eight years (baseline) and nine years (proposed) for leafy greens; and 13 years (baseline) and 14 years (proposed) for tomatoes.

As an example, indoor cannabis has a 12-year EUL. Over the 30-year analysis period, this results in two replacements in years 12 and 24. Therefore, in addition to the initial incremental cost of \$1.23/canopy square foot, and additional discounted incremental costs of \$1.23/canopy square foot $\times (1/1.03)^{12}$ for the 12th year replacement and \$1.23/canopy square foot $\times (1/1.03)^{24}$ for the 24th year replacement resulting in a total net present value incremental cost of \$2.70 per canopy square foot.

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. These are described as “Not Applicable.”

Results of the per-unit cost-effectiveness analyses are presented in Table 21 and Table 22 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 21: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – 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	\$111.05	\$2.70	41
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	\$40.64	\$0.00	Not Applicable
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	\$38.69	\$0.31	124
Greenhouse Cannabis	\$17.38	\$0.44	39
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$3.36	\$0.00	Not Applicable
Greenhouse Tomatoes/ Vine/ Flowering	\$4.71	\$0.31	15

Table 22: 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	\$111.66	\$2.70	41
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	\$40.29	\$0.00	Not Applicable
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	\$39.01	\$0.31	125
Greenhouse Cannabis	\$18.78	\$0.44	43
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$4.11	\$0.00	Not Applicable
Greenhouse Tomatoes/ Vine/ Flowering	\$5.53	\$0.31	18

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

Table 24: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) and Greenhouse – Cannabis, Leafy Greens, and Tomatoes presents statewide energy and LSC savings for new construction by climate zone, with values summed across all prototypes. Table 25 presents statewide energy and LSC savings for alterations by prototype with values summed across all climate zones. Table 26 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 value dollars) are segmented by climate zone. Total first year savings are shown in Table 27 by new construction vs. alterations and in Table 28 by prototype.

Table 23: Statewide Energy and LSC Impacts – New Construction and Additions – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.037	0.59	44.94	N/A	0.54	\$4.16
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	0.002	0.01	0.98	N/A	0.014	\$0.08
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	0.001	0.01	0.50	N/A	0.006	\$0.05
Greenhouse Cannabis	0.037	0.08	11.13	N/A	0.15	\$0.64
Greenhouse Leafy Greens/ Microgreens/ Herbs	0.037	0.01	2.25	N/A	0.04	\$0.12
Greenhouse Tomatoes/ Vine/ Flowering	0.049	0.03	3.83	N/A	0.06	\$0.23
Total	0.164	0.73	63.62	N/A	0.82	\$5.29

Table 24: 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 2029 (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	0.00004	0.0002	0.02	N/A	0.0002	\$0.00
2	0.00421	0.0200	1.74	N/A	0.0230	\$0.15
3	0.01031	0.0482	4.14	N/A	0.0557	\$0.36
4	0.00323	0.0144	1.28	N/A	0.0164	\$0.11
5	0.00555	0.0245	2.15	N/A	0.0276	\$0.18
6	0.00056	0.0025	0.22	N/A	0.0028	\$0.02
7	0.00597	0.0261	2.27	N/A	0.0290	\$0.19
8	0.00049	0.0021	0.19	N/A	0.0024	\$0.02
9	0.00049	0.0021	0.19	N/A	0.0024	\$0.02
10	0.08922	0.3917	34.14	N/A	0.4406	\$2.83
11	0.00038	0.0018	0.16	N/A	0.0021	\$0.01
12	0.00459	0.0216	1.88	N/A	0.0247	\$0.16
13	0.00184	0.0084	0.76	N/A	0.0098	\$0.06
14	0.02933	0.1267	11.21	N/A	0.1418	\$0.90
15	0.00361	0.0159	1.38	N/A	0.0176	\$0.12
16	0.00457	0.0216	1.90	N/A	0.0243	\$0.16
Total	0.16438	0.7279	63.62	N/A	0.8202	\$5.29

Table 25: Statewide Energy and LSC Impacts – Alterations – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.219	3.45	261.67	N/A	3.17	\$24.40
Indoor (Warehouse) Leafy Greens/ Microgreens/ Herbs	0.018	0.09	8.53	N/A	0.12	\$0.72
Indoor (Warehouse) Tomatoes/ Vine/ Flowering	0.006	0.03	2.49	N/A	0.03	\$0.24
Greenhouse Cannabis	0.216	0.49	68.00	N/A	0.93	\$4.06
Greenhouse Leafy Greens/ Microgreens/ Herbs	0.325	0.14	23.20	N/A	0.41	\$1.33
Greenhouse Tomatoes/ Vine/ Flowering	0.247	0.16	21.73	N/A	0.34	\$1.37
Total	1.031	4.35	385.63	N/A	5.00	\$32.12

Table 26: 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 2029 (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	0.013	0.06	5.42	N/A	0.08	\$0.47
2	0.011	0.05	4.59	N/A	0.06	\$0.38
3	0.055	0.24	21.09	N/A	0.28	\$1.82
4	0.016	0.07	5.94	N/A	0.07	\$0.50
5	0.136	0.56	49.98	N/A	0.64	\$4.18
6	0.168	0.69	60.37	N/A	0.78	\$5.09
7	0.022	0.09	7.37	N/A	0.10	\$0.65
8	0.015	0.06	5.64	N/A	0.07	\$0.46
9	0.033	0.14	11.97	N/A	0.16	\$1.01
10	0.204	0.84	74.29	N/A	0.96	\$6.11
11	0.058	0.27	24.28	N/A	0.31	\$1.97
12	0.107	0.47	41.23	N/A	0.56	\$3.53
13	0.111	0.48	43.80	N/A	0.57	\$3.54
14	0.055	0.22	19.51	N/A	0.26	\$1.60
15	0.017	0.07	6.05	N/A	0.07	\$0.52
16	0.010	0.04	4.10	N/A	0.05	\$0.31
Total	1.031	4.36	385.63	N/A	5.00	\$32.14

Table 27: 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\$)
New Construction & Additions	0.73	0.06	N/A	0.82	\$5.29
Alterations	4.35	0.39	N/A	5.00	\$32.12
Total	5.08	0.45	N/A	5.82	\$37.42

Table 28: 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\$)
Cannabis	New Construction & Additions	0.67	0.056	N/A	0.70	\$4.81
	Alterations	3.93	0.329	N/A	4.10	\$28.47
Leafy Greens/ Microgreens/ Herbs	New Construction & Additions	0.02	0.003	N/A	0.05	\$0.21
	Alterations	0.23	0.032	N/A	0.53	\$2.05
Tomatoes/ Vine/ Flowering	New Construction & Additions	0.03	0.004	N/A	0.07	\$0.28
	Alterations	0.19	0.024	N/A	0.37	\$1.61
All	Total	5.08	0.449	N/A	5.82	\$37.42

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 29 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 308 metric tons of carbon dioxide equivalent (CO₂e) 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 29: First-Year Statewide GHG Emissions Impacts

Facility Type	Crop Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO ₂ e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO ₂ e)	Total Reduced GHG Emissions (Metric Ton CO ₂ e)	Total Monetary Value of Reduced GHG Emissions (\$)
Indoor (Warehouse)	Cannabis	196	N/A	196	\$31,902
	Leafy Greens/ Microgreens/ Herbs	7	N/A	7	\$1,161
	Tomatoes/ Vine/ Flowering	2	N/A	2	\$298
Greenhouse	Cannabis	57	N/A	57	\$9,303
	Leafy Greens/ Microgreens/ Herbs	24	N/A	24	\$3,888
	Tomatoes/ Vine/ Flowering	22	N/A	22	\$3,496
TOTAL	All	308	N/A	308	\$50,048

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 $\mu\text{mol}/\text{J}$ to 2.5 $\mu\text{mol}/\text{J}$ and does not involve a change in lamp type or introduce new equipment or testing requirements, no material impacts were identified.

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).

New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics*.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.⁸ New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “**Section 601.1** [Section 130.0(a)] **General**” contains the content that is in the current Section 130.0(a).

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

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)

SECTION 201

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 integrated luminaires and luminaires with removable, serviceable lamps.](#)

SECTION 908

CONTROLLED ENVIRONMENTAL HORTICULTURE (CEH) (NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)

...

908.1.5 [Section 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:

1. 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.

~~1. 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:~~

~~1.1. Integrated, non-serviceable luminaires shall have a rated PPE of at least 2.3 micromoles per joule; or~~

~~1.2. Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 2.3 micromoles per joule.~~

908.4 [Section 141.1, 141.1(c)] **Additions and alterations to existing buildings.** Covered processes in additions or alterations to existing buildings that will be nonresidential, hotel/motel, or multifamily occupancies shall comply with the applicable requirements of [Section 400.5.1](#) [Section 110.2(a)] and [Section 913](#) [Section 120.3].

908.4.3 [Section 141.1(c)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 908.1.5](#) [Section 120.6(h)5].

Exception to Section 908.4.3: 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 Nonresidential and Multifamily Compliance Manuals should be updated to reflect the revised luminaire PPE threshold of 2.5 $\mu\text{mol}/\text{J}$ and the updated terminology for

luminaire photosynthetic photon efficacy. 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

The Statewide CASE Team does not propose any changes to the ACM Reference Manual for this measure.

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

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. This additional acceptance test is proposed to ensure the CEH control sequence properly accounts for CEH-specific parameters and operating conditions, rather than relying on indoor nonresidential control logic that does not fully represent CEH system behavior or intended functionality.

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 30 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 30: 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	Part 6, Sections 201, 908.1 and 908.4 Nonresidential Reference Appendix 7	NRCC-PRC-E NRCI-PRC-E NRCA-PRC-XX-F		N/A	
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 tomatoes and other 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; NYSERDA, 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-response 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 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, 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 of \$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 3.6 Daylight Responsive Controls for Greenhouses - Proposed Code Language of this report offers the detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

SUBCHAPTER 2 DEFINITIONS

SECTION 201 – DEFINITIONS: 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.

SUBCHAPTER 9 PROCESS SYSTEMS AND EQUIPMENT

Section 908.1.2 [Section 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.

Section 908.1.5 [Section 120.6(h)5]: 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-response controls measure with federal conservation practice standards (United States Department of Agriculture, 2021). The proposed daylight-response 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-response 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).

The proposed measure adds new lighting controls requirements for greenhouses with 40 kW of lighting load or greater. Unlike the lighting efficacy measure, this proposal introduces new acceptance testing requirements due to the functional nature of control systems. Because acceptance testing is performed by the field technician and does not require independent verification, this measure minimizes compliance burden while ensuring proper system functionality. 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.

Overall, the proposal is expected to increase clarity and consistency across all market actors while introducing minimal additional compliance burden.

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

The impacts described above are summarized in Table 31, which aligns key responsibilities and considerations across market actor groups.

Table 31: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/Developer^a	Be aware of new requirements, increased upfront costs, and acceptance testing requirements associated with daylight-responsive controls.	CEH Energy Code Ace Fact Sheet and training resources should be updated to include new requirements. Outreach to owners could improve understanding of the benefits of daylight-response controls for greenhouses.
Design Professional^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.
Construction Team^c	Install controls meeting the new and updated requirements. Conduct acceptance testing as field technician. The acceptance test will require a handheld PPFd meter.	Horticultural lighting controls installers should be provided training on the Energy Code updates and supporting documentation, compliance requirements, acceptance testing, and compliance documentation.
Building Department^d	Plans checker will review the submitted NRCC-PRC-E form and design documents to confirm	Additional outreach and education are needed to ensure building departments are aware of CEH code

Market Actor	Impact(s)	Suggested Outreach and Education
	<p>that the design includes lighting controls meeting the updated requirement.</p> <p>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.</p>	<p>requirements. Smaller AHJs and those with a high concentration of greenhouses may require more outreach.</p>
Manufacturers and Distributors	<p>Sales of compliant lighting controls systems will increase.</p> <p>May need to update “code guideline” documents.</p>	<p>Outreach to manufacturers will help manufacturers understand the code changes and what products can comply with the code.</p>
Growers, Managers, and Operators^e	<p>Need to train staff to operate greenhouses with lighting control system.</p>	<p>Updates to the Energy Code Ace Fact Sheet and training resources to include daylight-response controls.</p> <p>Outreach to operations personnel could improve understanding of the benefits of daylight-response controls for greenhouses.</p>

- a. Owner/Developer is funding the project and is the primary decision-maker.
- b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
- c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
- d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection staff.
- e. Growers, Managers, and Operators operate the systems and use the greenhouse to grow plants.

The [2028 CASE Methodology Report](#) presents a quantitative assessment of how changes to the California building code impact builders, design professionals, energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on owners, developers, design professionals, construction teams, building departments, manufacturers, distributors, growers, managers, and operators, since these market actors are expected to experience the most direct impacts from requirements for daylight-responsive control of horticultural lighting in greenhouses. The following section provides a qualitative description of how this proposed code change

affects key industry sectors and workforce groups involved in greenhouse construction and operation.

Construction Team: The proposed measure primarily affects contractors responsible for installing and commissioning lighting control systems in greenhouse facilities. These contractors will need to incorporate acceptance testing into their workflow. Because testing can be performed by existing installation personnel, impacts are expected to be modest and limited to minor increases in labor time. Table 32 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Owner/Developers: Owner/developers may experience increased upfront costs associated with the installation of daylight-responsive control systems. However, these costs are offset by long-term energy savings and improved operational efficiency.

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

Overall, the proposed measure is not expected to disrupt existing industry practices but will result in modest shifts in installation practices and equipment selection.

Table 32: 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 \$)
Nonresidential Electrical Contractors	3,245	72,794	\$7.8
Other Nonresidential Equipment Contractors	580	9,749	\$1.1
All Other Nonresidential Trade Contractors	948	17,084	\$1.7

Source: (State of California, n.d.)

* An establishment is a single economic unit, typically at one physical location, which 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 and Distributors: 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. Manufacturers and distributors of horticultural lighting control systems may see increased demand for compliant products.

The proposed measure is not expected to create supply constraints, as multiple vendors currently offer compliant technologies.

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-response 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-response 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-response controls, costs are expected to be limited to short courses or online modules, which can be integrated into existing industry training programs.

The plan review function would consist of reviewing the NRCC-PRC-E form and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing the NRCC-PRC-E form and the NRCA-PRC-XX-F form and ensuring that the information on the forms is consistent with the approved NRCC-PRC-E form and with what is actually installed.

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, TrolMaster, and Link4. The market for these daylight-response 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-response 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-response controls measure for cannabis growers. Absent regulation, daylight-response 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.

Recent California market research indicates that while adoption of automated and sensor-based controls is increasing, it is not uniform across the CEH sector (Schimelpfenig, 2025). Large facilities are more likely to employ advanced controls, while smaller and retrofit facilities often rely on basic control strategies such as timeclock-based operation or manual control. Even in facilities with automated systems, lighting operation is frequently based on fixed schedules rather than dynamic daylight-responsive strategies, resulting in continued over-lighting under high daylight conditions (Schimelpfenig, 2025). These findings support the use of a timeclock-based baseline for this analysis, consistent with current Title 24, Part 6 requirements.

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 manuals are 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-response 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:

- i. **Sensor placement and calibration** at representative canopy locations to ensure accurate measurement of photosynthetically active light levels;
- ii. **Integration with lighting controllers** to modulate fixture output in real time;
- iii. **Programming setpoints** based on target DLI; and
- iv. **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-response 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 Manuals are 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 design professionals, installers, and commissioning agents with the skills needed to implement these systems effectively.

3.3.3 Energy Equity and Environmental Justice

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

Based on market analysis, stakeholder input, and cost-effectiveness results, the Statewide CASE Team determined that this measure is unlikely to have significant impacts. This conclusion is based on several key assumptions and findings. This conclusion is based on several key assumptions and findings.

From a health and comfort perspective, the measure reduces unnecessary lighting operation and associated waste heat, which may improve working conditions in greenhouse environments without introducing any new safety risks. From a cost perspective, incremental first costs are relatively low and are outweighed by energy cost savings over time, limiting potential financial burden on operators, including those in ESJ communities. From a resilience perspective, reduced electricity consumption and peak demand improve grid reliability and reduce exposure to energy price volatility, providing modest system-level benefits. Overall, the measure does not introduce new risks and may provide small net benefits in comfort and operational efficiency, supporting the conclusion that significant adverse impacts are unlikely.

3.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 33, Table 34, and Table 35 outline the statewide implications for these job categories. For more information on the Statewide CASE Team's economic and fiscal impacts methodology, see the [2028 CASE Methodology Report](#).

The Statewide CASE Team does not anticipate that the proposed changes would lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic

disruption to any sector of the California economy. Rather, it would lead to modest changes in the employment of existing jobs.

The proposed requirement for daylight-responsive lighting controls in greenhouses is not expected to create or eliminate job categories. The measure primarily affects specification, installation, and commissioning of lighting control systems and does not fundamentally change construction practices or required labor skill sets.

Modest increases in economic activity are expected due to additional spending on controls, sensors, and installation labor. These impacts are distributed across existing occupations, including electrical contractors (NAICS 238210), control system installers, greenhouse system integrators, and building design professionals (NAICS 541310, 541330).

The Statewide CASE Team does not anticipate significant long-term employment gains or losses attributable to this measure.

Table 33: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	5.7	\$0.456	\$0.686	\$1.485
Indirect Effect (Additional spending by firms supporting Commercial Builders)	3.3	\$0.263	\$0.452	\$0.792
Total Economic Impacts	9.1	\$0.719	\$1.139	\$2.277

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.¹⁰

¹⁰ IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

Table 34: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building designers and energy consultants)	2.0	\$219,823	\$217,622	\$343,973
Indirect Effect (Additional spending by firms supporting building designers and energy consultants)	0.8	\$65,452	\$90,966	\$146,436
Total Economic Impacts	2.8	\$285,276	\$308,588	\$490,409

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

Table 35: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building inspectors)	0.3	\$29,841	\$35,388	\$43,003
Indirect Effect (Additional spending by firms supporting building inspectors)	0.0	\$2,764	\$4,304	\$7,497
Total Economic Impacts	0.3	\$32,605	\$39,692	\$50,500

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

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

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.¹¹

Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have advantageous or an adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity

¹¹ Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

associated with the proposed measure and its expected effect on business income. The Statewide CASE Team’s IMPLAN modeling resulted in an estimated \$203,059 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.¹²

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm’s capital stock (referred to as net private domestic investment, or NPDI).¹³ As Table 36 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

Table 36: Net Domestic Private Investment and Corporate Profits, U.S.

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates

¹² 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 36.

¹³ Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

the proposed code change would result in a \$47,666 increase in net private investment by California businesses.

3.3.5 Economic and Fiscal Impacts

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

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

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

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

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals. The proposed measure may apply to state-owned greenhouse facilities, such as those operated by public universities for research and teaching. These facilities would experience modest increases in first cost and corresponding long-term energy savings. The measure has been demonstrated to be cost effective and is not expected to impose a net financial burden on state agencies

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments

plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

3.3.5.2 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because local agencies and school districts do not typically operate controlled environment horticulture facilities with large-scale supplemental lighting systems.

3.3.5.3 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts because local agencies and school districts do not typically operate controlled environment horticulture facilities subject to this measure.

3.3.5.4 Costs or Savings to Any State Agency

There are no costs or savings to state agencies beyond those associated with state-owned greenhouse facilities, which would experience modest increases in first cost and long-term energy savings.

3.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies because the measure does not affect programs or services provided by local governments.

3.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state because federal funding is not dependent on horticultural lighting control requirements under Title 24.

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 for each simulated crop type (Energy Solutions, 2023). 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 the cannabis greenhouse prototype, the Statewide CASE Team conservatively applied savings only to the flowering canopy area, which represents approximately 65 percent of total cannabis canopy area based on typical greenhouse canopy composition. This assumption was confirmed through stakeholder outreach. The three prototypes analyzed were: greenhouse leafy greens, greenhouse tomatoes, and greenhouse cannabis.

For each prototype, climate zone, and crop type, the analysis calculated lighting energy use on an hourly basis using canopy area per luminaire, photoperiod, required photosynthetic photon flux density (PPFD), lighting photosynthetic photon efficacy (PPE), greenhouse light transmittance, and available daylight. Baseline values reflect the minimum compliant controls required by the 2025 Energy Code, consisting of

timeclock-based on/off control with lights operating at 100 percent output during the scheduled photoperiod. Proposed values reflect the proposed 2028 Energy Code updates for daylight-responsive greenhouse lighting controls, modeled as timeclock control combined with a photosynthetically active radiation (PAR) sensor, continuous dimming, and off capability.

The proposed control model estimates available sunlight at the canopy for each climate zone and hour of the year using outdoor solar irradiance data adjusted for the portion of sunlight in the PAR range and for greenhouse light transmittance. The model then compares available daylight at the canopy to the crop-specific PPFD target. When daylight is sufficient, supplemental lighting is turned off. When daylight is insufficient, the model dims the electric lighting to provide only the light needed to maintain the target PPFD during the photoperiod, subject to the modeled minimum dimming and off-control logic. The proposed measure also allows compliance through daily light integral (DLI)-based control; however, the Timeclock + PAR sensor pathway was modeled for this analysis. DLI-based control systems are expected to achieve equal or greater savings because they optimize lighting operation based on cumulative daily light targets rather than instantaneous PPFD alone. More details on the methodology for calculating energy savings from the proposed code change are provided in Appendix A.

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 assume venting as the primary cooling mechanism and did not include interactive effects with an HVAC system. This simplifying assumption reflects the high variability of greenhouse operating strategies and crop production practices, including ventilation schedules, humidity management, irrigation practices, crop transpiration rates, and dehumidification approaches. As a result, potential secondary impacts on latent load and humidity control were not quantified in the prototype-level model. 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 37 highlights key lighting assumptions. The assumptions were confirmed via 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 37: Greenhouse CEH Lighting Assumptions for Daylight Responsive Controls Energy Savings Analysis

Parameter	Cannabis - Flower	Leafy Greens/ Microgreens/ Herbs	Tomatoes/ Vine/ Flowering
Canopy Area per Luminaire (ft ²)	20	58	56
Photoperiod (hours/day)	12	18	12
PPFD (μmol/m ² /s)	600	200	350
Baseline PPE (μmol/J)	2.5	2.5	2.5
Proposed PPE (μmol/J)	2.5	2.5	2.5

Although stakeholder input and recent studies indicate that some greenhouse facilities already use sensor-based or automated lighting controls, adoption is not uniform across the market. Smaller facilities and retrofit projects frequently rely on timeclock-based or manual control strategies due to lower first cost, perceived simplicity, and reduced commissioning requirements.

Consistent with the [2028 CASE Methodology Report](#), the baseline reflects the current Title 24, Part 6 requirements, which do not require daylight-responsive controls for greenhouse lighting. Although some facilities have adopted advanced controls, these systems are not universally implemented and often do not optimize lighting operation based on available daylight.

Field studies and market assessments indicate that advanced daylight-responsive controls, including DLI-based strategies, can reduce greenhouse lighting energy use by approximately 20 to 70 percent, depending on climate and crop type. These savings occur by reducing unnecessary lighting operation during periods of sufficient daylight. To avoid overstating statewide impacts, the Statewide CASE Team applied a market adoption adjustment reflecting the estimated share of installations already using advanced controls. This approach ensures that savings are attributed only to installations that would otherwise remain at the baseline level without the proposed code change.

Table 38 through Table 42 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 ft² 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/ft², depending on climate zone and crop type. The per-unit energy savings do not vary between new construction and additions/alterations.

The savings from this measure are expected to persist over the 30-year analysis period, assuming equipment is maintained and replaced, as necessary.

While the measure savings are calculated relative to the code-minimum baseline, this comparison does not fully reflect current market practices. The existing market baseline for horticultural LED lighting systems likely includes a mix of centralized and distributed control strategies, including a meaningful share of facilities that rely on control approaches such as PAR-based on/off operation, basic timeclock scheduling with multiple programmed operating windows, or manual/behavioral adjustments where lighting schedules are modified based on grower judgment and perceived plant needs.

The prevalence and effectiveness of these intermediate operating strategies is also hypothesized to vary by crop type, target PPF_D requirements, cultivation approach, and seasonal operating conditions. Facilities growing high-light crops or operating to maintain elevated PPF_D targets may exhibit different lighting schedules and dimming behavior than facilities cultivating lower-light crops or operating seasonally. Similarly, seasonal daylight availability and regional climate conditions may influence how aggressively growers adjust lighting schedules or rely on manual interventions.

As a result, actual incremental savings attributable to the proposed measure may vary compared to savings estimated strictly against code minimum. At the time of this report, little to no data was available to estimate the market share of these strategies accurately. As such, savings estimates are presented compared to code minimum only.

Table 38: 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/ Microgreens/ Herbs	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/ Vine/ Flowering	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 39: 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/ Microgreens/ Herbs	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/ Vine/ Flowering	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 40: 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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Greenhouse Leafy Greens/ Microgreens/ Herbs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Greenhouse Tomatoes/ Vine /Flowering	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 41: 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/ Microgreens/ Herbs	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/ Vine/ Flowering	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 42: Total 30-Year LSC Savings (2029 PV\$) 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	\$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
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$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
Greenhouse Tomatoes/ Vine/ Flowering	\$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.
- **Acceptance Testing:** Labor for acceptance testing of controls, typically performed by technician installing the controls.
- **Design:** Engineering time to specify PAR sensor placement and zoning, develop control sequences and dimming integration with the lighting system, and coordinate commissioning requirements.

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 1,709, 5,126, and 2,929 canopy square feet. The cost of labor for installation and acceptance testing was based on the average prevailing wage for an electrician in 2029 dollars at \$110.32 per hour, while design labor was assumed to be a fully loaded engineering rate of \$208.62 (State of California Department of Industrial Relations, 2026). Installation time was assumed to be 1.5 hours for the baseline and 4 hours for the proposed measure case; the proposed measure case also includes 8 hours of design and 2.5 hours of acceptance testing. Equipment first costs and incremental costs per square foot of canopy are presented in Table 43. 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 43. One control system is required per zone, so the total cost per zone is consistent across crop types.

First cost estimates for the baseline were collected between November and December 2025, and estimates for the proposed measure were developed in March 2026 using a combination of manufacturer quotes, distributor pricing, and stakeholder interviews. These estimates were presented to stakeholders at the March 5, 2026 Utility-Sponsored Stakeholder Meeting. Poll responses indicated mixed feedback on the proposed incremental cost: one respondent indicated it was much too high, one indicated it was slightly too high, three indicated it was slightly too low, and one indicated it was much too low.

Table 43: Baseline, Proposed, and Incremental Cost for Equipment and Installation, Per Canopy Square Foot – Daylight Responsive Controls (\$/canopy square foot)

Prototype	First Cost	Proposed Cost per Canopy Square Foot (sf)	Baseline Cost per Canopy Square Foot (sf)	Incremental Cost per Canopy Square Foot (sf)
Cannabis Greenhouse	Design	\$0.98	\$0.00	\$0.98
	Equipment	\$0.78	\$0.04	\$0.74
	Install	\$0.26	\$0.10	\$0.16
	Acceptance Testing	\$0.16	\$0.00	\$0.16
	Total	\$2.17	\$0.13	\$2.04
Greenhouse Leafy Greens/ Microgreens/ Herbs	Design	\$0.33	\$0.00	\$0.33
	Equipment	\$0.26	\$0.01	\$0.25
	Install	\$0.09	\$0.03	\$0.05
	Acceptance Testing	\$0.05	\$0.00	\$0.05
	Total	\$0.72	\$0.04	\$0.68
Greenhouse Tomatoes/Vine/ Flowering	Design	\$0.57	\$0.00	\$0.57
	Equipment	\$0.45	\$0.02	\$0.43
	Install	\$0.15	\$0.06	\$0.09
	Acceptance Testing	\$0.09	\$0.00	\$0.09
	Total	\$1.27	\$0.08	\$1.19

Table 44. 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 (\$)
Greenhouse Cannabis	1,709	\$2.04	\$3,487
Greenhouse Leafy Greens/ Microgreens/ Herbs	5,126	\$0.68	\$3,487
Greenhouse Tomatoes/ Vine/ Flowering	2,929	\$1.19	\$3,487

3.4.4 Incremental Maintenance and Replacement Costs

The proposed daylight-response 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 vetted this assumption with stakeholders. At the utility sponsored stakeholder meeting in March 2026, respondents indicated that the EULs were largely accurate. The incremental replacement cost analysis assumes replacement of all components every eight years. As an example for the controls serving the cannabis greenhouse, the incremental cost is \$2.04/ft², assuming the same inflation adjusted cost would occur at 8 years, 16 years and 24 years, and using a 3 percent real discount rate, the total present valued incremental cost of the measure including equipment replacement, PVinc, would be:

PVinc =

$$\$2.04/\text{ft}^2 + \$2.04/\text{ft}^2 \times (1/1.03)^8 + \$2.04/\text{ft}^2 \times (1/1.03)^{16} + \$2.04/\text{ft}^2 \times (1/1.03)^{24}$$

$$\text{PVinc} = \$5.92/\text{sf}$$

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.

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 45 and Table 46 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.

Supplemental lighting operating schedules vary by greenhouse crop type and production practices. As part of an in-progress CalNEXT study assessing energy savings from advanced lighting controls¹⁴, a pair of greenhouses were monitored that

¹⁴ SmartAg Controls: Incentivizing Efficiency & Yields <https://www.etcc-ca.com/reports/smartag-controls-incentivizing-efficiency-yields>

only used supplemental lighting during the winter months. To assess the sensitivity of the results to reduced horticultural lighting operating hours from seasonal operation, a hypothetical case was considered in which annual measure benefits were reduced by 75 percent while incremental measure costs remained unchanged. Under this assumption, the benefit-to-cost ratios for the new construction prototypes decrease from 65 to approximately 16 for the cannabis prototype, from 140 to 35 for the leafy greens/microgreens/herb prototype, and from 121 to 30 for the tomato/vine/flowering crop prototype. These values remain substantially greater than 1.0, indicating that the proposed daylight-responsive lighting controls remain highly cost-effective even under significantly reduced supplemental lighting operation.

Table 45: 30-Year Cost-Effectiveness Summary Square Canopy Foot Area – New Construction and Additions – 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	\$242.48	\$3.76	65
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$175.11	\$1.25	140
Greenhouse Tomatoes/ Vine/ Flowering	\$265.90	\$2.19	121

Table 46: 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	\$238.99	\$3.76	64
Greenhouse Leafy Greens/ Microgreens/ Herbs	\$175.32	\$1.25	140
Greenhouse Tomatoes/ Vine/ Flowering	\$264.01	\$2.19	120

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 additional detail on how construction forecasts were translated into affected floor area.

To contextualize the statewide results, Table 47 summarizes the key assumptions used to translate per-unit savings into statewide impacts. These assumptions reflect building stock characteristics, measure applicability, equipment turnover, and current market adoption of daylight-responsive controls.

Table 47: Key Assumptions for Statewide Impact Analysis

Assumption	Definition	Value	Source
Total Existing CEH Floorspace	Estimated statewide controlled environment horticulture (CEH) building stock	40.2 million ft ²	CEC Statewide Construction Forecast (2025)
Annual New Construction	Projected CEH floorspace added in 2029	2.1 million ft ² /year	CEC Statewide Construction Forecast (2025)
Greenhouse Share of CEH	Portion of CEH floorspace that is greenhouse (vs. indoor)	68%	2022 CEH Final CASE Report (Energy Solutions, 2023)
Lighting Threshold Applicability	Share of floorspace with ≥40 kW lighting load subject to measure	70%	CASE Team assumption based on typical facility sizes and applicability threshold
Equipment Turnover Rate (Alterations)	Annual replacement rate based on effective useful life of controls	12.5% (8-year EUL)	CASE EUL assumptions for controls (time clocks, PAR sensors)
First-Year Alteration	Portion of existing stock affected in first	8.75%	Derived: 70% × 12.5%

Assumption	Definition	Value	Source
Applicability	year (threshold × turnover)		
Market Adoption of Controls	Existing penetration of daylight-responsive controls	62%	Stakeholder feedback + CalNEXT study (Schimelpfenig, 2025)
Incremental Savings Applicability	Share of installations eligible for savings (not already adopted)	38%	Derived: 100% – existing adoption (62%)
Crop Representation	Modeled greenhouse crop types used to represent sector	Cannabis, leafy greens, tomatoes	CASE modeling approach; aligned with 2025 CASE Report prototypes
Cannabis Canopy Adjustment	Portion of cannabis canopy assumed affected (flowering only)	65% of canopy	Industry practice; stakeholder-confirmed canopy distribution
Prototype Coverage	Climate zone and crop representation approach	All 16 CZs; crops mapped to representative types	CASE modeling framework; consistent with Title 24 methodology

These assumptions are intended to provide a conservative estimate of statewide impacts by accounting for partial market adoption, equipment turnover, and variation in greenhouse operations across crop types and facility sizes.

Table 48 presents statewide energy and LSC savings for new construction and additions by prototype, with values summed across all climate zones. Table 49 presents statewide energy and LSC savings for new construction and additions by climate zone, with values summed across all prototypes. Although per-unit energy savings are relatively similar across climate zones, total statewide savings vary substantially because the amount of impacted CEH floor area differs significantly by climate zone. In other words, statewide savings are driven primarily by the geographic distribution of forecasted CEH construction rather than large differences in energy savings per canopy square foot.

Table 50 presents statewide energy and LSC savings for alterations by prototype with values summed across all climate zones. Table 51 presents statewide energy and LSC savings for alterations by climate zone, with values summed across all prototypes. Statewide savings from alterations are significantly larger than savings from new construction and additions because the affected existing CEH building stock is substantially larger than the forecasted annual volume of new construction. The statewide alteration analysis reflects the portion of existing CEH floor area expected to undergo qualifying equipment replacement or renovation in 2029.

The relative distribution of savings across climate zones also differs somewhat between new construction and alterations because the geographic distribution of existing CEH facilities differs from the projected distribution of future CEH construction. However, the per-unit energy savings assumptions used in the analysis are the same for new construction, additions, and alterations for each climate zone.

Appendix C provides additional detail on statewide savings by climate zone and prototype. Table 52 summarizes total first-year savings by construction type, and Table 53 shows total first-year savings by prototype.

Statewide savings for this proposed measure are significantly larger than those for lighting efficacy because this measure affects lighting operation throughout the day, reducing runtime and dimming lights rather than improving fixture efficiency alone. To avoid overstating impacts, statewide savings estimates incorporate assumptions about current market adoption of advanced controls. Only the portion of installations not already using daylight-responsive strategies is assumed to achieve full incremental savings.

Table 48: Statewide Energy and LSC Impacts – New Construction and Additions – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.08	3.19	141.17	N/A	0.93	\$18.76
Greenhouse Leafy Greens/ Microgreen/ Herbs	0.12	3.30	175.20	N/A	1.54	\$20.84
Greenhouse Tomatoes/ Vine/ Flowering	0.16	6.95	340.15	N/A	2.56	\$42.20
Total	0.36	13.45	656.53	N/A	5.03	\$81.79

Table 49: 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 2029 (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	0.0001	0.002	0.12	N/A	0.001	\$0.01
2	0.0091	0.316	16.77	N/A	0.107	\$1.94
3	0.0223	0.788	42.53	N/A	0.273	\$4.83
4	0.0070	0.264	13.01	N/A	0.097	\$1.63
5	0.0120	0.450	22.12	N/A	0.169	\$2.81
6	0.0012	0.046	2.26	N/A	0.018	\$0.28
7	0.0129	0.482	24.01	N/A	0.191	\$2.98
8	0.0010	0.040	1.95	N/A	0.015	\$0.24
9	0.0010	0.040	1.96	N/A	0.015	\$0.25
10	0.1927	7.345	354.99	N/A	2.756	\$44.49
11	0.0008	0.028	1.41	N/A	0.010	\$0.17
12	0.0099	0.358	18.27	N/A	0.126	\$2.24
13	0.0040	0.148	7.01	N/A	0.050	\$0.90
14	0.0633	2.482	117.93	N/A	0.952	\$14.93
15	0.0078	0.305	14.83	N/A	0.119	\$1.90
16	0.0099	0.350	17.36	N/A	0.132	\$2.18
Total	0.3551	13.446	656.53	N/A	5.029	\$81.79

Table 50: Statewide Energy and LSC Impacts – Alterations – Climate Zones 1-16

Prototype	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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\$)
Greenhouse Cannabis	0.26	10.41	463.03	N/A	3.01	\$61.81
Greenhouse Leafy Greens/ Microgreens/ Herbs	0.40	10.95	586.38	N/A	4.99	\$69.76
Greenhouse Tomatoes/ Vine/ Flowering	0.53	22.88	1128.45	N/A	8.24	\$140.07
Total	1.19	44.24	2177.86	N/A	16.23	\$271.63

Table 51: Statewide Energy and LSC Impacts – Alterations – Cannabis, Leafy Greens, and Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.015	0.47	24.39	N/A	0.16	\$2.89
2	0.013	0.45	23.71	N/A	0.15	\$2.75
3	0.063	2.22	119.95	N/A	0.77	\$13.61
4	0.018	0.70	34.32	N/A	0.25	\$4.29
5	0.156	5.87	288.12	N/A	2.20	\$36.56
6	0.193	7.31	360.04	N/A	2.80	\$44.85
7	0.025	0.93	46.16	N/A	0.37	\$5.73
8	0.018	0.67	32.85	N/A	0.26	\$4.05
9	0.038	1.46	71.21	N/A	0.56	\$9.11
10	0.235	8.97	433.70	N/A	3.37	\$54.35
11	0.067	2.32	114.64	N/A	0.78	\$14.15
12	0.123	4.45	227.26	N/A	1.56	\$27.91
13	0.128	4.78	226.65	N/A	1.61	\$29.20
14	0.064	2.49	118.49	N/A	0.96	\$15.00
15	0.019	0.76	36.92	N/A	0.30	\$4.74
16	0.011	0.39	19.45	N/A	0.15	\$2.44
Total	1.187	44.24	2177.86	N/A	16.23	\$271.63

Table 52: 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\$)
New Construction & Additions	13.45	0.66	N/A	5.03	\$81.79
Alterations	44.24	2.18	N/A	16.23	\$271.63
Total	57.69	2.83	N/A	21.26	\$353.43

Table 53: 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\$)
Cannabis	New Construction & Additions	3.19	0.14	N/A	0.93	\$18.76
	Alterations	10.41	0.46	N/A	3.01	\$61.81
Leafy Greens/ Microgreens/ Herbs	New Construction & Additions	3.30	0.18	N/A	1.54	\$20.84
	Alterations	10.95	0.59	N/A	4.99	\$69.76
Tomatoes/ Vine/ Flowering	New Construction & Additions	6.95	0.34	N/A	2.56	\$42.20
	Alterations	22.88	1.13	N/A	8.24	\$140.07
All	Total	57.69	2.83	N/A	21.26	\$353.43

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 54 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 1,125 metric tons of CO₂e 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 54: 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	209	N/A	209	\$33,895
Greenhouse Leafy Greens/ Microgreens/ Herbs	345	N/A	345	\$56,077
Greenhouse Tomatoes/ Vine/ Flowering	571	N/A	571	\$92,793
TOTAL	1,125	N/A	1,125	\$182,765

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 PPF for a 40kW zone. Statewide estimates were developed by multiplying these per-unit values by the first-year impacted square footage.

Table 55 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 55: 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 ₂ e)
Mercury	No Change	0	0	0
Lead	Increase	0.0001	53	-0.03
Copper	Increase	0.0356	20,950	-26.61
Steel	Increase	0.0424	24,992	-13.75
Plastic	Increase	0.4397	258,907	-217.48
Zinc	Increase	0.0003	185	-0.26
Aluminum	Increase	0.0015	872	-3.25
Lithium	Increase	0.0004	238	-0.77
Manganese Dioxide	Increase	0.0009	555	-0.25
TOTAL	N/A	0.52	306,752	-262.40

3.5.5 Environmental Impacts

Requiring daylight-response 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, the 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. The Statewide CASE Team anticipates no impact on material consumption.

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.

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).

New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics*.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.⁸ New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “**Section 601.1** [Section 130.0(a)] **General**” contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from the

requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

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)

SUBCHAPTER 2 DEFINITIONS

SECTION 201 DEFINITIONS

DAILY LIGHT INTEGRAL (DLI): Photosynthetic photon flux density (PPFD) of daylight and electric light integrated over 24 hours in units of mol/m²/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 $\mu\text{mol/s}$, 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 ($\mu\text{mol/m}^2/\text{s}$), 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 ($\mu\text{mol/m}^2/\text{s}$) and used to monitor light levels for the purpose of managing and controlling CEH lighting systems.

SECTION 908 CONTROLLED ENVIRONMENTAL HORTICULTURE (CEH) (NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)

908.1 *[Section 120.6(h)]* **Mandatory requirements (Newly Constructed, Additions, Alterations).**

908.1.1 *[Section 120.6(h)1]* **Indoor growing, dehumidification.**

...

908.1.2 [Section 120.6(h)2] Indoor growing and greenhouse, electrical power distribution systems.

~~Electrical power distribution systems serving CEH spaces shall comply with 601.2.6 [Section 130.5], and be designed so that a measurement device is capable of monitoring the electrical energy usage of aggregate horticultural lighting load. shall be considered a lighting type.~~

908.1.3 [Section 120.6(h)3] Conditioned greenhouses, building envelope.

...

908.1.4 [Section 120.6(h)4] Conditioned greenhouses, space-conditioning systems.

...

908.1.5 [Section 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:~~

~~1. 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:~~

~~1.1 Integrated, nonserviceable luminaires shall have a rated PPE of at least 2.3 micromoles per joule; or~~

~~1.2 Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 2.3 micromoles per joule.~~

~~**1. 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.~~

~~2. 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.~~

~~3. Multilevel lighting controls shall be installed and comply with Section 130.1(b).~~

~~**2. 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:~~

~~2.1 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.

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

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

2.4 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.

2.5 All lighting control zones shall be shown on the plans.

3. Greenhouse lighting control. Horticultural lighting systems serving greenhouse spaces shall be controlled by items 3.1 and 3.2, or by item 3.3.

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

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

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

3.1.3 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.

3.1.4 All lighting control zones shall be shown on the plans.

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

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

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

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

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

3.2.5 All *PAR sensor* locations and associated lighting control zones shall be shown on the plans.

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

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

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

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

3.3.4 A single sensor may serve multiple control zones, as long as:

3.3.4.1 Each zone has independent calibration settings, and

3.3.4.2 DLI is calculated separately for each zone.

3.3.5 All daylight sensor locations and associated lighting control zones shall be shown on the plans.

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 40 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.

Light output measurement. Light output may be measured as lighting illuminance level at the crop canopy reference plane or as the power draw of the controlled lighting

for the lighting control zone. Current measurements may be used instead of power measurements. Where the lighting control system reports the controlled lighting output, the reported output may be documented.

The crop canopy reference plane. The crop canopy reference plane shall be the top of the plant canopy when plants are present, the design canopy height shown in the construction documents when plants are not present, or another documented representative crop-light measurement plane.

(a) Full Output Test. Using the lighting control system, set the lighting to full (100%) output.

- i. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
- ii. Light output should be stable with no visible flicker.

(b) 75% Output Test. Using the lighting control system, set the lighting to 75% output.

1. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Measured or documented value must show a reduction of 25% from Full Output Test.
3. Light output is stable with no visible flicker.

(c) 50% Output Test. Using the lighting control system, set the lighting to 50% output.

1. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Measured value must show a reduction of 50% from Full Output Test.
3. Light output is stable with no visible flicker.

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

1. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.

2. Measured value must show a reduction of 90% from Full Output Test.
3. Light output is stable with no visible flicker.

(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 or other daylight sensor locations and associated lighting control zone(s) are shown on plan documents.
- (e) Where a shared PAR sensor serves more than one lighting control zone, each served zone has documented calibration settings.
- (f) 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. The daylight-responsive control setpoint for each lighting control zone is shown on plan documents or commissioning documentation.
 3. Automatic time schedule control is installed and programmed to match the schedule and lighting dimming setpoints on the plan documents.
 4. The correct time and date are properly set in the lighting scheduling controller.
 5. The battery back-up is installed and energized.
- (g) If DLI Control is used, verify the following information
 1. The DLI controls setpoint for each lighting control zone is shown on plan documents or commissioning documentation.
 2. The DLI control is installed and programmed to match the DLI setpoint shown on plan documents or commissioning documentation.
 3. Where a shared daylight input serves more than one lighting control zone, DLI is calculated separately for each served zone.
 4. The correct time and date are set in the DLI controller.

5. 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.

Light output measurement. Light output may be measured as lighting illuminance level at the crop canopy reference plane or as the power draw of the controlled lighting for the lighting control zone. Current measurements may be used instead of power measurements. Where the lighting control system reports the controlled lighting output, the reported output may be documented.

The crop canopy reference plane. The crop canopy reference plane shall be the top of the plant canopy when plants are present, the design canopy height shown in the construction documents when plants are not present, or another documented representative crop-light measurement plane.

(a) Full Off Test. Using the lighting control system, set the lighting system to full off. Verify all lights in the control zone turn off.

Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.

(b) 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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Light output should be stable with no visible flicker.
3. Subtract the Full Off lighting output from the Full Output lighting output to obtain the Electric Lighting Output value.

(c) 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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control

zone. Alternatively, total electrical current for the lighting control zone may be measured.

2. Measured value must show a reduction of 25% of the Electric Lighting Output Value from the Full Output Test lighting output.
3. Light output should be stable with no visible flicker.

(d) 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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Measured value must show a reduction of 50% of the Electric Lighting Output Value from the Full Output Test lighting output.
3. Light output should be stable with no visible flicker.

(e) 10% Output Test. Using the lighting control system, set the lighting to 10% 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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Measured value must show a reduction of 90% of the Electric Lighting Output Value from the Full Output Test lighting output.
3. Light output should be stable with no visible flicker.

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

1. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Confirm that the lighting power level is within 10% of the value obtained in (a).

(g) Restore Normal Operation. Restore PAR sensors to normal operation and return dimming to normal scheduled operation.

NA7.x.1.5 Greenhouse Daylight Responsive Control Functional Testing

Greenhouses complying via with 908.1.5.3 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.

Light output measurement. Light output may be measured as lighting illuminance level at the crop canopy reference plane or as the power draw of the controlled lighting for the lighting control zone. Current measurements may be used instead of power measurements. Where the lighting control system reports the controlled lighting output, the reported output may be documented.

The crop canopy reference plane. The crop canopy reference plane shall be the top of the plant canopy when plants are present, the design canopy height shown in the construction documents when plants are not present, or another documented representative crop-light measurement plane.

Available daylight PPFD. The available daylight PPFD is the measured or calculated daylight PPFD value used by the lighting control system to determine electric lighting output for the tested lighting control zone.

Provided lighting conditions. Daylight conditions may be simulated or provided using actual daylight, lighting control system input override, sensor covering, sensor illumination, sensor override, calculated zone daylight override, or other documented commissioning method.

PPFD setpoint. The PPFD setpoint is a target PPFD for the lighting control zone at the crop canopy reference plane, which is used to control the dimming of the horticultural lighting.

- a. **Daylight Responsive Control Test Setup.** Prior to functional testing, document the following for each lighting control zone being tested:
 1. The lighting control zone being tested.
 2. The PPFD setpoint for the lighting control zone.
 3. The PAR sensor being used for the lighting control zone.
 4. If the PAR sensor serves more than one lighting control zone, confirm that the tested zone has documented calibration settings.
- b. **No Daylight Test.** Simulate or provide conditions without daylight. Verify and document the following:
 1. Record the lighting illuminance level at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.

2. Daylight responsive control system turns on all controlled lighting to meet PPFD setpoint.
 3. Record the PPFD at the crop canopy reference plane, which should be equal to the setpoint PPFD.
 4. Light output is stable with no visible flicker.
 5. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.
- c. **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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
 2. Subtract the No Daylight Test lighting output from the Full Output Test lighting output to obtain the Electric Lighting Output value.
- d. **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 daylight-responsive controls.
- e. **Partial Daylight Test.** Simulate or provide daylight conditions where the daylight PPFD is 60-90% of the setpoint PPFD. Verify and document the following:
1. The lights in the lighting control zone are on.
 2. Record the lighting illuminance level at the crop canopy reference plane.
 3. Verify that the lighting illuminance level is no less than the lighting illuminance level measured at this location during the No Daylight Test.
 4. Verify that the PPFD at this location is no greater than 150 percent of the setpoint PPFD.
 5. Light output is stable with no visible flicker.
 6. Only luminaires in the lighting control zone are affected by the zone's PAR sensor reading.
- f. **Restore Normal Operation.** Restore the lighting control system to normal automatic operation. Verify and document the following:
1. Temporary overrides, simulated inputs, sensor coverings, test lights, and manual commands have been removed.
 2. The active PPFD setpoint is restored.

3. The active daylight input is restored to the normal measured or calculated value.
4. The lighting control zone operates according to the documented control sequence.

NA7.x.1.6 Greenhouse Daily Light Integral Control Functional Testing

Greenhouses complying via with 908.1.5.3 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 crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured. Where the lighting control system reports the controlled lighting output, the reported output may be documented.
2. Light output is stable with no visible flicker.

(b) Reduced DLI Setpoint Test. Using the lighting control system, set the lighting system DLI setpoint to 50% of the design setpoint. Verify and document the following:

1. Record the lighting illuminance level at the at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting control zone. Alternatively, total electrical current for the lighting control zone may be measured.
2. Lighting output level is reduced relative to the Design DLI Setpoint Test, or if consistent with the documented DLI control sequence.
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.

(c) Increased DLI Setpoint Test. Using the lighting control system, set the lighting system DLI setpoint to 200% of the design setpoint. Verify and document the following:

1. Record the lighting illuminance level at the at the crop canopy reference plane or measure the power draw of the controlled lighting for the lighting

control zone. Alternatively, total electrical current for the lighting control zone may be measured.

2. Lighting output level is increased relative to the Design DLI Setpoint Test, or if consistent with the documented DLI control sequence.
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.

(d) Restore Normal Operation. Restore the lighting control system to normal automatic operation. Verify and document the following:

1. DLI setpoint is returned to design 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 does not propose any 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

4.1 Space Conditioning Systems - Measure Description

4.1.1 Proposed Code Change

This proposed measure would establish new mandatory sizing, functional, and controls requirements and would update existing equipment requirements for space conditioning systems that provide heating, cooling, and dehumidification to support plant growth in indoor growing spaces. This proposal would establish mandatory requirements only and clarifies that indoor growing spaces are not subject to prescriptive HVAC or envelope requirements for nonresidential buildings and are therefore not eligible for performance-based compliance.

The new requirements would apply where a space conditioning systems serves 5,000 square feet or more of indoor plant canopy area¹⁵, with horticultural lighting power density greater than or equal to 30 W per square foot of plant canopy area. These thresholds¹⁶ are intended to target high-intensity indoor cultivation applications, which are predominantly associated with cannabis production in California. Updated code language will also clarify which existing mandatory requirements are appropriate and applicable to all Indoor Growing spaces.

The proposal recognizes that cooling, dehumidification, airflow, reheat, heat rejection, and controls in high intensity indoor growing spaces operate as an integrated process system and therefore must be designed and controlled in a coordinated manner.

To clearly delineate that the purpose of these systems is to support an agricultural process, the proposal would revise the definition of Process Space to include CEH Spaces, narrow the definition of CEH Space, and unify HVAC, dehumidification, and envelope requirements for indoor growing spaces in the process section of the energy code. The proposal also clarifies applicability for mixed space indoor facilities containing both indoor growing and other nonresidential spaces.

¹⁵ 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.

¹⁶ The threshold of 30 W/ft² of plant canopy is intended to identify indoor CEH spaces with high lighting intensity and the associated interactions between latent and sensible loads and setpoints, which require specialized HVAC/D design and controls. While this threshold does not regulate a specific crop, it provides a useful proxy for high-intensity lighting conditions that are predominately associated with indoor cannabis flower rooms in California.

For indoor growing spaces with over 5,000 square feet of canopy under high intensity lighting, the proposal builds upon existing mandatory requirements for indoor growing dehumidification systems by: (1) expanding the scope to include both HVAC and dehumidification equipment, (2) closing gaps that allow inefficient designs, (3) adding detailed equipment and controls definitions and specifications, (4) increasing efficiency for all HVAC/D system types, and (5) by improving the compliance process to ensure systems are sized, designed, and installed to these new specifications.

The proposal distinguishes between federally regulated consumer dehumidifiers and non-federally regulated commercial dehumidifiers, the latter of which are used in indoor growing applications with high lighting intensity and latent loads. Consumer dehumidifiers remain subject to federal appliance standards under 10 CFR Part 430. The proposal establishes separate qualification, testing, and certification requirements for commercial dehumidifiers designed and marketed for use in California indoor agriculture facilities.

Because commercial dehumidifiers used in indoor growing are not covered by federal or state appliance standards, the proposal includes a new Joint Appendix describing qualification requirements, a California-specific test procedure derived from the consumer dehumidifier test procedure, a new Commercial Integrated Energy Factor Standard, and product certification to the California Energy Commission.

For high-lighting intensity indoor agriculture spaces, the applicant would be required to identify whether the space conditioning system is (1) an integrated HVAC/D system capable of providing cooling, dehumidification, and reheat within a unified system; or (2) a decoupled system using separate commercial dehumidifiers and commercial HVAC equipment.

The proposal would require all HVAC/D system types to meet peak sensible and latent load conditions. Integrated HVAC/D equipment would need to be sized to meet at least 80 percent of the design peak sensible and latent loads, allowing for either integrated or supplemental equipment to meet the remaining load. Integrated systems would also be required to modulate sensible heat ratio, heat recovery, heat rejection, and airflow to respond to changing latent and sensible loads throughout the grow cycle.

For high-energy-intensity indoor growing spaces, systems using separate dehumidification and HVAC components would be required to use qualifying commercial dehumidifiers and qualifying commercial HVAC equipment, together with integrated temperature and humidity controls.

Because integrated system 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 integrated HVAC/D systems could comply with the requirements, such as an integrated direct

expansion (DX) system, a desiccant-based system, or a four-pipe heat recovery chiller system.

Examples of integrated DX systems include (1) products designed and marketed exclusively to the indoor ag industry, including indoor pool dehumidification equipment that has been modified to adjust compressor capacity and fan speed in response to variable loads in indoor growing facilities and (2) off-the-shelf and custom-designed DX DOAS equipment that has been configured for 100 percent recirculated air.

An example of a qualifying desiccant-based system is a liquid desiccant system that use chilled water or refrigerant to cool and disperse a liquid desiccant solution on a wetted medium, which strips moisture from return air, while cooling the airstream. The diluted liquid desiccant is then regenerated using hot water, refrigerant, or other source of waste heat, effectively using the same heat recovery principles used in other integrated systems.

An example a qualifying system with a heat recovery chiller is a four-pipe chilled water system, which functions much like an integrated DX system, offering both variable equipment SHR and variable heat recovery/rejection. Rather than modulating refrigerant, the chilled water Fan Coil Unit adjusts flow and/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 sends hot water generated by the heat recovery chiller to a reheat coil to meet the target supply air temperature.

The proposal would require design heating, cooling, and dehumidification loads to be calculated according to a new Joint Appendix and specified in construction documents for indoor growing spaces with high lighting intensity. All types of HVAC/D systems would need to be sized to meet both sensible and latent loads for representative mid- and late-stage grow cycle conditions, including both lights-on and lights-off operation.

All covered systems would be required to use integrated temperature and humidity controls capable of coordination cooling, dehumidification, airflow, and supplemental equipment based on canopy-level measurements.

Systems using commercial dehumidifiers in combination with separate HVAC equipment would be required to centrally coordinate and sequence all equipment to meet temperature and humidity setpoints. Dehumidifiers without modulating heat recovery and rejection would need to be automatically staged based on dehumidification load and limited to operation under specified conditions.

Control system functionality would be verified through acceptance testing performed by a field technician.

The requirements would apply in all 16 California Climate Zones to new construction, additions, and major alterations. Replacing a single component of a larger system would

not trigger the requirements. Covered alterations would include those projects that increase plant canopy area by at least 5,000 square feet, replace greater than 50 percent of the total capacity of heating, ventilation, air conditioning, cooling, and dehumidification systems serving at least 5,000 square feet of plant canopy area in indoor growing spaces, or increase the lighting power density to at least 30 W per square foot of canopy area.

A prescriptive and performance compliance framework was evaluated during measure development, including the use of a detailed EnergyPlus-based prototype¹⁷ to support a potential performance pathway. However, due to the current absence of an approved and standardized compliance modeling approach for indoor growing space conditioning systems within the Title 24 compliance software environment, neither prescriptive nor performance compliance pathways are included in this code cycle.

To ensure enforceability and timely implementation, the proposal focuses on mandatory requirements that establish minimum system functionality, sizing, and control performance. Development of prescriptive and performance compliance pathways may be considered in future code cycles as modeling approaches and compliance tools for indoor growing applications mature.

The proposal also includes updates and clarifications to existing mandatory requirements for dehumidification, HVAC, envelope, non-horticultural lighting, and controls. This includes clarifying that several mandatory requirements for nonresidential buildings are not appropriate for indoor growing spaces and may negatively impact plant growth and development if required. Existing requirements will otherwise continue to apply to all indoor growing spaces, including those with less than 5,000 square feet of canopy under high-intensity lighting, and indoor growing spaces with lighting intensity of less than 30 watts per square foot of canopy.

This proposal would also revise outdoor air ventilation requirements for CO₂-enriched CEH spaces. The proposal would establish these spaces as process environments and remove continuous minimum outdoor air ventilation requirements that can interfere with CO₂ enrichment and increase conditioning loads. Occupant safety would continue to be addressed through existing California Fire Code requirements for CO₂ monitoring, alarm response, and purge ventilation. The proposed approach is consistent with treatment of other process spaces in Title 24, Part 6, including refrigerated and freezer spaces, which are not subject to minimum outdoor air ventilation rates.

¹⁷ Supplemental materials, including the indoor CEH prototype and EnergyPlus models used to estimate per-unit energy savings, are available at: <https://title24stakeholders.com/measures/2028-cycle/controlled-environment-horticulture-requirements-for-space-conditioning-systems/>

The proposal does not include any new requirements for non-CEH spaces within CEH facilities. Instead, it clarifies that indoor growing spaces are subject only to certain mandatory requirements, while non-CEH spaces are subject to both mandatory and prescriptive requirements for nonresidential buildings.

Finally, the proposal would clarify that prescriptive requirements for nonresidential buildings do not apply to CEH process spaces within nonresidential buildings, and that indoor growing spaces only need to comply with mandatory requirements, including mandatory envelope requirements based on construction type. The proposal would also clarify that CEH process spaces are not eligible for HVAC or envelope tradeoffs through the performance compliance pathway.

Table 56 summarizes the scope of the proposed code change.

Table 56: 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"> Part 6, Sections 201, 401.2, and 908.1 Nonresidential Reference Appendix Sections NA7 and NA9 Joint Appendix JA19 	NRCC-MCH-E NRCC-PRC-E NRCI-PRC-E NRCA-PRC-XX-F	N/A

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	

4.1.2 Proposed Changes Relative to Current Code

4.1.2.1 Overall Framework and Scope

Current:

- The only space-conditioning requirement that applies specifically to Indoor Growing in the current code is the mandatory indoor growing dehumidification requirement.
- Current code also includes CEH-specific horticultural lighting and electrical power distribution requirements, but it does not include CEH-specific requirements for HVAC sizing, HVAC controls, integrated HVAC/dehumidification system operation, or Indoor Growing envelope performance.
- Because Indoor Growing spaces are typically mechanically cooled or heated to maintain temperatures between 55F and 90F, they do not meet the current definition of Process Space. As such, they have often been treated as directly conditioned nonresidential spaces, unless a specific exception applies.
- As a result, current nonresidential mandatory, prescriptive, and performance-path requirements have been interpreted to apply to Indoor Growing spaces, even though those requirements were largely developed around conventional nonresidential buildings, human occupancy schedules, and comfort HVAC assumptions.
- Current space-type definitions and code requirements have been interpreted in an inconsistent manner, with respect to how prescriptive nonresidential requirements apply to CEH spaces and Indoor Growing. In practice, Indoor Growing spaces are often treated as conditioned warehouses or similar nonresidential spaces for compliance purposes, even though the loads, controls, schedules, and equipment are substantially different.

Proposed:

- Create a clearer mandatory-only framework for Indoor Growing within the CEH covered-process section of the code.
- Clarify that Indoor Growing spaces are process space, and not directly conditioned space, for purposes of applying nonresidential prescriptive and performance requirements.
- Establish two categories of Indoor Growing requirements:
 - Base requirements that apply to all Indoor Growing spaces, regardless of canopy area or lighting intensity.
 - These include requirements that are already appropriate as mandatory requirements or are directly related to CEH

dehumidification, equipment, ducts, piping, envelope backstops, horticultural lighting, and metering.

- Additional high-intensity Indoor Growing requirements that apply only where the space-conditioning system serves at least 5,000 square feet of plant canopy area and horticultural lighting power density is greater than or equal to 30 W/ft² of plant canopy area.
 - These include indoor-growing-specific sizing, integrated HVAC/D or coordinated decoupled HVAC/D system requirements, plant-canopy sensing, coordinated controls, commercial dehumidifier qualification, commercial HVAC requirements, recovered heat requirements, and acceptance testing.
- Clarify that other nonresidential spaces in the same facility remain subject to applicable nonresidential requirements. This includes drying rooms, processing rooms, packaging rooms, offices, corridors, restrooms, break rooms, storage rooms, and other support spaces.
- These requirements would only apply to indoor growing spaces. Conditioned greenhouses are a separate type of CEH space and remain outside the scope of this Indoor Growing HVAC/D proposal.

4.1.2.2 Definitions and Space Types

Current:

- Current code defines CEH space broadly as a space dedicated to plant production by manipulating indoor environmental conditions such as lighting, irrigation, mechanical heating, mechanical cooling, or dehumidification.
- Current code defines Indoor Growing as a subtype of CEH space in a building with a skylight roof ratio less than 50 percent, including warehouses with or without skylights.
- Current code defines Directly Conditioned Space based on mechanical heating and mechanical cooling capacity thresholds and excludes process space. However, the current Process Space definition is tied to temperature ranges that do not capture conditions typical of cannabis flower rooms or other Indoor Growing spaces.
- Because most Indoor Growing spaces fall within the directly conditioned space definition, current nonresidential requirements may be triggered even where the systems are designed to support plant production rather than human comfort.

Proposed:

- Modifies the broad CEH space definition from “a building space dedicated to plant production” to “a building space dedicated to plant cultivation.” Therefore, it would

not include drying rooms, processing rooms, packaging rooms, storage rooms, offices, corridors, restrooms, or other support spaces where actively growing plants are not cultivated.

- Indoor Growing would be the primary applicability trigger for the HVAC/D requirements because it is limited to indoor spaces where actively growing plants are cultivated.
- Change the definition of Process Space to include CEH Spaces. This will clarify that Indoor Growing spaces are not considered directly conditioned space for purposes of the nonresidential prescriptive and performance compliance paths.
- Creates a high-intensity Indoor Growing category for additional HVAC/D requirements. The high-intensity category is based on plant canopy area and lighting power density, not gross building area.

4.1.2.3 Compliance Paths and Approach to Prescriptive Measures

Current:

- Current code allows most nonresidential buildings to comply using either the prescriptive path or the performance path, with mandatory requirements applying in either case.
- Since Indoor Growing spaces are treated as directly conditioned nonresidential space, project applicants can model those spaces as warehouses or similar nonresidential spaces and use performance tradeoffs between envelope, HVAC, lighting, and other modeled features.
- Current nonresidential compliance models do not represent the key drivers of Indoor Growing HVAC/D energy use, including high-intensity horticultural lighting, plant evapotranspiration, grow-cycle load variation, lights-on/lights-off operation, integrated dehumidification and reheat, and plant-canopy temperature and humidity controls. Therefore, significant software updates would be required to make performance-based compliance a viable path for indoor growing spaces.
- Prescriptive nonresidential HVAC and envelope requirements have been interpreted to apply to Indoor Growing spaces, unless specifically exempted. However, these requirements were not developed for plant-growth process spaces.

Proposed:

- Indoor Growing spaces would comply through mandatory requirements only.
- Indoor Growing spaces would not use the nonresidential performance path for HVAC/D or envelope compliance in the 2028 code cycle.

- Prescriptive nonresidential requirements would not apply to Indoor Growing spaces. However, some language from prescriptive sections would be added to new mandatory sections for Indoor Growing.
- Existing nonresidential mandatory requirements that are appropriate for Indoor Growing will be incorporated by reference in the CEH section.
- Existing nonresidential mandatory requirements that need significant revisions to align with Indoor Growing spaces would be described directly in the CEH section rather than incorporated by reference.

4.1.2.4 Mandatory Nonresidential Requirements Preserved for Indoor Growing

Current:

- Current code includes multiple mandatory nonresidential requirements that are not inherently based on human occupancy assumptions and can be appropriate for Indoor Growing when the relevant equipment or building component is installed.
- These include requirements for regulated equipment, appliance certification, equipment efficiency, ducts and plenums, pipe insulation, envelope components, service water-heating equipment, electrical power distribution, horticultural lighting, and acceptance testing where specific features are installed.
- Current code does not clearly distinguish between mandatory nonresidential requirements that are appropriate for Indoor Growing versus those that may negatively impact plant growth, efficiency, or create additional cost or compliance burden without significant benefit.

Proposed:

- Would apply the following categories of requirements to all Indoor Growing spaces, generally by reference, where applicable:
 - General product, system, appliance, and component requirements.
 - Appliance certification requirements for regulated appliances.
 - Equipment efficiency and certification requirements for listed commercial HVAC equipment and listed components.
 - Heat pumps with supplementary heaters, where conventional heat pumps are installed.
 - Furnace requirements, where furnaces are installed.
 - Open- and closed-circuit cooling tower water-management and control requirements, where qualifying cooling towers are installed.
 - Duct and plenum construction, insulation, sealing, and leakage requirements, where ducts or plenums serve Indoor Growing.

- Pipe insulation requirements for space cooling, space heating, process cooling, process heating, dehumidification, reheat, heat recovery, and service water-heating piping.
- Mandatory envelope component requirements for assemblies enclosing Indoor Growing spaces.
- Commercial boiler and service water-heating requirements, where those systems serve Indoor Growing spaces.
- Electrical power distribution and energy monitoring requirements, including CEH-specific horticultural lighting metering.
- Horticultural lighting requirements applicable to Indoor Growing.
- Equipment-efficiency requirements apply to equipment types that are listed in the existing equipment-efficiency framework, but existing ratings would not replace CEH-specific sizing and performance documentation.

4.1.2.5 Equipment Efficiency, Certification, and Integrated HVAC/D Requirements

Current:

- Many equipment types used in Indoor Growing are already rated and certified under existing equipment-efficiency frameworks. This includes conventional commercial unitary cooling equipment, commercial heat pumps, VRF systems, chillers, heat-recovery chillers, cooling towers, furnaces, and some DX dedicated outdoor air systems.
- However, existing ratings are generally based on comfort-cooling, conventional commercial operation, or 100 percent outdoor-air operation, not Indoor Growing conditions.
- Some integrated HVAC/D systems used in Indoor Growing are derived from DX dedicated outdoor air equipment but are reconfigured or customized for 100 percent recirculated air. These products may have certified ratings for the original equipment category, but those ratings may not represent the installed Indoor Growing configuration.
- Other integrated HVAC/D systems are based on pool dehumidification equipment or are purpose-built for indoor agriculture. These products may not have an existing equipment category or certified rating that matches their installed CEH application.

Proposed:

- Carry over existing equipment-efficiency and certification requirements for equipment types that are already listed and rated under existing standards.

- Treat existing ratings as minimum equipment-efficiency backstops, not as proof that the equipment can meet Indoor Growing sensible load, latent load, heat recovery, heat rejection, reheat, airflow, or control requirements.
- Require commercial dehumidifiers used in high-intensity indoor growing spaces to comply with the proposed commercial dehumidifier test procedure, rating, and certification pathway.
- For integrated HVAC/D systems that are not listed under an existing equipment category, allow compliance through CEH-specific functional requirements, manufacturer data, engineering calculations, design-load documentation, and acceptance testing.
- Require listed components within an integrated HVAC/D system to comply with applicable component or equipment requirements where those components are separately regulated or listed.
- Require equipment to document CEH performance at indoor growing design conditions. A certified comfort-cooling or dedicated-outdoor-air rating should not be used by itself to demonstrate CEH capacity or HVAC/D functionality.

4.1.2.6 Dehumidification and HVAC/D System Options

Current:

- Current code provides four mandatory options for Indoor Growing dehumidification:
 - Federally regulated dehumidifiers tested under the federal consumer dehumidifier test procedure and complying with federal minimum efficiency standards for consumer products.
 - Integrated HVAC systems with on-site heat recovery designed to fulfill at least 75 percent of annual dehumidification reheat energy.
 - Chilled-water systems with on-site heat recovery designed to fulfill at least 75 percent of annual dehumidification reheat energy.
 - Solid or liquid desiccant dehumidification systems for designs that require a dewpoint of 50°F or less.
- The current requirement is focused on dehumidification equipment and does not consider interactions and overlap between functions of the entire HVAC/D system.
- Current code effectively treats HVAC and dehumidification as separate systems, even though cooling, dehumidification, reheat, heat recovery, and heat rejection are highly interactive in indoor growing spaces.

Proposed:

- Retain a base dehumidification requirement for all indoor growing spaces, including dehumidifiers that meet federal standards for consumer products.

- For Indoor Growing spaces below the high-intensity threshold, continue to allow the existing dehumidification options, with the addition of qualifying commercial dehumidifiers where the proposed commercial dehumidifier pathway is used.
- For high-intensity Indoor growing spaces, replace the four current dehumidification options with two HVAC/D system pathways:
 - A coordinated decoupled HVAC/D system using qualifying commercial dehumidifiers in combination with qualifying commercial HVAC equipment.
 - An integrated HVAC/D system that provides cooling, dehumidification, recovered reheat, heat rejection, and airflow control as a unified system.
- For integrated HVAC/D systems, require at least the following capabilities:
 - On-site heat recovery to meet at least 90 percent of the reheat load based on design conditions, not annual energy consumption.
 - Primary integrated capacity sized to meet at least 80 percent of peak sensible load and at least 80 percent of peak latent load based on indoor grow design conditions.
 - Modulation of heat recovery from 0 percent to 90 percent of heat of rejection.
 - Modulation of heat rejection outside the space from 10 percent to 100 percent of heat of rejection.
 - Modulation of supply fan speed.
 - Modulation of sensible heat ratio in response to measured temperature, humidity, and setpoints.
- For coordinated decoupled systems, require qualifying commercial dehumidifiers, qualifying commercial HVAC equipment, and centralized controls that coordinate cooling, dehumidification, reheat, heat recovery or heat rejection, supplemental heating, and airflow.
- Allow the remaining load not served by a primary integrated system to be served by supplemental equipment, provided the overall HVAC/D system meets design loads and control requirements.
- Do not allow consumer dehumidifiers for high-intensity Indoor growing spaces.
- Exclude residential cooling equipment, portable air conditioners, room air conditioners, and similar residential or room-scale equipment from serving as the primary cooling equipment in high-intensity indoor growing spaces, unless the equipment also qualifies under applicable commercial equipment requirements.

4.1.2.7 HVAC and Dehumidification Controls

Current:

- Current HVAC controls requirements are generally based on human comfort, occupied and unoccupied schedules, and conventional thermostat control.
- Current nonresidential requirements include thermostatic controls for each zone, comfort setpoint limitations, deadbands, unoccupied heating and cooling setbacks, automatic shutoff, and demand-response capability where applicable.
- Current code includes some process-related exceptions, including limited exceptions related to plants, humidity control, recovered reheat, and process loads. However, these exceptions are piecemeal and do not adequately address differences between comfort and CEH controls.
- Current code allows the use of separate thermostats and humidistats to control separate cooling and dehumidification equipment.

Proposed:

- For high-intensity indoor growing spaces, require one integrated control system that controls both temperature and humidity based on readings from temperature and humidity sensors co-located in the plant canopy.
- Require controls to automatically stage or modulate all HVAC/D equipment, including cooling, dehumidification, heat recovery, heat rejection, supplemental heating, and airflow, to maintain Indoor growing temperature and humidity setpoints.
- Require a central controller for coordinated decoupled systems to sequence or modulate individual commercial dehumidifiers and cooling equipment.
- Require controls to limit resistance or combustion supplemental heating to periods when heating loads exceed available recovered heat capacity.
- Preserve requirements for heat pump supplementary heater controls where conventional heat pumps with supplementary heaters are installed. This requirement should operate separately from CEH-specific recovered-heat lockout requirements for integrated systems.

4.1.2.8 HVAC/D System Sizing and Load Calculations

Current:

- Current prescriptive HVAC sizing requirements are based on conventional heating and cooling load calculations and are generally focused on avoiding oversized comfort HVAC equipment.

- Current sizing assumptions rely on comfort indoor design conditions, outdoor design conditions, ventilation loads, envelope loads, conventional lighting loads, people loads, process loads where known, and limited safety factors.
- Current sizing language does not provide a CEH-specific method for calculating plant evapotranspiration, high-intensity horticultural lighting loads, grow-cycle variation, lights-on/lights-off operation, required dehumidification capacity, reheat load, or heat-rejection capacity.
- For indoor growing spaces, initial undersizing of systems can lead to increased long-term energy use, as additional, often inefficient, equipment is added to address deficiencies and maintain desired setpoints.

Proposed:

- For high-intensity Indoor growing spaces, require mandatory CEH-specific load calculations and sizing to meet the loads rather than prescriptive comfort-HVAC sizing. These sizing requirements would apply to any facility with at least 5,000 ft² of plant canopy grown under at least 30W/canopy ft² of lighting.
- Require HVAC/D systems to be sized to meet design heating, sensible cooling, latent cooling, dehumidification, heat-rejection, heat recovery, and reheat loads.
- Require sizing calculations to account for plant canopy area, horticultural lighting power and schedule, irrigation rates, evapotranspiration, grow-cycle stage, lights-on and lights-off operation, temperature and humidity setpoints, allowable tolerances, motor heat, and applicable outdoor design conditions.
- Require calculations for representative mid-stage and late-stage grow-cycle conditions, including both lights-on and lights-off operation.
- Shift the code objective from “smallest HVAC equipment that meets comfort heating and cooling loads” to “sufficient HVAC/D capacity and control functionality to meet plant-growth sensible and latent loads under design grow-cycle conditions.”
- Do not require the CEH-specific sizing procedure for indoor growing spaces below the high-intensity threshold.

4.1.2.9 Economizers, Outdoor Air, CO₂ Enrichment, and Ventilation

Current:

- Current nonresidential ventilation requirements are based on occupancy categories and human occupancy assumptions. Current ventilation tables do not provide a dedicated indoor growing category that reflects sealed, carbon-dioxide-enriched plant-production rooms.
- Current prescriptive economizer requirements generally apply to cooling systems above specified capacities but include exceptions where economizer operation

would increase overall building long-term system cost due to impacts on humidification, dehumidification, or other systems.

- Current code also includes an economizer exception for CEH spaces where economizer use would affect carbon dioxide enrichment systems.
- Current code does not establish a comprehensive indoor growing ventilation strategy that distinguishes energy-code ventilation from safety-code requirements for carbon dioxide monitoring, alarm response, and purge ventilation.

Proposed:

- For carbon-dioxide-enriched indoor growing spaces, set the minimum outdoor air ventilation rate to zero, for the purposes of Title 24 Part 6.
- Define new indoor growing category and minimum ventilation rate for non-CO₂-enriched spaces.
- Remove outdoor-air economizing as a default compliance assumption for indoor growing because outdoor air may increase dehumidification loads, disrupt carbon dioxide enrichment, introduce pathogen risks, or otherwise conflict with plant production.
- Relies on the California Fire Code, California Mechanical Code, and other applicable safety codes for worker safety, carbon dioxide monitoring, alarm response, emergency purge, hazardous conditions, and life-safety ventilation.

4.1.2.10 Envelope Requirements

Current:

- Current code includes mandatory envelope requirements for assemblies that separate conditioned space from unconditioned space or ambient air, including requirements for insulation, air leakage, fenestration, doors, roofs, walls, floors, and related envelope components.
- Current code also includes prescriptive envelope requirements, including roof and wall insulation levels, cool roof requirements, air barrier requirements, window and skylight limits, fenestration performance, visible transmittance, daylighting-related requirements, and exterior door requirements.
 - These prescriptive requirements are based on heat transfer, solar gain, daylighting, fenestration, and conventional building-load assumptions that often have limited relevance to sealed, windowless, high-intensity Indoor growing spaces dominated by internal lighting and plant latent loads.

- Current code includes envelope requirements for conditioned greenhouses, but conditioned greenhouse requirements are separate from indoor growing and are not the focus of this measure.

Proposed:

- Apply mandatory envelope component requirements to indoor growing spaces as base requirements, including appropriate requirements for opaque assemblies, fenestration products if present, doors, insulation, air leakage, and roofing products.
- Do not apply nonresidential prescriptive envelope requirements to indoor growing spaces.
- Do not allow lower u-factor or more tightly sealed envelope to be traded against less efficient HVAC/D, and do not allow increased HVAC/D efficiency to be traded against indoor growing envelope insulation or air sealing measures.
- For indoor growing, focus envelope requirements on minimum insulation, air sealing, and separation from other spaces.
- Apply all applicable nonresidential envelope requirements to other nonresidential spaces in the same facility, including offices, corridors, restrooms, storage, processing, and other non-grow spaces.
- Prescriptive requirements for roofing products would apply to all spaces covered by the roof but could not be used for performance compliance for indoor growing spaces.

4.1.2.11 Other Prescriptive HVAC Requirements

Current:

- Current nonresidential prescriptive HVAC requirements may apply to indoor growing if the space is treated as directly conditioned space and no specific exception applies.
- Current prescriptive HVAC provisions include requirements related to HVAC sizing, fan power, zone controls, economizers, simultaneous heating and cooling, reheat, supply-air temperature reset, electric resistance heating, heat rejection, chiller efficiency, limitations on air-cooled chillers, hydronic variable flow, fan airflow control, mechanical shutoff controls, exhaust transfer air, DOAS, exhaust air heat recovery, DDC control logic, and mechanical heat recovery.
- Some of these requirements include process-load or humidity-related exceptions, but the current exceptions do not comprehensively address indoor growing HVAC/D.

Proposed:

- Does not carry over prescriptive nonresidential HVAC requirements into the Indoor growing section.

4.1.2.12 Additions, Alterations, and Replacements

Current:

- Current code includes additions and alterations requirements for nonresidential buildings and separate requirements for covered processes.
- For buildings with indoor growing, current code states that newly installed heating, ventilation, air conditioning, or dehumidification systems must meet the applicable CEH dehumidification and metering requirements. However, the indoor growing dehumidification requirement does not establish a comprehensive HVAC alteration framework.
- Because Indoor growing may currently be treated as directly conditioned nonresidential space, nonresidential alteration requirements for HVAC, envelope, ducts, pipe insulation, controls, and equipment may also be interpreted to apply.
- This creates ambiguity for small indoor growing additions and alterations and for partial replacements such as replacement of a compressor, condensing unit, air handler, dehumidifier, duct section, piping, control panel, or lighting system.

Proposed:

- Apply base indoor growing mandatory requirements to all additions and alterations to Indoor growing spaces, regardless of size or lighting intensity.
- Apply high-intensity indoor growing HVAC/D requirements only to new construction, additions, and major alterations that meet the high-intensity threshold or cause a system or space to cross that threshold.
- Trigger the high-intensity requirements when:
 - A project creates or increases Indoor growing plant canopy area such that the total plant canopy area served by the HVAC/D system is at least 5,000 square feet and lighting power density is greater than or equal to 30 W/ft² canopy.
 - A project increases Indoor growing plant canopy area by at least 5,000 square feet and lighting power density is greater or equal to than 30 W/ft² canopy.
 - A project replaces more than 50 percent of the total installed heating, cooling, ventilation, air-conditioning, or dehumidification capacity serving high-intensity Indoor growing spaces.

- A project increases horticultural lighting power density to greater than or equal to 30 W/ft² canopy in Indoor growing spaces with at least 5,000 square feet of canopy area.
- Do not trigger the full high-intensity HVAC/D package solely because a single component of a larger HVAC/D system is replaced.
- Require replacement components to comply with applicable base requirements, such as equipment efficiency, commercial dehumidifier requirements, duct requirements, pipe insulation, and controls.

4.1.2.13 Acceptance Testing and Field Verification

Current:

- Current nonresidential mechanical acceptance testing applies to specific HVAC features and controls where triggered, including economizers, demand control ventilation, supply fan variable-flow controls, hydronic variable-flow controls, automatic demand shed controls, and related systems.
- Current acceptance testing is not tailored to indoor growing HVAC/D operation and does not verify canopy sensor placement, integrated temperature and humidity control, dehumidifier staging, heat recovery modulation, heat rejection modulation, supplemental heat lockout, or lights-on/lights-off performance.
- Current acceptance testing does not provide a CEH-specific method to verify that HVAC and dehumidification equipment are coordinated to meet plant-growth setpoints.

Proposed:

- Adds CEH-specific acceptance testing for high-intensity Indoor growing HVAC/D controls and system operation.
 - Verify that temperature and humidity sensors used for control are located in the plant canopy.
 - Verify that equipment capacities and performance characteristics are documented in construction documents.
 - Verify central controller sequencing of commercial dehumidifiers in coordinated decoupled systems.
 - Verify supplemental heating lockout when recovered heat is available.
 - Verify integrated cooling, dehumidification, reheat, heat recovery, heat rejection, and airflow operation under representative operating conditions.
 - Verify sensible-only, sensible-plus-latent, and latent-plus-heating operating modes to reflect lights-on and lights-off conditions.

- Integrates existing acceptance testing requirements for HVAC equipment by listing appropriate tests under mandatory acceptance testing requirements for indoor growing, while noting that many will not apply unless triggered by the selection of specific equipment.
- All acceptance testing to be performed by field technicians, not by certified Acceptance Test Technicians.

4.1.2.14 Shared Systems and Mixed-Space Buildings

Current:

- Aside from a few exceptions for CEH spaces and specific mandatory requirements for indoor growing, CEH facilities that include indoor growing spaces and other nonresidential spaces in the same building are subject to the same nonresidential code requirements.
- Other spaces subject to nonresidential code may include drying rooms, processing rooms, packaging rooms, offices, corridors, restrooms, break rooms, storage rooms, fertigation rooms, electrical rooms, and other support areas.
- Current code may apply requirements based on the occupancy and conditioning status of the building or space.

Proposed:

- Indoor growing spaces should comply with the indoor growing requirements in the CEH section.
- Non-Indoor growing spaces in the same facility should continue to comply with applicable nonresidential requirements based on occupancy and space type.
- Where a system or component exclusively serves indoor growing spaces, apply the indoor growing requirements.
- Where a system or component exclusively serves non-indoor growing spaces, apply the applicable nonresidential requirements.
- Where a system serves a mix of indoor growing space, high-intensity Indoor growing space, and/or other nonresidential spaces, the components of the system serving each space would need to comply with the specific mandatory requirements applicable to that space.
- For shared service water heating, photovoltaic, battery energy storage, and solar-ready requirements, building-level or occupancy-based requirements would apply to the overall building or non-Indoor growing spaces.

4.1.2.15 Items Outside the Scope of this Measure

- The proposal does not resolve all ambiguity related to conditioned greenhouses. Conditioned greenhouses are CEH spaces, but they are not indoor growing spaces as targeted by this HVAC/D proposal.
- The proposal does not create a performance compliance pathway for Indoor growing in the 2028 code cycle because there is no approved standardized Indoor growing compliance model or prototype for CEH HVAC/D systems.
- The proposal does not attempt to regulate worker safety ventilation, carbon dioxide monitoring, emergency purge, or alarm response beyond the energy-code ventilation treatment described above. Those requirements should remain coordinated with applicable fire, mechanical, occupational safety, and local codes.
- The proposal does not require a specific HVAC/D technology for all high-intensity Indoor growing spaces. It allows both integrated HVAC/D systems and coordinated decoupled systems, provided they meet mandatory CEH sizing, equipment, control, heat recovery, and acceptance testing requirements.

4.1.3 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 was 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 indoor growing facilities found an average Energy Use Intensity (EUI) of 760 kBtu/yr per ft² (Stober & Weitze, 2024).

Since large-scale indoor farming is relatively new, driven primarily by legalization of cannabis in California, indoor growing facility designers initially had little choice but to repurpose conventional HVAC equipment and consumer 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 SHR¹⁸ (sensible heat ratio), or

¹⁸ 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).

staging of equipment with fixed SHR. Controls, sizing methods, design approaches, and equipment requirements are vastly different from those for spaces designed primarily for human occupancy, and off-the-shelf 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 high-capacity, efficient commercial dehumidifiers, plant canopy sensors, and controls that can integrate HVAC and dehumidification equipment, as well as variable capacity, fully integrated space conditioning systems that are suitable for high latent loads, and capable of adjusting to highly variable loads.

Energy models and field data reviewed by the CASE Team indicate that modern, well designed integrated HVAC/D systems offer significantly better environmental control and more efficient operation than code-minimum, fixed-capacity fully decoupled¹⁹ systems. However, not all integrated systems are inherently efficient, and not all decoupled systems are inherently inefficient. This proposal addresses common design and performance failures seen in both integrated and decoupled systems.

Decoupled systems that use high-efficiency equipment and a central control system that stages and/or modulates equipment based on readings from humidity and temperature sensors co-located in the canopy can also operate efficiently. Unfortunately, many designers continue to use inefficient fully decoupled equipment in the design of new facilities, even though much more efficient, better performing equipment and controls are now available from multiple manufacturers and have 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).

Integrated systems with undersized hot gas reheat capacity, inability to modulate hot gas reheat, lack of airflow modulation, or excessive reliance on electric resistance heat can also perform poorly. Although some early integrated DX systems installed in California cannabis facilities lacked these key functional capabilities, those features are now widely available from multiple manufacturers and would be explicitly required under the proposed 2028 code requirements. As a result, the proposed code would effectively prohibit integrated system designs that rely on fixed-capacity operation, insufficient heat recovery capacity, or routine use of electric resistance reheat to maintain space conditions.

¹⁹ 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 indoor growing facilities.

The proposal would improve performance for both integrated and coordinated decoupled system configurations by establishing enforceable requirements for sizing, controls, and equipment qualification, while also addressing a regulatory gap for commercial dehumidifiers commonly used in indoor growing facilities. The proposal also creates a state qualification pathway for commercial dehumidifiers used in indoor growing applications, where the existing federal consumer-dehumidifier framework does not adequately address the equipment commonly used in these spaces.

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 annual energy used by more efficient integrated HVAC/dehumidification (HVAC/D) systems is approximately 25 percent less than energy use by a fully decoupled, code-minimum HVAC and dehumidification system, consistent with measured and modeled data discussed in Section 4.1.4.

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 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.

Finally, by categorizing Indoor Growing as a unique space type that is not subject to most prescriptive requirements for nonresidential buildings, the proposal would simplify and align code with the unique properties of these spaces. This will help avoid the unintended consequences of applying code requirements developed for human-occupied spaces to spaces designed to support plant growth and development.

4.1.4 Background Information

Controlled environment horticulture (CEH) refers to the practice of growing plants in a protected, enclosed space where factors such as light, temperature, humidity, and airflow can be carefully managed. CEH includes greenhouses and indoor growing facilities without external light sources. CEH methods are used for crops such as vegetables, herbs, microgreens, flowers, cannabis, and other plants. For purposes of

Title 24, Part 6, CEH does not include mushroom production because mushrooms are fungi rather than plants.

The proposed code changes apply to indoor growing spaces with at least 5,000 square feet of plant canopy and lighting power density at least 30 W/ft² of canopy. The 30 W/ft² threshold is intended to identify indoor CEH spaces with high lighting intensity and significant interactions between latent loads, sensible loads, and environmental setpoints. These conditions require specialized HVAC/D design and controls. While the threshold does not regulate a specific crop, it is expected to primarily capture high-energy intensity cannabis flowering applications currently common in California's indoor CEH market.

The first draft of this CASE report recommended establishing prescriptive requirements for integrated HVAC/D systems, while allowing performance-based compliance for systems that did not meet those requirements. Due to the current limitations of CBCECC and other code-compliance software, as well as concerns raised by some stakeholders, the final CASE report has been updated to focus on mandatory requirements for all system types.

4.1.4.1 Indoor Growing Facilities in California

Indoor CEH facilities in California are used for a range of agricultural, research, and specialty crop applications. However, over 90 percent of indoor CEH facilities in California are currently used for cannabis cultivation. 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 may also engage in license stacking where multiple small licenses operate within a single larger facility.

Indoor cultivation of food crops remains relatively limited in California. Several large leafy greens vertical farms have exited the market, including Plenty's South San Francisco (AgFunderNewsletter, 2023) and Compton facilities (Herrick, 2024). Industry analysis suggests that California's mild climate makes greenhouse and outdoor production substantially less expensive and more economically viable than fully indoor cultivation for many crops (Taylor, 2025).

Smaller indoor CEH facilities continue to be used for specialty food production, research, and agricultural technology development. Examples include indoor microgreen and wasabi production facilities, university research vertical farms, plant propagation chambers, and indoor agriculture research and development facilities operated by agricultural technology companies (Malaias Microgreens, 2025; Cai Foods,

2025; Stumbos, 2021; Cal Poly BRAE Vertical Farm, 2025; Willo Farms, 2025; Omdena, 2024; Darwin Chambers, 2025).

California also has significant indoor mushroom production, but mushroom cultivation is outside the scope of this report because mushrooms are not included within the Title 24, Part 6 definition of Controlled Environment Horticulture.

4.1.4.2 Indoor CEH Facilities

Indoor CEH facilities are fundamentally different from conventional commercial buildings because they are designed to optimize plant growth rather than human comfort. These facilities maintain precise control over environmental variables including lighting, temperature, humidity, airflow, irrigation, and carbon dioxide concentration. In many facilities, outdoor air ventilation is minimized to retain enriched CO₂ levels and reduce introduction of contaminants and plant pathogens.

Facilities using high-intensity indoor cultivation methods are among the most energy-intensive building types in California. Indoor cannabis cultivation, in particular, has been identified as one of the most energy-intensive commercial activities on a site energy intensity basis, second only to data centers (Sabehe, Miner, & Perman, 2022). Unlike data centers, however, cannabis cultivation facilities serving the California market generally cannot relocate production to lower-cost electricity regions because cultivation and distribution are regulated on a state-by-state basis.

Indoor cultivation spaces also present unique HVAC and dehumidification challenges because sensible and latent loads vary significantly throughout the plant growth cycle. A typical flowering cycle lasts approximately eight to ten weeks and progresses through multiple growth stages, each with different lighting schedules, evapotranspiration rates, temperature targets, and humidity setpoints (Mr. Grow It, 2025). During later growth stages, evapotranspiration from mature plants can create substantial latent loads while simultaneously offsetting much of the sensible heat generated by lighting. Earlier growth stages, by contrast, are often dominated by sensible cooling loads because immature plants transpire significantly less moisture.

As a result, indoor flower rooms are often the most energy-intensive spaces within CEH facilities and require HVAC/D systems capable of continuously adapting to changing sensible and latent loads (Stober & Weitze, 2024). 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 facilities transition to more efficient LED lighting, the proportion of energy used for space conditioning is expected to increase. Further increasing the importance of efficient HVAC/D system design and operation

4.1.4.3 Space Conditioning Systems in Indoor Growing Spaces with High Lighting Intensity

Space conditioning systems in indoor growing spaces with high lighting intensity 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.

Although this code proposal does not differentiate between crop types, the Statewide CASE Team has not identified any indoor crops, aside from cannabis, that are grown under lighting intensities of over 30W/square foot. As such, the assumptions and analysis presented in this report are based on current market practice for cannabis flower rooms.

4.1.4.3.1 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, equipment with high SHR ratings must be used in combination with low SHR equipment, such as standalone dehumidifiers, to control both latent and sensible loads in cannabis farms.

4.1.4.3.2 Evolution of Space Conditioning Systems in California Cannabis Facilities

Historically, indoor growing 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 self-contained, 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.

However, code-minimum decoupled systems remain significantly less efficient than well-designed integrated solutions with variable capacity, modulating reheat, and variable speed fans. Stand-alone dehumidifiers exhaust all their condenser heat back

into the grow space. This dehumidification process simply converts latent heat to sensible heat and does not increase the total cooling load. However, standalone dehumidifiers also reject heat from the compressor and fan motors. 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. Finally, variable capacity integrated systems can maintain the low coil temperatures required and reduced airflows needed to manage the latent-dominant loads in these spaces, continuously dehumidifying. In contrast, fixed capacity cooling equipment must cycle the compressor on and off, re-entraining moisture into the space, reducing efficacy and control.

4.1.4.3.3 *Integrated Space Conditioning Systems for Indoor Growing Spaces*

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. Because the supply air temperature closely matches the desired conditions for the plants, integrated systems can reduce the need for additional circulation fans to mix the hot dry air delivered by dehumidifiers with cold air delivered by cooling systems.

Well-designed integrated DX systems use variable capacity compression systems 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 and additional reheat capacity. Examples of purpose-built integrated DX equipment include products from manufacturers such as Agronomic IQ, DesertAire, and Cultiva. Examples of off-the-shelf DX DOAS equipment that can be configured for 100 percent recirculated air include products from AAON, CaptiveAire, and Trane.

An example of a qualifying desiccant-based system is a liquid desiccant system that use chilled water or refrigerant to cool and disperse a liquid desiccant solution on a wetted medium, which strips moisture from return air, while cooling the airstream. The diluted liquid desiccant is then regenerated using hot water, refrigerant, or other source of waste heat, effectively using the same heat recovery principles used in other integrated systems. Examples of liquid desiccant systems that use waste heat for regen include products from Mojave and AirGreen.

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. Heat recovery chillers are available from major manufactures like Trane, Carrier, York, and Daikin, as well as many smaller manufacturers.

4.1.4.3.4 *Decoupled Space Conditioning Systems for Indoor Growing Spaces*

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 the least efficient examples of these systems, multiple pieces of cooling equipment are controlled by a single, wall-mounted thermostat and multiple dehumidifiers are controlled by a single humidistat.

An example of a fully decoupled system is fixed capacity residential splits or 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.

Although decoupled systems are the most common HVAC/D system type in small, medium, and some large indoor cannabis farms, not all are created equal. Some operators have upgraded these systems through the installation of integrated sensors and controls, which measure temperature and humidity near the plant canopy and sequence individual cooling and dehumidification units to meet loads. In the worst cases, operators who have excess latent load (a common result of transitioning to LED lighting) modify cooling equipment to reduce its coil temp and SHR, adding electric resistance to reheat air. In better performing systems, operators add commercial dehumidifiers to handle additional latent load, using condenser heat for reheat.

The best performing decoupled system also stage or modulate individual pieces of equipment in response to increasing sensible and latent loads. For example, in a room with 10 standalone dehumidifiers a central control reading canopy sensors would bring one or two units on at a time, as needed to manage humidity. This approach allows individual units to achieve longer run times, increasing efficacy of the equipment. It also avoids overdrying the room and avoids creating a large, instantaneous sensible load that triggers the cooling systems to activate, further drying the room. Some manufacturers are now offering variable capacity standalone dehumidifiers that can individually adjust to latent conditions and avoid defrost cycles that can plague fixed-capacity dehumidifiers when room conditions are cold and dry.

The proposal addresses these inefficiencies by requiring 1.) that systems are sized to design conditions at three points in the flower cycle, 2.) requiring integrated sensors and controls for HVAC and dehumidification equipment, 3.) requiring staging or modulation of unitary equipment, 4.) requiring the use of commercial dehumidification and HVAC equipment, and 5.) establishing efficiency requirements for commercial dehumidifiers.

Under the current code, federally regulated consumer dehumidifiers (classified as either “whole home” or “portable”) may be used as one indoor growing dehumidification option. Under the proposed code, that option would remain available only for indoor growing spaces at or below the lower applicability threshold; covered high-intensity spaces would instead be required to use qualifying commercial dehumidifiers or an integrated system path. 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 for consumer products.

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, standard commercial VRF cooling equipment can only modulate cooling capacity. Since standard space-conditioning VRF equipment is designed for high-SHR applications, it is relatively 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 the plants’ 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 or with commercial HVAC equipment. However, this hybrid approach requires a central control system to synchronize the standalone dehumidifiers integrated HVAC/D or a conventional HVAC system. Accordingly, when used in combination with integrated HVAC/D, the proposed code change permits the use of supplemental dehumidification, provided the equipment is automated to operate when the HVAC system cannot meet the full load, or when the waste heat generated by the dehumidifiers contributes usefully to the room’s heating requirements.

Coordinated decoupled systems can improve performance when temperature and humidity controls are integrated, equipment is staged or modulated, and canopy-level sensors are used. However, these systems generally require more careful control integration than packaged integrated HVAC/D systems because cooling and dehumidification functions are distributed across separate equipment.

4.1.4.3.5 Conventional and Proposed HVAC and Dehumidifier Standards for Indoor Growing Process Spaces

Conventional commercial HVAC codes and standards are ineffective for ensuring the efficiency of indoor growing 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 HVAC equipment and consumer dehumidifiers are based on operation in commercial and residential buildings. Federal test procedures and energy performance ratings, such as Seasonal Energy Efficiency

Ratio (SEER), Energy Efficiency Ratio (EER), or Integrated Energy Efficiency Ratio (IEER) for air conditioning, Integrated Part Load Value (IPLV – for chillers), and Integrated Seasonal Moisture Removal Efficiency (ISMRE2 – for DOAS) establish baseline efficiency of regulated equipment, but the test procedures used to obtain these ratings are based on typical residential and 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 an indoor growing 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 indoor growing facilities are based on pool dehumidifiers, or are purpose built for indoor agriculture, and not covered by current federal standards. 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 metric.

New federal test procedures and efficiency standards for packaged commercial cooling and heat pump equipment were adopted in 2024. These new standards will take effect on January 1st, 2029, the same date that Title 24 2028 Standards are scheduled to take effect. Although the new Integrated Ventilation Energy Consumption (IVEC) and Integrated Ventilation Heat Efficiency (IVHE) test procedures still do not reflect the operating conditions found in indoor growing flower rooms, commercial products meeting minimum IVEC and IVHE standards are considerably more efficient than residential products that meet minimum residential efficiency standards, which were last updated in 2017. Furthermore, Title 24 already requires commercial packaged cooling equipment to have between two and four cooling stages, improving environmental control and increasing the efficiency of decoupled HVAC/D systems.

Similarly, test procedures and ratings for VRF systems do not reflect the conditions found in indoor agriculture. However, since VRF is a variable capacity technology, it is better suited to the variable loads found in indoor growing than fixed capacity cooling equipment.

Efficiency ratings are unavailable for some integrated HVAC/D equipment used in indoor growing facilities and those products that are rated use test procedures do not reflect the actual operating conditions in these facilities. Therefore, the proposed code changes for integrated HVAC/D systems focus on other performance-based requirements including sufficient heat recovery, modulating dehumidification and reheat capacity, load sizing calculations, and controls verification, which are not addressed by federal or ASHRAE standards.

Although the federal test procedure for consumer dehumidifiers does not reflect the dynamic operating conditions found in indoor growing facilities, there are elements of

the consumer test procedure that are already used by manufacturers of commercial dehumidifiers, and with some modifications can provide a useful, if not perfect, standard for commercial dehumidifiers used in California indoor growing facilities. Therefore, the CASE Team has proposed that California use a variation of that test procedure to establish minimum efficiency requirements for commercial dehumidifiers.

Commercial dehumidifiers used in indoor growing facilities are typically installed in an un-ducted configuration, but occasionally installed with ducting, which can target the parts of the room with the most humidity, improve supply distribution, avoid short-circuiting, and in some cases integrate with an air handler. Although ducting increases the static pressure and dehumidifier energy use in a controlled test environment, that increased energy may be offset by the factors described above. Therefore, the proposed test procedure for commercial dehumidifiers does not include separate requirements for ducted vs. un-ducted installations. Instead, it includes testing under both ducted and un-ducted configurations for commercial dehumidifiers that can be installed with or without ducts.

Furthermore, federal test procedures for consumer dehumidifiers only specify a single set of test conditions. Appendix X, which is currently marked “reserved”, is an older framework that was used to calculate energy factor (EF). It does not distinguish between whole-home and portable dehumidifiers and does not account for standby energy use. Appendix X uses test conditions of 80F / 60% RH, which are the conditions commonly reported by manufacturers of commercial dehumidifiers for both capacity and efficiency, in pints-per-day and pints/kWh. However, the current consumer test procedure, described in Appendix X1, specifies test conditions of 65 F / 60% RH and 73F / 60% RH for portable and whole-home dehumidifiers, respectively, while requiring 0.20 in. w.c. of static pressure for whole-home dehumidifiers.

Although each of these consumer dehumidifier test conditions represent a set of conditions that is likely to occur during the course of a typical flower cycle, none of them reflect the cool/dry conditions typical in the last few weeks of the flower cycle that are common in cannabis flower rooms. For example, the energy models developed by the Statewide CASE Team assume lights-on setpoints of 82F / 67 % RH in the first phase of the flower cycle, 79F / 57 % RH in the middle of the flower cycle, and 73F / 48% RH during the late flower cycle, which are consistent with industry practice, based on input from multiple subject matter experts (SMEs).

Although not all growers target cool and dry conditions in the late flower cycle, some manufacturers have designed equipment to improve its performance in cool, dry conditions²⁰.

To maintain consistency with existing test procedures for consumer dehumidifiers, while better reflecting the real-world performance for commercial dehumidifiers used in indoor growing spaces, the proposal recommends testing commercial dehumidifiers at the following conditions:

- 80 F / 60% RH, 0.00 w.c. static pressure
- 73 F / 60% RH, 0.20 w.c. static pressure
- 73 F / 50% RH, 0.00 w.c. static pressure

The proposal recommends using an average of the results from these three tests to set efficiency requirements for commercial dehumidifiers. Since the first two test conditions are already established in Appendix X and X1, respectively, manufacturers have likely already tested their equipment to one or both of those conditions, requiring no more than two additional tests to comply with the proposed requirements.

It should be noted that although RH is typically higher during the first phase of the flower cycle, dehumidification loads are very low during the first phase, so although testing performance under those conditions is relevant, it is not weighted for real-world load conditions.

The results of testing at each of the three conditions described above would be averaged together to calculate the Commercial Integrated Energy Factor (CIEF). For example, a commercial dehumidifier that achieved a rating of 3.7L/kWh at 80F / 60% RH unducted, 3.1L/kWh at 73F / 60% RH ducted, and 2.6L/kWh at 73F/50% RH unducted would have a CIEF of $(3.7+3.1+2.6)/3=3.13\text{L/kWh}$.

The proposal would establish a CIEF standard of 3.0L/kWh for dehumidifiers used in indoor growing facilities with over 5,000 square feet of plant canopy under high-intensity lighting.

The CASE Team reviewed published data from a major manufacturer of commercial dehumidifiers, combined with results from an online calculator provided by the same manufacturer to estimate the CIEF for eight of their commercial dehumidifier products. All but one of those eight products available from that manufacturer would comply with the proposed CIEF standard.

²⁰ <https://www.anden.com/blog/ask-anden-how-to-reduce-defrost-cycles-with-anden-senior-applications-engineer-randy-lenz/>

The proposed test procedure for commercial dehumidifiers is described in the proposed language for Joint Appendix 19 Qualification Requirements for Commercial Dehumidifiers, provided in Section 4.6.4.

These additions aim to improve energy performance and system reliability for CEH applications.

4.1.4.3.6 Minimum Ventilation Rates in CO₂-Enriched Spaces

Section 401.2.1 [*Section 120.1*] – Requirements for Ventilation and Indoor Air Quality, establishes minimum outdoor air ventilation rates for different categories of nonresidential spaces. However, there are currently no ventilation categories or requirements specifically addressing CEH spaces, including spaces enriched with CO₂ to support plant growth. As a result, designers, contractors, and code officials have had to interpret how conventional ventilation requirements should apply to these unique process spaces.

Several subject matter experts involved with HVAC/D design for cannabis cultivation facilities report that industry standard practice is to provide little-to-no continuous outdoor air ventilation in CO₂-enriched CEH spaces. This approach is used to retain enriched CO₂ within the growing environment, reduce conditioning loads, and limit the introduction of outside contaminants and plant pathogens.

Without a specific CEH occupancy category, designers and code officials have generally relied on miscellaneous occupancy categories in Table 401.2-A [*Table 120.1-A*] – Minimum Ventilation Rates include Miscellaneous Spaces such as Warehouse and All Others, which require a minimum outdoor air ventilation rate of 0.15 cfm/ft².

However, several SMEs have reported that many code officials recognize the operational conflicts associated with applying continuous outdoor air ventilation to CO₂ enriched cultivation spaces and there either exempt these spaces from the requirement or do not actively enforce it.

Indoor CEH cultivation spaces are fundamentally process environments designed to support plant growth rather than continuous human occupancy. Workers typically enter these spaces intermittently to perform cultivation, maintenance, and harvesting activities. The primary occupant safety concern in CO₂-enriched spaces is elevated carbon dioxide concentration rather than oxygen depletion. Although these spaces intentionally maintain elevated CO₂ concentrations, they also typically maintain normal or elevated oxygen concentrations during lights-on operation because oxygen is continuously generated through plant photosynthesis.

The life-safety risks associated with elevated CO₂ concentrations are already addressed through the California Fire Code (Title 24, Part 9).

Section 5307.4 of the 2025 California Fire Code (Carbon Dioxide Enrichment Systems) establishes requirements for the design, installation, and operation of carbon dioxide enrichment systems, including gas detection systems, alarm-response, automatic shutoff of CO₂ injection systems, and mechanical purge ventilation. The Fire Code requires exhaust ventilation systems capable of at least one cfm/square foot when an unsafe CO₂ concentration is detected and requires these systems to remain operational until manually reset. The Fire Code also requires CO₂-enriched spaces to be maintained at a negative pressure relative to adjacent spaces, which can be achieved through ventilation strategies serving surrounding spaces other than continuous exhaust ventilation directly within the cultivation room.

The proposed approach is also consistent with treatment of other process spaces already addressed in Title 24, Part 6. For example, refrigerated and freezer spaces in Table 401.2-A are assigned a minimum outdoor air ventilation rate of zero cfm/ft² because they are conditioned primarily to support a process function rather than continuous human occupancy. Similarly, CO₂-enriched CEH spaces are operated to maintain specific environmental conditions necessary for agricultural production, and continuous outdoor air ventilation can interfere with those process conditions by exhausting enriched CO₂ and increasing conditioning loads.

Accordingly, the proposal would add a new “CO₂-Enriched CEH Space” category to Table 401.2-A [Table 120.1-A] with a minimum outdoor air ventilation rate of zero cfm/ft², while continuing to rely on the California Fire Code for CO₂ monitoring, alarm response, and purge ventilation requirements. Outdoor air ventilation would not be prohibited, but the proposal would remove the requirement for continuous minimum outdoor air ventilation in these specialized process environments. This approach aligns ventilation requirements with current industry practice, existing life-safety regulations, and the operational characteristics of CO₂-enriched cultivation spaces.

4.1.4.3.7 Other Nonresidential Requirements

Determining which nonresidential energy code requirements apply to indoor growing spaces has required interpretation beyond the specific mandatory requirements identified for Controlled Environment Horticulture (CEH) spaces. While certain exceptions for CEH spaces are explicitly identified in the code, other general exemptions, such as those applicable to process spaces, require the applicant or enforcement agency to determine applicability. Except where exemptions apply, indoor growing spaces have generally been subject to the mandatory and prescriptive requirements of the nonresidential code.

Many existing mandatory requirements are appropriate for indoor growing spaces; however, several were developed primarily for human-occupied spaces and may increase energy use, add unnecessary cost, or adversely affect plant growth and

development when applied to cultivation environments. Under the proposed approach, mandatory nonresidential requirements that are appropriate for indoor growing spaces would be explicitly identified and incorporated into the CEH requirements.

Fewer prescriptive nonresidential requirements are appropriate for indoor growing spaces. In addition, the absence of representative modeling assumptions and software capabilities for indoor cultivation environments limits the validity of performance-based compliance analyses for these spaces. As a result, prescriptive requirements that lack a viable performance compliance alternative effectively function as mandatory requirements. The proposed changes would therefore clarify that prescriptive nonresidential requirements do not apply to indoor growing spaces and that energy modeling may not be used to demonstrate compliance for these spaces.

4.1.4.3.8 *Estimated Energy Savings from Integrated HVAC/D Systems*

Energy modeling by the Statewide CASE Team shows that integrated systems can reduce annual HVAC and dehumidification energy use by approximately 25 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 percent reduction in HVAC energy use after replacing packaged rooftop units and standalone dehumidifiers with an integrated system (Smith, Redding, Braddock, & Svaren, 2019). In another case study, a cannabis farm in Canby, Oregon had 30 percent HVAC energy savings with installation of an integrated DX system, variable speed drive, hot gas reheat coil, and advanced controls (Energy Trust of Oregon, 2018). Given the high energy intensity (Southern California Edison, 2021) 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 can be achieved using either a flat plate heat exchanger, a wrap-around heat pipe, a heat recovery chiller, or a combination of these strategies. Heat recovery 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).

Some of the same principles that apply to integrated HVAC/D systems can be applied to decoupled systems, resulting in improved process efficiency and energy savings. Although no studies have focused specifically on energy savings potential from control integration, staging, or the use of more efficient equipment in decoupled systems, studies and anecdotal reports cite separate controls for HVAC and dehumidification as a key cause of poor environmental control and efficiency.

4.1.4.3.9 Sizing CEH Space Conditioning Systems

A key challenge in sizing space conditioning systems for high-lighting intensity indoor growing facilities, such as cannabis flower rooms, is the dominance of latent loads from plant transpiration. The latent-dominant environment is particularly pronounced in LED flower rooms, 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 and compressor 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, desired setpoints, variable latent loads, and sensible process heat from dehumidifiers that do not reject process heat.

Since decoupled systems address latent and sensible loads separately, they 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 horticulture. Most qualified designers rely on proprietary

approaches and internal tools developed from experience designing systems for CEH spaces rather than published tables based on crop type.

However, when limiting the scope of sizing to indoor cannabis flower rooms sizing inputs and assumptions 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.

4.1.4.3.10 Market Adoption

Despite the process stability and energy savings benefits, market adoption of efficient integrated and coordinated decoupled 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 percent of respondents) and standalone dehumidifiers (75 percent of respondents) (Sabe, Miner, & Perman, 2022). Although this study did not investigate control types, an HVAC service provider specializing in cannabis facilities reported that decoupled systems with separate wall-mounted thermostats and humidistats are still far more common than coordinated decoupled systems with canopy-level sensors and integrated controls.

Furthermore, many early systems marketed and sold as “integrated HVAC/D” lacked one or more of the key features necessary to achieve efficient operation, such as variable speed fans, sufficient reheat capacity, or the ability to modulate hot gas reheat. However, recent advances have made integrated systems more reliable, more responsive to room conditions, and more widely available. In fact, adoption of integrated HVAC/D 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 Statewide 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.

4.1.4.4 Proposal Evolution

This section describes the evolution of the proposed measure, including key design decisions, stakeholder feedback, and revisions leading to the final proposal.

The proposed requirements for space-conditioning systems in indoor controlled environment horticulture (CEH) facilities have evolved significantly through stakeholder and regulator engagement, as well as internal review.

There were several proposal evolutions:

- System type based on canopy square feet: shift from establishing different prescriptive system types for facilities between 5,000 and 22,000 square feet versus those over 22,000, towards a unified approach and definition for multiple types of integrated HVAC/D to comply prescriptively in facilities with over 5,000 square feet of high-light intensity canopy.
- Compliance framework evolution: shift from integrated-focused prescriptive/performance concept to mandatory-only requirements for all covered system types; and
- Dehumidifier framework evolution: shift from reliance on existing consumer-product treatment toward a distinct commercial-dehumidifier classification and California-specific test procedure.

Initial Proposal

The initial draft of this measure included prescriptive and performance compliance pathways. The prescriptive pathway established specific functional and performance requirements for integrated HVAC and dehumidification (HVAC/D) systems. System configurations that did not meet these prescriptive requirements, including most decoupled system designs, would have been required to comply using the performance approach. The proposal also included mandatory requirements for load-based sizing requirements and control integration.

To support development of a performance compliance pathway, the Statewide CASE Team undertook significant effort to develop and vet a representative full-building indoor CEH prototype, including detailed characterization of plant canopy loads, lighting, and space-conditioning interactions. In parallel, the CASE Team developed and calibrated an EnergyPlus-based building energy model aligned with this prototype, with the intent of enabling future integration into CBECC and supporting performance-based compliance.

The prototype and associated model were subject to extensive stakeholder engagement and technical review. This process included a public prototype review meeting, incorporation of stakeholder comments received during and after that meeting, and additional outreach to solicit targeted feedback from industry participants. The Statewide CASE Team also presented the prototype and modeling approach to the California Building Energy Modeling (CalBEM) community, including Working Group 3,

and requested detailed technical input. The model and supporting materials were publicly posted, and stakeholder feedback was solicited and incorporated.

This iterative development and review process was intended to ensure that the prototype and associated model reasonably represent real-world indoor CEH facility operation and could serve as a credible foundation for future performance-based compliance.

Despite this extensive development effort, feedback from the California Energy Commission (CEC) indicated that implementation of a performance compliance pathway in this code cycle would not be feasible due to current compliance software development timelines and prioritization constraints, as well as the need for additional validation of standardized modeling approaches. As a result, the performance compliance pathway is deferred to a future code cycle, while the current proposal focuses on establishing enforceable mandatory requirements.

Stakeholder Feedback

Stakeholder feedback was received from a range of participants, including equipment manufacturers, mechanical designers, and California Energy Commission (CEC) staff.

The team also actively participated and led many discussions with the ASHRAE 90.1 Indoor Agriculture working group. These discussions focused on the CEH HVAC/D requirements proposed for Title 24. In addition to the original members of this working group, representing several manufactures, mechanical designers, and efficiency advocates, the Statewide CASE Team invited several other specialized distributors, manufactures, and subject matter experts, who regularly participated the 90.1 working group, providing feedback and contributing to the development of code language for the draft CASE proposal. After receiving and integrating feedback from this working group and other stakeholders, two of the ASHRAE working group members developed a 90.1 proposal, which generally mirrored the Title 24 HVAC/D proposal described in the Draft CEH CASE Report. The 90.1 measure was presented to the Mechanical Subcommittee at the 2026 ASHRAE Winter Meeting and subsequently released for public review and comment.

Key themes that emerged through the stakeholder engagement process included:

- **Generally supportive response from manufacturers, distributors, and other stakeholders:** Not surprisingly, several manufacturers and distributors of integrated HVAC/D systems expressed support for the original prescriptive approach focused on integrated systems. These same stakeholders were also supportive of the functional, control, and sizing requirements proposed by the Statewide CASE Team, which have been converted to mandatory-only requirements in the final CASE report.

- **Treatment of decoupled systems:** Stakeholders noted that the initial proposal offered a relatively simple prescriptive compliance path for integrated HVAC/D systems, while decoupled system configurations would have relied on the performance compliance pathway, creating an additional hurdle for decoupled systems. One stakeholder objected to the characterization of integrated systems as generally more efficient than decoupled systems, citing instances of integrated systems with insufficient hot gas reheat capacity.
- **Lack of time and resources to develop compliance modeling capability:** Given current limitations in compliance software and modeling approaches for CEH spaces, stakeholders raised concerns about the feasibility and clarity of this approach.
- **Need for system-level regulation:** Stakeholders generally supported the concept of regulating HVAC and dehumidification equipment as a combined HVAC/D space-conditioning system, but some emphasized the importance of focusing on functional outcomes (e.g., control, sizing, and coordination) rather than specific technologies.
- **Applicability of federal dehumidifier standards:** Stakeholders and technical reviewers noted that federally regulated consumer dehumidifiers are not representative of the equipment commonly used in indoor CEH facilities. In particular, commercial dehumidifiers used in these applications operate under different load conditions and are not subject to federal appliance standards or associated test procedures for consumer products. Stakeholders highlighted concerns with existing Title 24 dehumidification requirements, which only allow equipment that is “subject to” federal standards for consumer products, noting that most products designed and marketed for use in CEH facilities do not meet this requirement. They emphasized the need for a more appropriate framework to evaluate the performance of commercial dehumidification equipment used in CEH spaces.
- **Enforceability and verification:** Stakeholder feedback emphasized the need for clear, enforceable requirements that could be verified through plan review and acceptance testing.
- **Outdoor air ventilation requirements:** Stakeholders noted that most CO₂-enriched spaces are designed for zero outdoor air, and that applicants and AHJs often found workarounds or waived minimum outdoor air ventilation in these spaces.

Final Revisions

In response to stakeholder feedback, the proposed measure was revised to establish mandatory requirements only, removing both prescriptive and performance compliance pathways for this code cycle.

The final proposal reflects the following key changes:

- **Shift to mandatory-only framework:** The proposed measure now establishes mandatory requirements applicable to all covered system configurations, improving clarity and enforceability.
- **Requirements for multiple system configurations:** The revised proposal establishes mandatory requirements for both integrated HVAC/D systems and coordinated decoupled systems, with tailored mandatory requirements for each system type.
- **Deferral of performance compliance:** Development of a performance compliance pathway was deferred to future code cycles due to current limitations in energy code compliance software and modeling approaches for CEH spaces.
- **Establishment of commercial dehumidifier classification and efficiency requirements:** The revised proposal distinguishes between federally regulated consumer dehumidifiers and commercial dehumidifiers used in CEH applications. To address this regulatory gap, the proposal introduces a modified test procedure, based on the federal framework but adapted to better reflect commercial equipment operation, and establishes minimum efficiency requirements for commercial dehumidifiers. The proposal also includes provisions for product registration with the California Energy Commission.
- **Establishment of product class requirements for HVAC equipment:** The revised proposal clarifies that conventional HVAC equipment used in CEH process spaces would need to be rated and registered as commercial or industrial equipment.

These revisions improve feasibility, enforceability, and clarity while ensuring that common CEH space-conditioning configurations are subject to clear, enforceable requirements.

Due to the significant shifts in direction between the release of the Table 61 CEH CASE report and Final CEH CASE report, the team leading the development of an aligned proposal for ASHRAE 90.1 elected to pause that effort until more stakeholder feedback is received.

Recommendations for Future Code Cycles

Title 24, Part 6 does not currently include prescriptive measures for CEH spaces, and CBECC does not currently include an indoor CEH prototype. To promote improved efficiency while providing facility designers with flexibility in equipment selection, the

Statewide CASE Team recommends that CBECC is updated in future code cycles so it can be used to demonstrate compliance using the performance approach.

To quantify savings and support the original proposal for prescriptive and performance pathways, the Statewide CASE Team has developed a new indoor CEH prototype and building energy model. Should this space type be available in the CBECC software in future code cycles, the CASE Team will consider developing prescriptive requirements along with the option to comply via the performance pathway.

4.1.5 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.

4.1.5.1 Energy Code Change Summary

SUBCHAPTER 2 DEFINITIONS

SECTION 201 – DEFINITIONS: The proposed edits to definitions related to Controlled Environment Horticulture (CEH) spaces, process spaces, dehumidifiers, indoor growing space conditioning systems, integrated HVAC/D systems, and heat recovery terminology clarify that CEH process spaces are regulated separately from conventional nonresidential comfort-conditioning spaces and establish terminology necessary to implement the proposed HVAC/D sizing, controls, and equipment requirements.

SUBCHAPTER 4 SPACE-CONDITIONING AND VENTILATION

Section 401.2.1.1.3 **[Section 120.1(c)3]:** The proposed changes would revise Table 401.2-A [*Table 120.1-A*] to add new categories for Controlled Environment Horticulture (CEH) Spaces with Carbon Dioxide Enrichment, establishing a minimum outdoor air ventilation rate of 0 cfm/ft², and for Controlled Environment Horticulture (CEH) Spaces without Carbon Dioxide Enrichment, aligning with default values, but clarifying the code.

This revision recognizes that CO₂-enriched CEH spaces are process spaces where continuous outdoor air ventilation may adversely affect system performance and plant growth. The proposed change aligns ventilation requirements in Title 24, Part 6 with the functional requirements of CEH process spaces and with the safety provisions for carbon dioxide systems in the California Fire Code (Title 24, Part 9).

SUBCHAPTER 9 PROCESS SYSTEMS AND EQUIPMENT

Subsection 908.1 [Section 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 space-conditioning systems to meet latent and sensible loads ensures that the indoor growing space conditioning systems are correctly sized, reducing the need to later add supplemental equipment.

The proposed regulations would require integrated temperature and humidity controls that coordinate supplemental heating, cooling, and dehumidification equipment based on measured space conditions and available recovered heat.

The proposed regulations would establish functional, sizing, and control requirements for both integrated HVAC/D systems and coordinated decoupled systems using commercial dehumidifiers and commercial HVAC equipment. The proposal would require coordinated control of cooling, dehumidification, reheat, and airflow functions to respond to variable latent and sensible loads throughout the grow cycle.

The proposed regulations would also establish separate qualification and certification requirements for commercial dehumidifiers used in covered indoor growing applications and clarify the distinction between federally regulated consumer dehumidifiers and commercial dehumidification equipment designed for indoor agriculture process environments.

Subsection 908.4 [Section 141.1(c)]: The proposed regulations would establish applicability thresholds for additions and alterations to indoor growing space-conditioning systems and clarify when projects must comply with the new mandatory HVAC/D system requirements. The proposed changes would apply the requirements to projects that increase plant canopy area by at least 5,000 square feet, increase lighting power density of greater than or equal to 30 Watts per square foot of canopy area, or replace greater than 50 percent of installed heating, cooling, or dehumidification system capacity serving covered indoor growing spaces.

4.1.5.2 Reference Appendices Change Summary

Nonresidential Appendix (NA) 7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes: The proposed changes would expand this appendix to include acceptance tests for indoor growing space-conditioning systems, including verification of sensor placement, integrated control functionality, equipment staging, and coordinated operation of HVAC and dehumidification systems. This section would

Nonresidential Appendix (NA) 9 – 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 section 908.1 [Section 120.6(h)].

Joint Appendix (NA) 19 – Qualification Requirements for Commercial Dehumidifiers: This new joint appendix would establish qualification requirements,

test-method modifications, and certification requirements for commercial dehumidifiers installed to comply with section 908.1 [*Section 120.6(h)*].

4.1.5.3 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.

4.1.5.4 Alternative Calculation Method Reference Manual Change Summary

This proposal does not include any changes to the Alternative Calculation Method (ACM) Reference Manuals.

4.1.5.5 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 indoor growing facilities meet sizing requirements and space conditioning requirements. These forms would require new fields documenting system type, sizing calculations, qualifying dehumidifier pathway, equipment characteristics, and control sequences, as well as acceptance testing of integrated temperature and humidity control functions. These forms would also need to include fields from the other NRCC and NRCI forms to cover nonresidential items that are incorporated in the CEH section. 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 Occupancy Type field in the NRCC-MCH-E form would need to add CO₂-Enriched CEH space.

4.1.6 Measure Context

4.1.6.1 Comparable Model Codes or Standards

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

Title 24, Part 6 (2025): Section 908.1 [*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°F or less. These requirements form the baseline for indoor growing space conditioning in California. (California Energy Commission, 2023)

Federal Appliance Standards: Consumer 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. These standards apply to products classified as consumer (portable and whole-home) dehumidifiers and are based on test procedures that do not reflect the operating conditions or performance requirements of indoor growing facilities (Regulations, 2025).

Commercial dehumidifiers commonly used in indoor growing applications are not covered by these federal standards and therefore are not subject to consistent efficiency requirements, test procedures, or certification pathways. As a result, a regulatory gap exists for the equipment types most frequently used in high-intensity indoor cultivation. This proposal addresses that gap by establishing a California-specific qualification, testing, and certification framework for commercial dehumidifiers used in indoor growing space conditioning systems.

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)

4.1.6.2 Interactions with Other Regulations

The Statewide CASE Team found no conflicts with existing federal, state, or local regulations. The proposed changes enhance Title 24, Part 6 by establishing functional, control, sizing, and commercial dehumidifier qualification requirements for space conditioning systems in indoor growing spaces, without imposing more-stringent requirements on federally regulated products.

Consumer dehumidifiers are subject to federal efficiency standards under 10 CFR Part 430, which preempt state regulation of efficiency and test procedures for those covered products. This proposal retains the federal framework for consumer dehumidifiers and does not modify or supersede those requirements. Instead, it establishes a separate qualification, testing, and certification framework for commercial dehumidifiers used in indoor growing applications, which are not covered by federal appliance standards. Because these commercial products fall outside the scope of federal regulation, the proposed requirements do not conflict with federal preemption.

Federal standards also apply to commercial and residential HVAC equipment; however, the associated test procedures and performance metrics (e.g., EER, IEER, SEER) are based on comfort-cooling applications and do not reflect the operating conditions of CEH process spaces. Accordingly, the proposal focuses on system-level performance,

controls, and sizing requirements rather than relying solely on federally defined efficiency metrics.

The proposed revisions to outdoor air ventilation requirements for CO₂-enriched spaces bring Title 24, Part 6 regulations into better alignment with the California Fire Code, by deferring to existing Fire Code requirements for CO₂ monitoring and purge ventilation systems.

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 ensure that the proposed requirements can be clearly documented, reviewed during plan check, and verified through field inspection and acceptance testing.

The proposal intentionally targets large, high-intensity indoor growing process environments where HVAC and dehumidification systems operate continuously under highly dynamic latent and sensible loads. Smaller facilities and lower-intensity applications remain subject to existing Title 24 requirements and are not required to comply with the new high-intensity indoor growing HVAC/D sizing and controls provisions. Existing Title 24 compliance pathways and requirements remain applicable for systems outside the scope of the proposed provisions.

The CEC has published guidance²¹ indicating that indoor growing facilities are generally required to comply with nonresidential requirements other than exceptions explicitly provided for CEH spaces. Under this guidance, indoor growing facilities are typically subject to requirements including mandatory envelope requirements, prescriptive envelope requirements, nonresidential prescriptive HVAC equipment and controls requirements, and mandatory outdoor air ventilation. However, this interpretation does not fully resolve how conventional HVAC and ventilation requirements apply to CEH process loads, resulting in inconsistent application in practice.

Some requirements in the nonresidential code do not align with typical indoor growing facility operation (such as outdoor air ventilation requirements), resulting in inconsistent interpretation and enforcement. Furthermore, the lack of viable performance modeling

²¹ https://www.energy.ca.gov/sites/default/files/2023-09/2022_CEC-Controlled_Environment_Horticulture_ADA.pdf

assumptions for indoor growing spaces has created a regulatory grey area where performance-based compliance has been an option but has not reflected the design and operation of these spaces. The proposed updates would clarify that Indoor growing spaces are not subject to most prescriptive requirements, and not eligible for performance-based compliance. It would clearly identify all nonresidential mandatory requirements that apply to these spaces and further clarify specific requirements for HVAC and dehumidification systems serving indoor growing spaces by consolidating all regulations into Section 908.1 [Section 120.6(h)], associated appendices, and explicit references to other sections. The proposed mandatory HVAC/D system requirements allow multiple system configurations that meet defined functional and performance criteria.

This proposal requires calculation and documentation of design heating, cooling, and dehumidification loads using the procedures defined in the proposed Nonresidential Appendix. Systems must be sized to meet both sensible and latent loads under representative mid- and late-stage grow cycle conditions, including lights on and lights off operation. The compliance documents must identify the control sequences, equipment characteristics, and operating ranges used to respond to variable latent and sensible loads at different phases of each flower cycle, either through coordinated control of decoupled equipment, or through documented heat recovery capability and equipment operating ranges.

Compliance does not require whole-building simulation, custom energy modeling, or demonstration of comparative annual energy performance.

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).

During plan review, the plans examiner will verify that submitted project documentation demonstrates compliance with section 908.1 [section 120.6(h)] and is consistent with the NRCC form. Consistent with other Title 24 compliance processes, enforcement personnel are not expected to independently validate manufacturer performance data or recreate engineering calculations submitted by the design team.

To perform acceptance testing of the control system, the field technician would verify that required equipment capacities and system configurations are documented in the construction documents and that the installed system includes the required control capabilities. This includes confirming required control sequences for supplemental heating and staged dehumidification equipment. Acceptance testing focuses on verification of required control functionality, sensor placement, and system integration.

The proposed requirements are enforced through construction-phase documentation review, installation verification, and acceptance testing and do not establish ongoing operational compliance obligations.

During inspection, the building inspector will verify that installed equipment, sensors, and control systems match the NRCI-PRC-E form and that acceptance testing has been completed and documented on the NRCA-PRC-XX-F form.

Compliance with the controls requirements relies on acceptance testing, 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 proposed changes are expected to reduce ambiguity in plan review and inspection by consolidating indoor growing HVAC and dehumidification requirements into a single section. While new documentation and acceptance testing performed by a field technician will increase the level of effort, the proposed enforcement framework is intended to improve consistency and reduce ambiguity relative to current indoor growing compliance interpretation and enforcement practices.

A typical compliance workflow would include:

1. Submission of load and sizing calculations and system schedules through NRCC documentation;
2. Plan review verification that required system characteristics, controls, and equipment classifications are documented;
3. Installation verification through NRCI documentation and field inspection;
4. Functional confirmation of controls and sensor integration through NRCA acceptance testing performed by the field technician.

Standardized compliance forms and acceptance documentation are intended to improve consistency across jurisdictions and reduce variability in indoor growing enforcement practices.

The enforcement process is therefore structured around documentation review and functional verification consistent with other existing Title 24 mandatory process requirements. The proposed enforcement framework does not require enforcement personnel to possess specialized agricultural expertise, independently reproduce psychrometric calculations, or validate manufacturer performance models. Similar to other Title 24 compliance processes, enforcement is based on review of required documentation, verification that required calculations and system specifications are provided, and confirmation that installed systems and controls match approved construction documents and acceptance test results.

The proposed controls requirements are aligned with control strategies already implemented in a substantial portion of the California indoor growing market. The proposal therefore standardizes and documents practices already familiar to many controls vendors, contractors, and facility operators rather than introducing entirely new operational paradigms.

New definitions are being harmonized with existing definitions in Section 200 of Title 24, Part 6 to avoid confusion and conflicts.

4.2.2 Impact on Market Actors

Table 57 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 57: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/Developer^a	<p>Be aware of the new Energy Code language and how it impacts selection of space conditioning equipment and controls, how to identify certified commercial dehumidification equipment.</p> <p>They should be aware of the incremental costs of designing systems compliant with the new requirements, and of the new acceptance testing step to be performed by the field technician.</p>	<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 indoor growing HVAC+D training will help developers understand the impacts of the code on the facilities they are developing, sizing calculations, and the options for compliance. This training can leverage existing trainings such as the Indoor Agriculture Resiliency training offered by PG&E Energy Centers.</p>
Design Professional^b	<p>Design Professionals must be aware of the new code requirements and design HVAC/D systems, including equipment and controls, which 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 indoor growing HVAC/D in compliance with new Nonresidential Appendix.</p> <p>Design professionals must document compliance with NA9 sizing requirements and demonstrate that system configurations meet the functional and control requirements in Section 908.1 (section120.6(h)).</p>	<p>Designers of HVAC+D systems for high lighting intensity rooms in indoor growing facilities should be provided training on the energy code, sizing requirements, and mandatory requirements.</p> <p>Updates to the Energy Code Ace Fact Sheet and topic-specific training for Controlled Environment Horticulture can help ensure that designers are aware of the updated code requirements.</p> <p>Providing a spreadsheet for compliance with NA9 sizing, and training on how to use it will help designers comply.</p>

Market Actor	Impact(s)	Suggested Outreach and Education
Construction Team^c	<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 NRCI-PRC-E form.</p> <p>Controls technicians will perform verification testing to confirm controls comply with requirements, put results on NRCA-PRC-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.</p>
Building Department^d	<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 form and additional construction documents and confirm that the design (including both equipment and controls) 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-PRC-XX-F form to confirm acceptance testing was performed, in addition to reviewing additional fields on the NRCI-PRC-E form.</p>	<p>Provide education and training to local building department plans examiners to familiarize themselves with requirements, sizing calculations, and new acceptance tests.</p>

Market Actor	Impact(s)	Suggested Outreach and Education
Manufacturers and Distributors	<p>HVAC manufacturers/distributors must provide data on reheat capabilities of integrated HVAC/D equipment.</p> <p>Commercial dehumidifier manufacturers would need to test and certify products to the specifications outlined in the proposal.</p> <p>Manufacturers of integrated HVAC/D systems, high-efficiency commercial dehumidifiers, and commercial HVAC equipment will likely see increased sales.</p> <p>Manufacturers of residential dehumidifiers and residential cooling equipment may see decreased sales to this market.</p> <p>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.</p>	<p>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.</p> <p>Manufacturers also must understand the code changes so they can support California customers and clients in selection of compliant equipment.</p> <p>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.</p>
Operator/Grower	<p>Building owners, managers, and system operators can expect reduced energy bills, reduced maintenance costs, and improved crop yield.</p> <p>System operators will need to operate the central HVAC controls system.</p>	<p>Outreach to and training of owners and operations personnel could improve understanding of the benefits of integrated controls for HVAC+D systems and address concerns. Additional training could reinforce the yield and energy savings benefits of the newly required system enhancements.</p>

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

The [2028 CASE Methodology Report](#) presents a quantitative assessment of how changes to the California building code impact developers, construction teams, 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.

Construction team: 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 58 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 58: 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 \$)
Nonresidential Electrical Contractors	3,245	72,794	\$7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	\$5.8
Other Nonresidential Equipment Contractors	580	9,749	\$1.1
Nonresidential Site Preparation Contractors	1,147	19,273	\$1.9
All Other Nonresidential Trade Contractors	948	17,084	\$1.7

Source: (State of California, n.d.)

* An establishment is a single economic unit, typically at one physical location, which 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

Because the proposed requirements are mandatory and do not include a performance compliance pathway, no updates to CBECC or other compliance software are required.

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 NRCI-PRC-E:** Document key installed equipment specifications;
- 3 **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
- 4 **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. Training will be required for plan checkers and inspectors to review CEH-specific load calculations, system configurations, and acceptance test documentation.

If workforce training is needed to ensure correct design and installation of space conditioning systems required by this proposed measure, 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 indoor growing space conditioning systems that comply with the proposed mandatory measure includes multiple manufacturers of integrated HVAC and dehumidification systems, commercial dehumidifiers, commercial cooling equipment, and environmental control systems.

Manufacturers offering integrated HVAC/D systems suitable for high intensity indoor growing applications include manufacturers such as AAON, Trane, Desert Aire, Agronomic IQ, Inspire Transpiration Solutions, RuppAir, and Accelerated Growth Solutions. Desiccant systems that would comply with the measure include Mojave Energy and Airgreen. Manufacturers offering commercial dehumidifiers that could be qualified include Leizig Climate and Madison Air (Quest and Anden). Commercial VRF or packaged cooling equipment is available from numerous manufacturers.

Environmental control systems and controls platforms capable of coordinating temperature and humidity control are widely available and include both purpose-built CEH control systems and configurable building automation systems. Providers include Rhythm CSS, Tridium, and other building automation and controls vendors capable of integrating HVAC and dehumidification equipment.

Indoor 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, as well as commercial dehumidifiers and cooling equipment configured with coordinated controls. These solutions deliver better performance and energy savings when properly sized, compared with decoupled dehumidification and cooling systems with separate temperature and humidity controls. 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 finds that compliant equipment and system configurations are commercially available from multiple manufacturers and are expected to remain available prior through 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 indoor growing facilities have relied on conventional commercial cooling equipment paired with standalone dehumidifiers and basic thermostats, while only about 25 percent use variable-SHR²². 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 and integrated controls capable of adjusting to variable 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, the proposed regulations exempt small indoor farms, and 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 indoor growing facilities.

Some stakeholders also expressed concerns about unreliable or poorly designed first-generation integrated systems, creating skepticism about performance, but other stakeholders confirmed that more recently installed integrated systems are reliable. Recent generations of integrated equipment have addressed earlier reliability concerns

²² Based on review of Title 24 compliance data for indoor CEH facilities collected by the Statewide Compliance Improvement program in 2024 and 2025.

through improved controls, modulating hot gas reheat performance, improved reheat capacity, and better system integration.

Additional challenges include perceptions of higher incremental costs, a shortage of design professionals familiar with indoor growing environments, and limited access to conventional financing and tax benefits. While some stakeholders perceive higher upfront costs, properly sized systems with integrated controls can reduce total installed capacity and lifecycle costs. The Statewide CASE Team demonstrated that correctly sized, systems with integrated controls require less total capacity, reducing both upfront and lifecycle costs, as outlined in Section 4.4.3. To prepare the workforce, the Statewide CASE Team developed a standard sizing methodology and associated spreadsheet and plans to provide design guidelines in the compliance manuals, and support development of targeted training programs. Training programs can include information on leasing strategies that enable depreciation benefits 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, circulation fans, and equipment, along with moisture from plants. Indoor growing facilities require tight environmental tolerances, with loads, and often setpoints changing throughout the grow cycle. Most indoor CEH spaces have nearly all internal loads, minimal air exchange, and minimal envelope gains or losses, 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 between integrated and fully decoupled systems 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:** Decoupled systems typically use a greater quantity individual unitary equipment, increasing modularity and allowing 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. This type of control is included with many integrated systems, but integrating the components of a decoupled system requires additional, third-party controls.
- **Construction:** Integrated systems have fewer components and simplified ductwork, reducing installation time, labor, and space requirements, which is especially beneficial in tight environments.
- **Commissioning:** Modulating 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.

High efficiency commercial dehumidifiers from Quest, Anden, and Leizig Climate dominate the market for standalone dehumidification equipment. However, manufacturers and designers report that lower cost, potentially less efficient commercial dehumidifiers are entering the indoor CEH market. Smaller, consumer dehumidifiers are used in very small commercial grows and may be used for supplemental dehumidification in larger facilities. However, these supplemental products are not usually part of the original design, and therefore not subject to regulation by Title 24, Part 6.

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 percent 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).

The proposed revisions to outdoor air ventilation requirements for CO₂-enriched CEH spaces do not reduce occupant safety. These spaces are regulated as process environments, and the primary safety risk associated with CO₂ enrichment—elevated carbon dioxide concentrations—is addressed by the California Fire Code (Title 24, Part 9). Fire Code Section 5307.4 requires gas detection systems that activate alarms at elevated CO₂ concentrations, automatically shut off CO₂ supply, and initiate mechanical exhaust ventilation at a minimum rate of one cfm per square foot until conditions are safe. The proposed change would remove the requirement for continuous outdoor air ventilation in CO₂-enriched CEH spaces, while preserving the Fire Code requirements for CO₂ detection, alarm response, automatic CO₂ shutoff, and purge ventilation needed to protect occupant safety.

By relying on these existing safety requirements, the proposed measure allows elimination of continuous outdoor air ventilation that would otherwise increase energy use and interfere with CO₂ enrichment, while maintaining robust protections for occupant health and safety. In this way, the proposal aligns energy efficiency requirements with established life-safety regulations governing CO₂ monitoring and purge ventilation.

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 solutions to technical challenges and refined 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 manufacturers 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 indoor growing 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 57 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

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

The Statewide CASE Team evaluated potential impacts of this measure on Energy Equity and Environmental Justice communities and determined that it is unlikely to result in significant adverse or beneficial impacts. This conclusion is based on several key assumptions and findings. First, the measure applies primarily to large commercial indoor CEH facilities (e.g., high-intensity cannabis cultivation) and does not directly affect residential buildings or small-scale operations, limiting its direct exposure on ESJ communities. The measure does not affect housing costs, utility rates, or access to essential services, which are primary drivers of ESJ impacts.

From a health perspective, improved temperature and humidity control may reduce mold growth and associated worker exposure, providing a modest potential benefit in indoor CEH environments. The measure is not expected to significantly affect cost or affordability for ESJ communities, as it applies primarily to larger commercial indoor CEH facilities and does not directly impact residential or small-scale operations. In terms of resilience and comfort, the measure improves environmental control within CEH spaces but does not materially affect community-level resilience or occupant comfort outside of these specialized process environments. These conclusions are consistent with findings from prior code cycles, where CEH measures were evaluated and determined to have limited direct ESJ impacts.

4.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 59, Table 60, and Table 61 outline the statewide implications for these job categories. For more information on the Statewide CASE Team’s economic impacts methodology, see the [2028 CASE Methodology Report](#).

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

Table 59: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	67.2	\$5.34	\$8.04	\$17.40
Indirect Effect (Additional spending by firms supporting Commercial Builders)	39.2	\$3.09	\$5.30	\$9.28
Total Economic Impacts	106.3	\$8.43	\$13.35	\$26.69

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.²³

²³ IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

Table 60: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building designers and energy consultants)	0.7	\$73,212	\$72,479	\$114,559
Indirect Effect (Additional spending by firms supporting building designers and energy consultants)	0.3	\$21,799	\$30,296	\$48,770
Total Economic Impacts	0.9	\$95,010	\$102,775	\$163,330

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

Table 61: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building inspectors)	0.1	\$9,938	\$11,786	\$14,322
Indirect Effect (Additional spending by firms supporting building inspectors)	0.0	\$920	\$1,434	\$2,497
Total Economic Impacts	0.1	\$10,859	\$13,219	\$16,819

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

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

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

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team’s IMPLAN modeling resulted in an estimated \$1,852,060 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively

correlated with business income and that a portion of business income will be allocated to net business investment.

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm’s capital stock (referred to as net private domestic investment, or NPDI). As Table 62 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of incremental income that business owners would reinvest into expanding their capital stock.

Table 62: Net Domestic Private Investment and Corporate Profits, U.S.

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a \$434,751 increase in net private investment by California businesses.

4.3.5 Economic and Fiscal Impacts

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

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

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

The Statewide CASE Team does not expect the proposed code changes to have a measurable impact on California's General Fund, any state special funds, or local government funds. The measure applies to private commercial indoor CEH facilities and does not require direct state expenditures or new state-administered programs.

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals. The proposed code change is not expected to impact state buildings because the state does not own or operate indoor cannabis growing facilities.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section , the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

4.3.5.2 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because the proposed measure applies to private and commercial indoor CEH facilities and does not impose new programmatic requirements on local agencies.

4.3.5.3 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts requiring reimbursement. While local building departments will review compliance documentation and acceptance testing for indoor CEH systems, these activities are part of standard code enforcement duties and do not constitute a new program or higher level of service beyond the normal building code update cycle.

4.3.5.4 Costs or Savings to Any State Agency

There are no costs or savings to state agencies beyond routine code update, training, and enforcement activities. The proposed measure does not require new state programs, staffing, or capital expenditures. Any incremental workload associated with updating compliance materials or providing guidance is expected to be within existing budgets.

4.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings imposed on local agencies. The proposed measure does not require local agencies to perform activities outside of their existing authority to review building permit applications and enforce building codes.

4.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state. The proposed measure does not affect federal funding streams or require changes to federally funded programs.

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.

This measure allows two compliant system configurations: integrated HVAC/D systems and coordinated decoupled systems using commercial dehumidifiers with separate HVAC equipment. For the purposes of cost-effectiveness and statewide savings analysis, the Statewide CASE Team assumed use of integrated HVAC/D systems as a representative compliance approach. In general (i.e. other building types and efficiency measures) the most expensive technology or efficiency measure under consideration is also the measure with the highest energy savings. However, in this case, the integrated system has the same or greater energy savings than the coordinated, efficient decoupled system, with lower incremental cost relative to the baseline. This assumption is based on evidence that integrated systems can achieve lower total installed capacity and reduced operating costs when properly sized and controlled, as discussed in Section 4.4.3. In addition, integrated systems provide a consistent basis for modeling performance across projects with highly variable latent and sensible loads. This approach does not preclude compliance using coordinated decoupled systems but provides a reasonable and consistent basis for estimating statewide impacts.

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 indoor growing operations across California. A flower room prototype was modeled for both baseline and proposed cases using the software tools EnergyPlus, Trane TRACE 3D Plus (using the EnergyPlus engine), and Excel, and a full-facility prototype model was developed in EnergyPlus. The energy savings presented here used the EnergyPlus full building model. The Statewide CASE Team held a workshop to get feedback on the model prototype assumptions on December 10, 2025. The prototype was publicly posted²⁴ in advance of that meeting. Stakeholder input was incorporated into that prototype and into the EnergyPlus full building model. The EnergyPlus model was shared with CalBEM Working Group 3 and was posted publicly prior to the Utility-Sponsored Stakeholder Meeting held on March 5,

²⁴CEH Prototype <https://title24stakeholders.com/wp-content/uploads/2025/12/2028-T24-CEH-Prototype-for-Vetting.xlsx>

2026. Additional stakeholder and SME input was used to update the prototype and model to reach the version used to estimate per unit energy savings by climate zone.

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 96 in Appendix A shows several details of the prototype assumptions.

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

The full building indoor CEH EnergyPlus model was developed, aligned with the prototype and updated based on stakeholder input. This is described in detail in Appendix A.

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

The baseline case represents a code-compliant configuration under the current Title 24 framework, consisting of decoupled HVAC and dehumidification systems using dehumidifiers meeting federal minimum efficiency standards and fixed-capacity residential cooling equipment. While more advanced integrated systems exist in the market, they are not required by current code and are not consistently implemented in practice. The proposed measure establishes minimum functional, sizing, and control requirements that align system performance more closely with these advanced configurations.

Although there are typically other spaces in a cannabis facility used for cloning, vegetative growth, and drying, the proposed code changes only affect spaces with very high lighting intensity, such as flower rooms. The full-facility prototype includes these spaces, as well as other non-CEH spaces such as office, corridor, and processing to

help estimate whole-facility EUI and energy savings on a percentage basis. However, none of the spaces aside from flower rooms would be affected by the proposed code changes, and this report only considers the energy used in the flower room.

Cannabis facilities with over 5,000 square feet of flower room 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 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 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 typical conditions used by operators of modern facilities using LED lighting compliant with Title 24 requirements. Although some growers use different temperature and humidity setpoints, particularly in the late flower cycle, the assumptions used in the energy model provide a reasonable facsimile of industry practice for newly constructed facilities. However, it should be noted that maintaining warmer and more humid conditions during the late flower cycle will significantly reduce total system capacity, costs, and energy consumption.

The Statewide 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. And, as noted above, the dimension of individual flower rooms within a larger facility does not meaningfully impact energy use on a per-canopy-square foot basis. Furthermore, the envelope is entirely opaque, so factors like building footprint, floor-area-ratio, and window-to-wall ratio that are critical to estimating energy use intensity in other building types, have little impact on modeled per-square-foot energy intensity for cannabis flower rooms.

Still, the Statewide CASE Team sought to develop a prototype facility with dimensions and space allocations representative of new construction and major renovations in California cannabis facilities. The team reviewed floor plans from several California cannabis facilities and consulted with SMEs to determine how much space is typically allocated to each space type within a typical cannabis facility. In consultation with SME's, the team determined that, although the size of cannabis facilities can vary widely, a 25,620 ft² prototype facility with three 4,165 square feet flower rooms (about half of the total floor area) provided a reasonable representation of facilities with over 5,000 square feet of flower room canopy. Furthermore, due to the reasons discussed above, the development of additional prototypes would provide little improvement in the precision of the model, which was used to estimate cost and energy use on a per-canopy-square foot basis.

Table 96 summarizes the prototype flower room used to evaluate energy, demand, cost, and environmental impacts. The canopy area used in the model is 100 percent of the room square footage, representing a weighted average of single-tier and two-tier facilities. Based on SME input, the Statewide CASE Team estimates that 60 percent of facilities grow with a single tier (with a canopy area 70 percent of room area) and 40 percent of facilities grow 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 63; detailed hourly schedules are shown 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 110 in Appendix A. The high-intensity indoor growing schedules were developed in consultation with a team of subject matter experts and updated based on stakeholder feedback.

Table 63: 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 _a	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

Note: RH is relative humidity

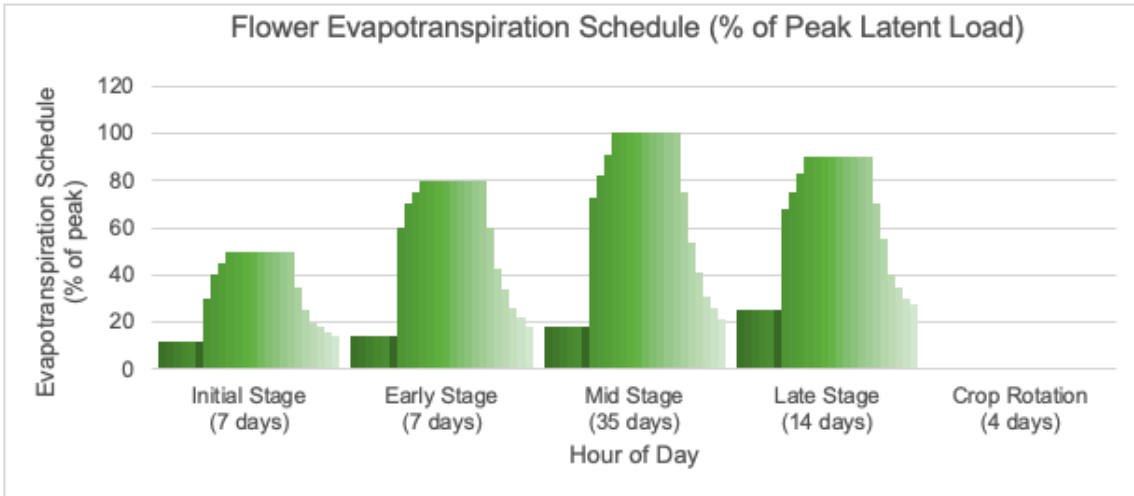


Figure 1: Evapotranspiration load in cannabis flower room, presented as a percentage of the peak latent load for the grow cycle.

All 16 Climate Zones were simulated in EnergyPlus using the prototypes described above and 2028 weather files. The EnergyPlus model includes three flower rooms with schedules staggered, starting three weeks apart. Statewide CASE Team SMEs suggested that staggered schedules are most common in cannabis growing facilities and present a more realistic hourly load profile than a single flower room of the same total size.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 64. Calculated per-unit energy savings for the first year range from 44.0 to 51.4 kWh/yr depending on climate zone. The system was modeled as all-electric for both baseline and proposed cases, so there are no natural gas reductions shown in the calculations. Demand reductions are expected to range between 0.0027 kW and 0.0032 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 64 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, and reflects projected changes to California’s electricity demand, sources, costs, and grid over that 30-year period. 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 annual indoor CEH flower room HVAC/D energy use by about 25 percent. Across the 16 Climate Zones, the average energy use intensity for indoor CEH flower rooms was 328.2 kWh/canopy ft²/yr for the proposed case and 376.5 kWh/canopy ft²/yr for the baseline. These values include lighting, which was approximately half of the energy consumption. The HVAC/D energy savings of about 25 percent aligns with energy savings found in the literature, described in detail in Section 4.1.4.3. 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 meet at least 90% of the heating load using recovered heat and 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 four-pipe chilled water system and 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 energy savings from this proposed measure will be persistent. Integrated HVAC/D systems and commercial dehumidifiers are purpose-built for high duty-cycle indoor CEH applications and typically have longer service lifetimes than equipment originally designed for residential or consumer applications. Integrated systems and decoupled systems with coordinated controls also provide improved environmental control, which can support higher yields. The energy savings from use of these approaches will reduce operational costs. Higher yields and reduced operational costs are expected to reinforce continued proper operation over time.

Savings associated with control system requirements may be more sensitive to operational practice. For example, sensor calibration may drift over time, and system performance may be affected if control sequences are modified or overridden. However, the proposed measure includes requirements for integrated control systems, documented sequences of operation, and acceptance testing to verify proper installation

and functionality. These requirements are expected to improve persistence by ensuring that systems are installed, configured, and initially operated as intended. In addition, the use of centralized control systems may facilitate ongoing monitoring and adjustment, which can support continued performance over time.

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 64: First Year Impacts per Canopy Square Foot – Indoor (Warehouse) Cannabis – Space Conditioning

Climate Zone	First Year Electricity Savings (kWh) Per Canopy Square Foot	First Year Peak Demand Reduction (kW) Per Canopy Square Foot	First Year Natural Gas Savings (kBtu) Per Canopy Square Foot	First Year Source Energy Savings (kBtu) Per Canopy Square Foot	Total 30-Year LSC Savings (2029 PV\$) Per Canopy Square Foot
1	44.03	0.0027	N/A	40.17	\$315.25
2	47.2	0.0027	N/A	41.54	\$333.05
3	48.35	0.0029	N/A	43.93	\$343.18
4	47.64	0.0028	N/A	42.11	\$335.75
5	48.28	0.0029	N/A	43.34	\$347.49
6	50.74	0.0031	N/A	45.41	\$347.49
7	51.35	0.0032	N/A	46.62	\$363.07
8	50.75	0.0031	N/A	44.36	\$356.15
9	49.69	0.0029	N/A	43.59	\$356.94
10	49.61	0.0029	N/A	42.8	\$346.65
11	47.46	0.0027	N/A	39.93	\$329.72
12	48.62	0.0027	N/A	41.95	\$344.09
13	48.48	0.0027	N/A	40.84	\$336.80
14	46.48	0.0028	N/A	40.67	\$315.48
15	50.66	0.0029	N/A	42.68	\$354.56
16	43.97	0.0027	N/A	40.75	\$316.91

4.4.3 Incremental First Cost

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

- **Baseline System:** Decoupled (code minimum fixed capacity split system and standalone dehumidifiers)
- **Proposed System:** Integrated (CEH purpose-built HVAC and dehumidification)
- **Installation:** Ductwork and connections
- **Controls Configuration and Commissioning:** labor for configuring and acceptance testing of controls
- **Design and Sizing:** labor for system sizing and design of integrated controls

The integrated system is assumed to consist of four 40-ton DX units, and the decoupled system is assumed to include 37 standalone dehumidifiers rated at 710 pints per day to meet the latent load, along with 24 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 4,165 square foot flower room. Subject matter expert members of the Statewide CASE Team and stakeholders agreed that cost is roughly linear with capacity 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.

Both the baseline and proposed cost estimates were based on systems designed for the expansion of an existing indoor cannabis farm in Sacramento, California. A team of three SME mechanical designers specializing in indoor cannabis worked with the facility owner to develop a floor plan, layout equipment and airflow distribution, establish lighting loads and schedules, and develop equipment schedules for expansion of the existing indoor farm to an adjacent, unconditioned warehouse space. The final design was provided to a professional construction estimator with experience providing estimates for cannabis HVAC/D system equipment and installation.

The two systems that were designed and priced for this facility expansion included an integrated DX system with 40-ton ground mounted units and a coordinated decoupled system consisting of ground-mounted VRF condensers, fan coils, standalone dehumidifiers, and integrated controls.

The estimator's quote for the coordinated, high-efficiency (VRF) decoupled quote was higher than the integrated system. However, since the decoupled quote represented an above-code option that included higher-cost variable capacity cooling equipment and integrated controls, the team updated the costs from the professional estimator to reflect code-minimum equipment and to align with the dimensions, sizing, and other attributes used in the EnergyPlus model. Where identical equipment was included in the cost

estimators bid and available online, the team used the more conservative (lower) cost for the baseline equipment.

For the baseline case, updated equipment costs were sourced online on April 24th, 2026, with pricing from HVACdirect.com and Greenthumbdepot.com for the DX system and standalone dehumidifiers, respectively. The baseline DX system included 24 5-ton split air conditioner systems priced at \$2,279 for each outdoor condenser (totaling \$54,696), \$1,335 for each indoor fan coil unit (totaling \$32,040), and included 4kW of supplemental heating on each system (totaling \$2,784). The 37 710-pint per day dehumidifiers were priced at \$7,888 each (totaling \$291,856). The HVAC/D installation costs and ancillary costs including testing and balancing, controls, electrical, ductwork, condensate drain piping, and refrigerant piping were scaled to match the prototype flower room, based on the estimator's quote obtained on April 21, 2026. Installation for each DX system and standalone dehumidifier was conservatively priced at \$1,000 each (totaling \$61,000). The total HVAC/D equipment and installation cost was \$442,376 for the baseline system. The ancillary costs were \$5,206 for testing and balancing, \$0 for controls, \$139,500 for electrical, \$288,909 for ductwork, \$151,279 for condensate drain and piping, and \$192,287 for refrigerant piping. The total ancillary costs were \$777,182 for the baseline system.

For the integrated system primary equipment and installation costs were based on the estimator's quote obtained on April 21, 2026, and scaled to the room square footage, canopy area, and loads. The equipment consisted of four 40-ton units at \$140,000 each (totaling \$560,000), and installation priced at \$71,680 each (totaling \$286,720). The total HVAC/D equipment and installation cost was \$846,820 for the integrated system. The ancillary costs were \$4,165 for testing and balancing, \$15,000 for controls, \$54,000 for electrical, \$311,765 for ductwork, \$5,856 for condensate drain and piping, and \$0 for refrigerant piping. Labor for configuring controls and performing acceptance testing include two hours of a controls or HVAC technician at \$110.32 per hour, based on the 2029 prevailing electrician wage (State of California Department of Industrial Relations, 2026). One atmospheric temperature and relative humidity sensor is included at \$358, along with associated controls cabling at \$50, based on a December 2025 controls quote. Labor for system sizing and design include 18 hours at \$300 per hour for a design engineer based on SME input. The total ancillary costs were \$396,815 for the integrated system.

The cost by category for each system is outlined in Table 65.

See Appendix A for a detailed breakdown of all costs for baseline and integrated systems.

Table 65: Equipment and Installation First Cost per 4,165 Square Foot Flower Room (4,165 canopy square feet)

Cost Element	Baseline First Cost	Proposed First Cost	Incremental First Cost
HVAC/D Equipment	\$106.21	\$203.29	\$97.08
Testing & Balancing	\$1.25	\$1.00	-\$0.25
Controls	\$0.00	\$3.60	\$3.60
Sensors	\$0.00	\$0.10	\$0.10
Design	\$0.00	\$1.30	\$1.30
Acceptance Testing	\$0.00	\$0.05	\$0.05
Electrical	\$33.49	\$12.97	-\$20.53
Ductwork	\$69.37	\$74.85	\$5.49
Condensate Drain & Piping	\$36.32	\$1.41	-\$34.92
Refrigerant Piping	\$46.17	\$0.00	-\$46.17
Total	\$292.81	\$298.57	\$5.76

Additionally, recently obtained construction estimates from a subject matter expert on the Statewide CASE Team showed a 23 percent lower total installed 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 pipe 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 percent more than installation of an integrated system, and installation of a VRF decoupled system cost 71 percent more than installation of an integrated system designed for the same grow room.

In interviews with the Statewide CASE Team, multiple manufacturers indicated that integrated system equipment cost may be as low as 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 is considerably lower than the integrated HVAC/D equipment estimate used for this analysis, which the cost estimator priced at \$3,500 per ton.

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 noted 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. This statement is consistent with the findings reported in the literature (Megerson & Anderson, 2023), as well as the costs provided by the professional cost estimator.

Table 66 presents equipment and installation first costs and incremental costs per square foot of canopy.

Table 66: Incremental Cost Per Canopy Square Foot – Space Conditioning

Cost Element	Baseline First Cost (\$ per Canopy Square Foot)	Proposed First Cost (\$ per Canopy Square Foot)	Incremental First Cost (\$ per Canopy Square Foot)
Equipment	\$106.21	\$203.29	\$97.08
Ancillary	\$186.60	\$95.27	-\$91.32
TOTAL	\$292.81	\$298.57	\$5.76

The Statewide CASE Team based the proposed 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.

In interviews with the Statewide CASE Team, multiple CEH climate control equipment designer and facility operator stakeholders have described a cost-effective design using a smaller integrated cooling and dehumidification system sized to meet both sensible and latent loads for most of the grow cycle with standalone dehumidifiers 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 drier conditions for the last weeks of each flower cycle.

As such, the proposed measure only requires the integrated system to be sized to 80% of peak load. However, for the cost analysis, the integrated cooling and dehumidification was system sized to meet the full latent and sensible loads. Therefore, this is the more conservative assumption to use for cost-effectiveness analysis.

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 also require this type of control system when standalone dehumidifiers are used in combination with integrated HVAC/D. 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. Statewide CASE Team SMEs confirmed that this quote accurately represents typical costs for the type of controls that would be required when decoupled systems or supplemental cooling or dehumidifiers are used to meet the proposed requirements. Note that these controls are not included in the incremental first cost analysis because the Statewide CASE Team used the more conservative (more expensive) option of sizing the integrated system to meet loads throughout the grow cycle. When no supplemental cooling or dehumidification equipment is used, the controls provided with an integrated system can typically meet the proposed controls requirements.

4.4.4 Incremental Design and Sizing Costs

The proposed measure would require designers to size new HVAC/D systems to peak sensible and latent loads and setpoints at six different points in each grow cycle. While

this practice is already employed by some facility designers, several stakeholders and previous studies of indoor cannabis facilities cite failure to correctly size equipment as a consistent challenge in the industry, leading to poor environmental control and subsequent installation of additional equipment to manage loads, leading to inefficient operation.

Due to the unique properties of indoor cannabis farms, even mechanical engineers with experience designing other commercial HVAC systems can miscalculate loads and system sizing. As such, in order to comply with the proposed sizing requirements, the Statewide CASE Team assumes that project applicants will need to consult specialized engineering firms with experience designing systems for indoor cannabis flower rooms.

To calculate loads and size systems to serve the flower room with 4,165 square feet of canopy in the indoor CEH prototype facility of additional design time from a specialized mechanical engineer or consultant will require 18 hours at an average rate of \$300/hour, or \$5,400. This amounts to an incremental cost of approximately \$1.30 per square foot.

4.4.5 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 the estimation of the present value of maintenance and replacement costs.

Replacement cost assumptions for the baseline system includes equipment costs sourced online on April 24th, 2026, with pricing from HVACdirect.com and Greenthumbdepot.com for the DX system and standalone dehumidifiers, respectively. All other costs including integrated equipment costs, installation costs for both the integrated and baseline HVAC/D systems, and all ancillary costs were scaled to the flower room canopy area from a real contractor quote provided on April 21, 2026.

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. For this analysis, the Statewide CASE Team assumed no incremental routine maintenance costs, based on feedback from SMEs indicating that such costs are difficult to quantify because routine maintenance is typically performed by on-site staff on salary and is already incorporated into existing operational responsibilities.

Integrated systems have an assumed EUL of 12 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, commissioning, and contractor overhead costs (totaling \$221,680 per integrated unit). 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 a real contractor quote provided on April 21, 2026. The atmospheric temperature and relative humidity sensor were assumed to be replaced every eight years based on Statewide CASE Team subject matter expert input and manufacturer data (BAPI). Replacement costs include the initial sensor cost plus two hours of electrician labor at the 2029 prevailing wage, totaling \$579 (State of California Department of Industrial Relations, 2026). Previous values were shared with several industry stakeholders and updates were made based on their input.

The cooling equipment used in decoupled DX systems has an assumed EUL of six years, with compressors replaced every three years. Each decoupled system includes one 5-ton compressor. The replacement cost for a single-stage compressor is estimated at \$2,500 for parts and installation, and the replacement cost for each full decoupled DX system is estimated at \$4,730, based on online prices and a scaled contractor quote described above. These values were shared with several industry stakeholders who did not object to their use in this analysis.

Standalone dehumidifiers are assumed to be replaced every six years at a cost approximately equal to the initial equipment price plus \$1,000 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 four filter sets per cycle at \$200 each. The decoupled system requires 61 filters per cycle, including 37 dehumidifier filters at \$50 each and 24 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 67 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 that the inflation-adjusted costs remain constant with a three percent real

discount rate. The total net present value of incremental maintenance costs over the 30-year period is -\$43.34. The incremental and maintenance costs are assumed to be the same for new construction, additions, and alterations. Note that this table does not include incremental first costs, which are covered in Table 65 and Table 66.

Table 67: Incremental Replacement and Maintenance Cost Per Canopy Square Foot – Space Conditioning – New Construction, Additions, and Alterations

Costs Year	Integrated (Proposed) Full System (\$)	Integrated (Proposed) Compressors (\$)	Integrated (Proposed) Sensors (\$)	Integrated (Proposed) Filters (\$)	Integrated (Proposed) Total (\$)	Decoupled DX (Baseline) Full System (\$)	Decoupled DX (Baseline) Compressors (\$)	Decoupled DX (Baseline) Dehumidifiers (\$)	Decoupled DX (Baseline) Sensors (\$)	Decoupled DX (Baseline) Filters (\$)	Decoupled DX (Baseline) Total (\$)	Incremental Cost (\$)	Incremental Cost (\$/canopy ft2)	Incremental Net Present Value per Canopy ft2
1	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$3.31
2	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$3.21
3	N/A	N/A	N/A	\$3,200	\$3,200	N/A	\$60,000	N/A	N/A	\$18,920	\$78,920	-\$75,720	-\$16.41	-\$15.02
4	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$3.03
5	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.94
6	N/A	\$240,000	N/A	\$3,200	\$243,200	\$113,520	N/A	\$328,856	N/A	\$18,920	\$461,296	-\$218,096	-\$47.26	-\$39.58
7	N/A	\$240,000	N/A	\$3,200	\$243,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	\$224,280	\$48.60	\$39.52
8	N/A	N/A	\$579	\$3,200	\$3,779	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,141	-\$3.28	-\$2.59
9	N/A	N/A	N/A	\$3,200	\$3,200	N/A	\$60,000	N/A	N/A	\$18,920	\$78,920	-\$75,720	-\$16.41	-\$12.58
10	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.54
11	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.46
12	\$846,720	N/A	N/A	\$3,200	\$849,920	\$113,520	N/A	\$328,856	N/A	\$18,920	\$461,296	\$388,624	\$84.21	\$59.06
13	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.32
14	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.25
15	N/A	N/A	N/A	\$3,200	\$3,200	N/A	\$60,000	N/A	N/A	\$18,920	\$78,920	-\$75,720	-\$16.41	-\$10.53
16	N/A	N/A	\$579	\$3,200	\$3,779	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,141	-\$3.28	-\$2.04
17	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$2.06

Costs Year	Integrated (Proposed) Full System (\$)	Integrated (Proposed) Compressors (\$)	Integrated (Proposed) Sensors (\$)	Integrated (Proposed) Filters (\$)	Integrated (Proposed) Total (\$)	Decoupled DX (Baseline) Full System (\$)	Decoupled DX (Baseline) Compressors (\$)	Decoupled DX (Baseline) Dehumidifiers (\$)	Decoupled DX (Baseline) Sensors (\$)	Decoupled DX (Baseline) Filters (\$)	Decoupled DX (Baseline) Total (\$)	Incremental Cost (\$)	Incremental Cost (\$/canopy ft2)	Incremental Net Present Value per Canopy ft2
18	N/A	\$240,000	N/A	\$3,200	\$243,200	\$113,520	N/A	\$328,856	N/A	\$18,920	\$461,296	-\$218,096	-\$47.26	-\$27.76
19	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.94
20	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.89
21	N/A	N/A	N/A	\$3,200	\$3,200	N/A	\$60,000	N/A	N/A	\$18,920	\$78,920	-\$75,720	-\$16.41	-\$8.82
22	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.78
23	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.73
24	\$846,720	N/A	\$579	\$3,200	\$850,499	\$113,520	N/A	\$328,856	N/A	\$18,920	\$461,296	\$389,203	\$84.33	\$41.48
25	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.63
26	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.58
27	N/A	N/A	N/A	\$3,200	\$3,200	N/A	\$60,000	N/A	N/A	\$18,920	\$78,920	-\$75,720	-\$16.41	-\$7.39
28	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.49
29	N/A	N/A	N/A	\$3,200	\$3,200	N/A	N/A	N/A	N/A	\$18,920	\$18,920	-\$15,720	-\$3.41	-\$1.45
30	N/A	\$240,000	N/A	\$3,200	\$243,200	\$113,520	N/A	\$328,856	N/A	\$18,920	\$461,296	-\$218,096	-\$47.26	-\$19.47

4.4.6 Cost Effectiveness

The cost-effectiveness analysis evaluates incremental first costs, maintenance costs, and replacement costs relative to the baseline, 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 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 the equipment lifetime, replacement, and filter maintenance assumptions outlined in Section 4.4.5.

Energy cost savings were modeled using a prototype indoor cannabis flower room representative of covered indoor CEH spaces with lighting power density greater than or equal to 30 W/ft² of plant canopy and at least 5,000 ft² canopy area. Savings were calculated as the difference in site energy use and LSC savings between the baseline decoupled HVAC/D system and the representative integrated HVAC/D compliance case, applied across all California climate zones. Energy savings and incremental costs were calculated on a per-canopy-square-foot basis, as detailed in Section 4.4.2.

Results of the per-unit cost-effectiveness analyses are presented in Table 68 for new construction/additions and in Table 69 for alterations. Incremental first costs are estimated at \$5.76 per canopy square foot. The proposed case has lower present-valued replacement and maintenance costs than the baseline case, resulting in avoided maintenance and replacement costs of \$43.34 per canopy square foot over the 30-year analysis period. These avoided costs are included as other present value savings. Because avoided maintenance and replacement costs exceed incremental maintenance costs, total incremental PV costs consist of incremental first costs only.

Total benefits are the sum of LSC electricity savings and avoided maintenance and replacement costs. LSC savings vary by climate zone because both the cost of electricity and the energy savings vary by climate zone. The LSC savings vary from \$315.25 to \$363.07 per canopy square foot, and the total benefits (LSC savings plus the avoided maintenance and replacement costs of \$43.34 per canopy square foot) vary from \$358.59 to \$406.41 per canopy square foot. Because incremental first costs are low and total benefits are high, the proposed measure is cost-effective in all climate zones, with benefit-to-cost ratios ranging from 83 to 94 for new construction, additions, and alterations. The high benefit-to-cost ratio is primarily driven by the combination of large energy savings in high-intensity indoor growing applications and relatively small incremental first costs due to reduced total system capacity and lower installation costs for integrated systems. Because the analysis assumes full replacement of the HVAC/D system for alterations, and a new HVAC/D system for new construction/additions, costs

and benefits are the same for new construction, additions, and alterations, except for differences in weighted average results.

Table 68: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$358.59	\$5.76	62
2	\$376.39	\$5.76	65
3	\$386.52	\$5.76	67
4	\$379.09	\$5.76	66
5	\$390.82	\$5.76	68
6	\$397.88	\$5.76	69
7	\$406.41	\$5.76	71
8	\$399.49	\$5.76	69
9	\$400.28	\$5.76	69
10	\$389.99	\$5.76	68
11	\$373.06	\$5.76	65
12	\$387.43	\$5.76	67
13	\$380.14	\$5.76	66
14	\$358.82	\$5.76	62
15	\$397.90	\$5.76	69
16	\$360.25	\$5.76	63
Weighted Average	\$383.48	\$5.76	67

Table 69: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$358.59	\$5.76	62
2	\$376.39	\$5.76	65
3	\$386.52	\$5.76	67
4	\$379.09	\$5.76	66
5	\$390.82	\$5.76	68
6	\$397.88	\$5.76	69
7	\$406.41	\$5.76	71
8	\$399.49	\$5.76	69
9	\$400.28	\$5.76	69
10	\$389.99	\$5.76	68
11	\$373.06	\$5.76	65
12	\$387.43	\$5.76	67
13	\$380.14	\$5.76	66
14	\$358.82	\$5.76	62
15	\$397.90	\$5.76	69
16	\$360.25	\$5.76	63
Weighted Average	\$387.20	\$5.76	67

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 indicating that flower rooms typically account for over 50 percent of total facility square footage (Gillespie, 2025; Stober & Weitze, 2024) and one article indicating that flower rooms account for approximately 70 percent of total square footage (Streit, 2022).
- 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 versus 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 (Cannabis Business Times, 2026) indicates that 15 percent of growers who currently do not use vertical rack systems in flower areas are 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 [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 70) and alterations (Table 71) by climate zone. Table 72 presents first-year statewide savings from new construction, additions, and alterations.

Table 70: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00005	0.002	0.0001	N/A	0.002	\$0.02
2	0.00617	0.291	0.0169	N/A	0.256	\$2.06
3	0.01513	0.731	0.0433	N/A	0.665	\$5.19
4	0.00475	0.226	0.0131	N/A	0.200	\$1.59
5	0.00814	0.393	0.0239	N/A	0.353	\$2.83
6	0.00082	0.042	0.0025	N/A	0.037	\$0.29
7	0.00876	0.450	0.0278	N/A	0.408	\$3.18
8	0.00071	0.036	0.0022	N/A	0.032	\$0.25
9	0.00071	0.035	0.0021	N/A	0.031	\$0.25
10	0.13091	6.494	0.3856	N/A	5.604	\$45.38
11	0.00056	0.026	0.0015	N/A	0.022	\$0.18
12	0.00673	0.327	0.0182	N/A	0.282	\$2.32
13	0.00270	0.131	0.0073	N/A	0.110	\$0.91
14	0.04303	2.000	0.1192	N/A	1.750	\$13.57
15	0.00530	0.269	0.0154	N/A	0.226	\$1.88
16	0.00671	0.295	0.0183	N/A	0.273	\$2.13
Total	0.24119	11.749	0.6976	N/A	10.252	\$82.04

Table 71: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide Existing Building Stock Impacted by Proposed Change in 2029 (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	0.00478	0.21	0.01	N/A	0.19	\$1.51
2	0.00407	0.19	0.01	N/A	0.17	\$1.36
3	0.01992	0.96	0.06	N/A	0.87	\$6.83
4	0.00584	0.28	0.02	N/A	0.25	\$1.96
5	0.04951	2.39	0.15	N/A	2.15	\$17.20
6	0.06121	3.11	0.19	N/A	2.78	\$21.70
7	0.00785	0.40	0.02	N/A	0.37	\$2.85
8	0.00562	0.29	0.02	N/A	0.25	\$2.00
9	0.01209	0.60	0.03	N/A	0.53	\$4.31
10	0.07464	3.70	0.22	N/A	3.19	\$25.87
11	0.02119	1.01	0.06	N/A	0.85	\$6.99
12	0.03906	1.90	0.11	N/A	1.64	\$13.44
13	0.04068	1.97	0.11	N/A	1.66	\$13.70
14	0.02018	0.94	0.06	N/A	0.82	\$6.36
15	0.00616	0.31	0.02	N/A	0.26	\$2.19
16	0.00351	0.15	0.01	N/A	0.14	\$1.11
Total	0.37630	18.41	1.08	N/A	16.12	\$129.39

Table 72: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

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\$)
New Construction & Additions	11.7	0.70	N/A	10.3	\$82.04
Alterations	18.4	1.1	N/A	16.1	\$129.39
Total	30.2	1.8	N/A	26.4	\$211.43

4.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 73 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 1,395 metric tons of CO₂e 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 73: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO ₂ e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO ₂ e)	Total Reduced GHG Emissions (Metric Ton CO ₂ e)	Total Monetary Value of Reduced GHG Emissions (\$)
New Construction, Additions, & Alterations	1,395	N/A	1,395	\$226,661

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 proposed code change affects space conditioning systems by reducing the number and size of HVAC and distribution system components rather than replacing individual pieces of equipment. To estimate material impacts, the Statewide CASE Team evaluated the types and quantities of HVAC and distribution systems under both baseline and proposed measure conditions. The analysis considered primary system components and materials, including steel, copper, plastic, insulation, refrigerants, and trace amounts of lead.

Material impacts were assessed for major system elements, including HVAC equipment, electrical connections, ductwork, condensate piping, and refrigerant piping. Electrical impacts are primarily associated with copper wiring for equipment connections. Ductwork materials consist mainly of steel ducting with insulation, while condensate piping is primarily plastic piping with insulation, and refrigerant piping consists of copper piping.

Across all system components, the proposed measure results in an overall decrease in material use. These reductions are driven by a decreased number of pieces of

equipment, lower overall system weights, and a corresponding reduction in required electrical connections, piping, and associated materials.

Table 74 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. The [2028 CASE Methodology Report](#) provides more information on the Statewide CASE Team’s methodology and assumptions used to calculate embodied GHG emissions.

Table 74: 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 CO2e)
Mercury	No Change	N/A	N/A	N/A
Lead	Decrease	0.003	2,099.46	1.24
Copper	Decrease	0.656	405,318.75	514.75
Concrete	No Change	N/A	N/A	N/A
Steel	Decrease	0.247	152,334.15	83.78
Insulation	Decrease	0.140	86,633.49	96.16
Wood	No Change	N/A	N/A	N/A
Plastic	Decrease	0.167	103,305.65	86.78
Refrigerants	Decrease	0.020	12,534.99	9,164.21
Glass	No Change	N/A	N/A	N/A
Aluminum	Decrease	0.009	5,742.63	21.40
TOTAL	N/A	1.234	762,226.48	9,946.93

4.5.5 Environmental Impacts

Requirements for HVAC/D system controls, sizing, and performance criteria for indoor growing facilities with at least 5,000 square feet of canopy and lighting power density greater than or equal to 30 W per canopy square foot are expected to provide environmental benefits by reducing electricity use and associated GHG emissions. Allowing CO₂-enriched CEH Spaces to set outdoor air ventilation to zero may provide an additional reduction in GHG emissions. The Statewide CASE Team did not identify any indirect benefits or any direct or indirect adverse environmental impacts associated with this measure; therefore, mitigation strategies are not needed. The Statewide CASE

Team found no reasonable alternatives that would achieve comparable reductions in indoor growing space conditioning energy consumption with fewer environmental effects. The overall material consumption decreased, and material impacts analysis indicates a net reduction in embodied GHG emissions from this proposed measure.

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.

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). New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics*.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.⁸ New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “**Section 601.1** [Section 130.0(a)] **General**” contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from

the requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

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)

SUBCHAPTER 2 DEFINITIONS

SECTION 201

DEFINITIONS

DEHUMIDIFIER, COMMERCIAL is a dehumidifier that is powered by three-phase current, has a supply voltage rating of 208V or higher, or has a rated capacity of at least 185 pints/day at 80F / 60% RH, and is marketed for commercial use.

DEHUMIDIFIER, CONSUMER is a dehumidifier that is powered by single-phase current, has a supply voltage rating below 208V, and has a rated capacity of less than either 185 pints/day at 80F / 60% RH or 155 pints/day at 73F / 60% RH.

...

CONTROLLED ENVIRONMENT HORTICULTURE (CEH) SPACE is a building space dedicated to plant production cultivation 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.

...

INDOOR GROWING SPACE CONDITIONING SYSTEM is a system that provides dehumidification, mechanical cooling, reheat, or mechanical heating, and incorporates components, sensors, and controls that manage temperature and humidity within an indoor growing space.

...

INTEGRATED SPACE CONDITIONING SYSTEM is an HVAC and dehumidification system designed to handle both sensible and latent heat removal. Integrated HVAC/D systems may use one or more heat and/or moisture exchange mediums including refrigerant, chilled water, and/or liquid desiccants to dehumidify and cool air. Integrated HVAC/D systems use recovered heat to reheat air to meet supply air setpoints and/or regenerate desiccant media.

INTEGRATED DX HVAC/D SYSTEM is an 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, and single package air conditioners with at least one refrigerant circuit providing hot gas reheat, and dehumidifiers modified to allow external heat rejection.

COORDINATED DECOUPLED HVAC/D SYSTEM is a space-conditioning system serving an Indoor Growing space that uses separate commercial HVAC equipment and commercial dehumidification equipment controlled by a common control system that stages or modulates equipment to maintain temperature and humidity setpoints.

...

PLANT CANOPY AREA is the aggregate area, in square feet, that will be occupied by mature plants. 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.

...

PROCESS SPACE is a nonresidential space that is designed to be thermostatically controlled to maintain a process environment temperature less than 55° F or to maintain a process environment temperature greater than 90° F for the whole space that the system serves, or that is a space with a space-conditioning system designed and controlled to be incapable of operating at temperatures above 55° F or incapable of operating at temperatures below 90° F at design conditions, or that is a Controlled Environment Horticulture (CEH) Space.

...

RECOVERED HEAT CAPACITY RATIO is the percentage of reheat capacity provided by recovered heat, calculated as recovered reheat capacity divided by total reheat capacity. Reheat capacity can include sensible heating as well as regeneration of desiccant mediums.

...

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 401
NONRESIDENTIAL AND HOTEL/MOTEL OCCUPANCIES
(NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)

401.2.1.1.3 [Section 120.1(c)3] Mechanical ventilation.

TABLE 401.2-A[TABLE 120.1-A]– Continued Minimum Ventilation Rates

Occupancy Category – Miscellaneous Spaces	Minimum Occupant Load Density (persons / 1000 ft²)	Area-based Minimum Ventilation Ra (cfm/ft²)	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
<u>Controlled Environment Horticulture (CEH) Space with Carbon Dioxide Enrichment</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>G</u>
<u>Controlled Environment Horticulture (CEH) Space without Carbon Dioxide Enrichment</u>	<u>5</u>	<u>0.15</u>	<u>2</u>	<u>=</u>

Footnotes for Table 401.2-A [Table 120.1-A]:

1. The minimum occupant density is one half of the maximum occupant load assumed for egress purposes in the CBC.

Specific Notes:

- A. For high-school and college libraries, the values shown for “Public Assembly Spaces – Libraries” shall be used.
- B. Rate may not be sufficient where stored materials include those having potentially harmful emissions.
- C. Rate does not allow for humidity control. “Deck area” refers to the area surrounding the *pool* that is capable of being wetted during *pool* use or when the *pool* is occupied. Deck area that is not expected to be wetted shall be designated as an *occupancy category*.
- D. Rate does not include special exhaust for stage effects such as dry ice vapors and smoke.

- E. Where combustion *equipment* is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.
- F. Ventilation air for this occupancy category shall be permitted to be reduced to zero when the space is in occupied-standby mode.
- G. [See California Fire Code Section 5307.4 for carbon dioxide monitoring and purge ventilation requirements](#)

SECTION 908 CONTROLLED ENVIRONMENTAL HORTICULTURE (CEH) (NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)

908.1 [Section 120.6(h)] **Mandatory requirements (Newly Constructed, Additions, Alterations).**

[Controlled Environment Horticulture \(CEH\) spaces shall comply with the applicable requirements of Sections 908.1 through 908.4 and requirements of Section 913.1. Equipment, systems, controls, appliances, and components serving *Indoor Growing* spaces shall comply with the applicable requirements in Sections 101.2 \[Section 110.0\], and 101.3 \[Section 110.1\]. Service water-heating systems serving *Indoor Growing* spaces shall comply with Section 500 \[Section 110.3\]](#)

908.1.1 [Section 120.6(h)1] **Indoor growing, dehumidification.**

Dehumidification equipment [in *Indoor Growing* spaces with less than 5000 square feet of total *plant canopy area* or with lighting power density less than 30 Watts per square foot of *plant canopy area*](#) shall be one of the following:

1. [Consumer dehumidifiers](#) subject to regulation under federal appliance standards tested in accordance with 10 CFR 430.23(z) and Appendix ~~X~~ X1 to Subpart B of 10 CFR Part 430 as applicable, and complying with 10 CFR 430.32(v)2;

2. [Commercial dehumidifiers that comply with Reference Joint Appendix JA19 and certified as required by JA19.](#)

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

4. ~~3.~~ [Chilled water system](#) with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification *reheat*; or

5. ~~4.~~ [Solid or liquid *desiccant dehumidification* system](#) for system designs that require dewpoint of 50°F or less.

908.1.2 [Section 120.6(h)2] **Indoor growing and greenhouse, electrical power distribution systems.**

[Electrical power distribution systems](#) serving CEH spaces shall [comply with 601.2.6 \[Section 130.5\], and ~~be designed so that a measurement device is~~](#)

~~capable of monitoring the electrical energy usage of aggregate horticultural lighting load. shall be considered a lighting type.~~

908.1.3 [Section 120.6(h)3] Conditioned greenhouses and indoor growing, building envelope.

908.1.3.1 Conditioned greenhouses shall meet the following requirements:

1. Opaque wall and opaque *roof* assembly shall meet the requirements of Section 301.2 [Section 120.7]; and
2. Nonopaque *envelopes* shall have two or more *glazings* separated by either air or gas fill.

908.1.3.2 Indoor growing spaces shall meet the requirements of Sections 300.1 [Section 110.6], 300.2 [Section 110.7], 300.3 [Section 110.8], and 301.2 [Section 120.7].

...

908.1.6. Indoor growing space conditioning systems.

908.1.6.1 Equipment serving *Indoor Growing* spaces shall comply with the applicable requirements of Sections 400.5.1 [Section 110.2(a)], 400.5.3 [Section 110.2(b)], 400.5.5 [Section 110.2(e)], 401.2.1.4 [Section 120.1(f)], 401.2.1.5 [Section 120.1(g)], 401.2.2.1 [Section 120.2(a)], 401.2.2.3 [Section 120.2(d)], 401.2.2.6 [Section 120.2(f)], 401.2.2.7 [Section 120.2(g)], 401.2.2.9 [Section 120.2(i)], 401.2.2.10 [Section 120.2(j)], 401.2.2.12 [Section 120.2(l)], 401.2.4 [Section 120.4], and 501.2.2 [Section 120.9].

908.1.6.2 Indoor Growing spaces with greater than or equal to 5,000 square feet of total *plant canopy area* with lighting power density greater than or equal to 30 Watts per square foot of *plant canopy area* shall comply with all of the following:

1. Sizing, indoor growing space conditioning system. *Indoor growing space conditioning system(s)* shall be sized to meet the design heating, cooling, and dehumidification loads calculated according to NA9 and documented in construction documents.

2. Indoor growing space conditioning system characteristics. The *indoor growing space conditioning system* shall meet all requirements of one of the following systems:

2.1 Integrated space conditioning system meeting all of the following requirements:

2.1.1 Construction documents shall identify *an integrated space conditioning system* capable of providing cooling, dehumidification, and *reheat* using heat recovered from the dehumidification process. The *integrated space conditioning system* shall be one of the following:

2.1.1.1. An *integrated DX HVAC/D system*,

2.1.1.2. A four-pipe chilled water system,

2.1.1.3. A desiccant dehumidification system, or

2.1.1.4. Another system meeting the specifications outlined in 908.1.6.2.1.3.

2.1.2 The *integrated space conditioning system* and any supplemental cooling or dehumidification equipment must be sized to meet peak latent and sensible loads calculated in accordance with NA9. At least 80% of peak latent and sensible load must be met by the integrated system. Supplemental cooling and dehumidification equipment must meet the requirements in Section 2.2 of 908.1.6.2.

2.1.3 The integrated system and controls shall be capable of the following in response to process needs, indoor temperatures and humidity conditions:

2.1.3.1. Modulate *sensible heat ratio* in response to measured *indoor growing* space conditions and temperature and humidity setpoints, demonstrated through calculations in Nonresidential Appendix NA9;

2.1.3.2. Modulate heat recovery between 0% and 90% of heat of rejection of the primary system, as needed to meet supply air setpoints;

2.1.3.3. Modulate heat rejection outside of the space between 10% and 100% of heat of rejection of the primary system;

2.1.3.4. Modulate supply fan speed in response to measured space conditions and temperature and humidity setpoints; and

2.1.3.5. The *integrated space conditioning system* shall be controlled in accordance with 908.1.6.4.

2.2. A *coordinated decoupled HVAC/D system* meeting the requirements of 2.2.1 and either 2.2.2 or 2.2.3.

2.2.1 *Commercial dehumidifiers* that comply with Reference Joint Appendix JA19 and certified as required by JA19.

2.2.2 Commercial unitary air-conditioning, or *heat pump* equipment with a minimum of two stages of cooling capacity and at least two stages of fan control, tested in accordance with AHRI 1340²⁵ and meeting minimum IVEC and/or IVHE requirements effective 1/1/2029:

²⁵ https://www.energy.gov/sites/default/files/2024-04/cuac_nopr_km.pdf

2.2.2.1 65,000 to < 135,000 Btu/h: IVEC 13.8 (AC) or 13.4 (HP).

2.2.2.2 135,000 to < 240,000 Btu/h: IVEC 13.8 (AC).

2.2.2.3 240,000 to < 760,000 Btu/h: Specific efficiency requirements mandated by 10 CFR Part 431 Subpart F.

2.2.3. Variable refrigerant flow systems tested in accordance with AHRI 1230 and meeting minimum *IEER* requirements:

2.2.3.1. Up to < 135,000 Btu/h: 15.5 *IEER* (Heat Pumps: 14.6 *IEER*, 3.3 *COP*).

2.2.3.2 Up to < 240,000 Btu/h: 14.9 *IEER* (Heat Pumps: 14.4 *IEER*, 3.3 *COP*).

2.2.3.3 Up to < 760,000 Btu/h: 13.9 *IEER*.

3. Heat recovery. Dehumidifiers shall be capable of meeting a *recovered reheat capacity ratio* of at least 0.9 as demonstrated through manufacturer data or engineering calculations.

4. Supplemental heating. If used, electric resistance heating or combustion heating equipment shall comply with the following:

4.1. 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.

4.2. Equipment shall be controlled to only operate when heating load exceeds available recovered heat capacity.

5. Integrated temperature and humidity controls. Controls for space conditioning equipment shall meet all of the following requirements:

5.1. One integrated control system shall control both humidity and temperature based on readings from humidity and temperature sensors co-located within the plant canopy.

5.2. Controls shall automatically stage or modulate all space conditioning equipment to meet temperature and humidity setpoints.

5.3. *Commercial dehumidifiers* shall be controlled from a central controller that sequences or modulates operation based on dehumidification load.

6. Commercial dehumidifiers that reject all heat within the building envelope. If used, dehumidifiers that reject heat within the building envelope shall 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

7. 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 and documented on the applicable Certificate of Acceptance. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures outlined in Section 401.2.7 [Section 120.5].

908.4 [Section 141.1, 141.1(c)] Additions and alterations to existing buildings.

Covered processes in additions or alterations to existing buildings that will be nonresidential, hotel/motel, or multifamily occupancies shall comply with the applicable requirements of Section 400.5.1 [Section 110.2(a)] and Section 913 [Section 120.3].

908.4.1 [Section 141.1(c)1] Indoor Growing, Space-Conditioning Systems and Dehumidification.

All newly-For all additions or alterations that increase plant canopy area by at least 5000 square feet, all alterations that replace greater than 50 percent of the total installed capacity of heating, ventilation, air conditioning systems cooling, or and dehumidification systems serving at least 5000 square feet of plant canopy area in buildings with indoor growing, and all alterations in buildings with indoor growing that increase lighting power density to greater than or equal to 30 Watts per square foot of canopy shall meet the applicable requirements of Section 908.1.1 [Section 120.6(h)1], and Section 908.1.2 [Section 120.6(h)2], and Section 908.1.6 [Section 120.6(h)6].

Alterations that replace indoor growing space conditioning system equipment shall comply with applicable requirements in Section 401.5 [Section 141.0(b)].

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. 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 Indoor Growing 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 *Indoor Growing* space. These calculations will enable determination of whether a design complies with the code in section 908.1.6 [section 120.6(h)6A].

This load calculation and sizing procedure is applicable to *indoor growing* spaces with lighting power density greater than or equal to 30 Watts per canopy square foot in *indoor growing* facilities with canopy area greater than or equal to 5,000 square feet.

NA9.2 Canopy Square Footage

To determine total canopy area of *indoor growing* rooms in a facility, 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.
4. Total canopy area shall be calculated to determine if sizing and performance calculations are required, but sizing and performance calculations should be done on a room-by-room basis. As such, the room canopy area will often be less than 5,000 square feet.

NA9.3 Load Calculations

NA9.3.1. Design Loads

In calculating design loads, the following input values shall be specified (Default values may be used where project-specific data is not available, as provided in the compliance manual):

- 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 *indoor growing* space where lighting intensity is greater than 30 W/canopy square foot, provide the following:
 - i. Canopy square footage calculated as described in NA9.2 Canopy Square Footage.
 - ii. For 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. Relative humidity room conditions for lights on and lights off conditions.
 - D. 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.
 - E. 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.
 - F. Net plant irrigation per day, calculated as the amount delivered less runoff.
 - G. Percentage of net plant irrigation transpired during the lights-on period. This value shall be no less than 70% and no greater than 80%.
 - H. Lights on period length in hours per day.
 - I. 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 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 four operating conditions.
 1. The Sensible Space Load is calculated as the sum of the Horticultural Lighting Load, the Motor Heat Load, the Envelope Load, and the Standalone Dehumidifier Load. Power in kW can be converted to load in BTU/hr by multiplying by 3412 BTU/hr/kW.

Sensible Space Load

$$= (\text{Horticultural Lighting Load} + \text{Motor Heat Load} + \text{Envelope Load} + \text{Standalone Dehumidifier Load}) \times 3412 \frac{\text{BTU}}{\text{hour} \cdot \text{kW}}$$

- b. The Evapotranspiration Load is calculated for 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 four operating 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

$$= \frac{(\text{Net Irrigation}) \times 8.33 \frac{\text{lb}}{\text{gal}} \times (\% \text{ irrigation transpired while lights on/off}) \times \left(1060 \frac{\text{BTU}}{\text{lb}}\right)}{\text{hours lights on/off}}$$

2. The positive evapotranspiration load represents the evaporative cooling effect of plants within the space, acting as both a negative sensible load (cooling) and a positive latent load (moisture addition). Accordingly, the Net Sensible Load can be calculated as the Sensible Space Load minus the evaporative cooling effect of evapotranspiration, with the design condition corresponding to the combined Net Sensible Load and Evapotranspiration Load, which determines the total system cooling capacity requirement.

The sum of the Net Sensible Load and Evapotranspiration Load is approximately equal to the Sensible Space Load, which is used to confirm that Total Cooling Capacity is sufficient. However, it is necessary to calculate Evapotranspiration Load separately to verify that Total Latent Removal Capacity is also sufficient.

NA9.4 Cooling or Integrated Space Conditioning System Equipment Specification

- o Cooling or Integrated *Space Conditioning System* Performance is listed for the loads and operating conditions described for 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 four operating conditions. Performance shall be documented using manufacturer data or engineering calculations.

- System Air Flow in CFM is the system load side (room) air flow at the performance condition at each of the four specified conditions. Integrated systems must demonstrate that airflow varies between one or more of the specified conditions.
- Total Cooling Capacity in BTU/hr is the rate of cooling provided by the system at each of the four specified operating conditions. Total cooling capacity must be equal to or greater than total cooling load. Integrated systems capacity must be at least 80% of total cooling load. Supplemental equipment can be used for the remaining load.
- Latent Removal Capacity in BTU/hr is the rate of energy provided by the system to remove moisture from the load side (room) air at each of the four specified operating conditions. Total latent removal capacity must be equal to or greater than total evapotranspiration load. Integrated systems capacity must be at least 80% of total latent load. Supplemental equipment can be used for the remaining load.
- Sensible Heat Ratio is calculated as the sensible portion of the Total Cooling Capacity divided by the Total Cooling Capacity.

$$\text{Sensible Heat Ratio} = \frac{\text{Total Cooling Capacity} - \text{Latent Removal Capacity}}{\text{Total Cooling Capacity}}$$

- Reheat Capacity is the rate of energy required to reheat the supply airstream following dehumidification to maintain the desired room air conditions at the four specified operating conditions.
- Recovered Heat Capacity is the rate of energy recovered from the system using any of a variety of means to be utilized for reheat of the supply (load side) air stream. Integrated systems must use recovered heat to meet at least 90% of the reheat load.

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 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 four operating 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 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 four operating conditions.

4. The supplemental heating capacity shall be specified in BTU/hr for the loads and operating conditions for 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 four operating conditions.

NA9.6 System Capacity

1. The Total System Cooling Capacity is the rate of cooling provided by the equipment and specified for the loads and operating conditions described for the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions. The Total System Cooling Capacity is sized to meet 100% of the combined Net Sensible Load and Evapotranspiration Load, such that it represents the Sensible Space Load at each condition. Performance shall be documented using manufacturer data or engineering calculations.
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, and is sized to meet 100% of the Evapotranspiration Load at each of the four specified operating conditions. This shall be calculated for the loads and operating conditions described for the last week of the grow cycle, and a midpoint between weeks 3 and 6, for lights on and for lights off conditions. Performance shall be documented using manufacturer data or engineering calculations.

Appendix JA19 Qualification Requirements for Commercial Dehumidifiers

JA19.1 Purpose and Scope

Joint Appendix JA19 provides the qualification requirements for *commercial dehumidifiers* to comply with section 908.1[Section 120.6(h)]. All qualifying *commercial dehumidifiers* shall be certified to the Energy Commission according to all of the requirements in this Appendix.

JA19.2 Tests to be performed

Compliance with the requirements of this Appendix shall be determined by performance of the following test procedures, as applicable to the type of *commercial dehumidifier*.

Commercial dehumidifiers that are non-federally-regulated equipment shall be tested in accordance with 10 C.F.R. 430.23(z) and Appendix X1 with the following modifications:

1. Dehumidifiers shall be tested at the three following conditions:
 - a. 80F / 60% RH; 0.00 in. W.C.
 - b. 73F / 60% RH; 0.20 in. W.C.
 - c. 73F / 50% RH; 0.00 in. W.C.

2. Tests 1.a and 1.c shall be performed without ducting.
3. Test 1.b. shall be performed using the Uniform Test Method of Appendix X1 modified to the appropriate duct diameter and throttling device required to achieve a static pressure of 0.2 inches W.C. at the rated airflow of the equipment.

JA19.3 Qualification Requirements

The following qualification requirements must be met for the *commercial dehumidifier* to be certified to the Energy Commission.

The *commercial integrated energy factor* (CIEF) of a *commercial dehumidifier* tested under JA19.2 shall be an equally weighted mean value derived from tests 1.a, 1.b, and 1.c.

The mean value of these three tests shall be greater than 3.0 liters/kWh.

JA19.4 Data Reporting

The following test data shall be submitted to the California Energy Commission in the format specified in Table JA-19. The entity submitting the filing shall keep all test data and documentation required for compliance for at least two years from the date of certification and shall provide copies of this documentation to the Energy Commission within 10 days of written request received from the Energy Commission.

Table JA-19. Data to be Recorded and Submitted to the California Energy Commission

<u>Required Information</u>	<u>Permissible Answers</u>
<u>Manufacturer Name</u>	
<u>Model Number</u>	
<u>Equipment Type</u>	<u>Non-Federally Regulated Commercial Dehumidifier</u>
<u>Efficiency at 80F/60% RH, 0.0 W.C.</u>	
<u>Efficiency at 73F/60% RH, 0.2 W.C.</u>	
<u>Efficiency at 73F/50% RH, 0.0 W.C.</u>	
<u>Commercial Integrated Energy Factor (liters/kWh)</u>	
<u>Capacity (pints/day) at 80F/60% RH</u>	
<u>Voltage</u>	

<u>Required Information</u>	<u>Permissible Answers</u>
<u>Current Draw (Amps)</u>	

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

The Statewide CASE Team does not propose any changes to the ACM Reference Manual for this measure.

4.6.7 Compliance Forms

As discussed in Section 4.1.5.5, 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 indoor growing facilities meet sizing requirements and indoor growing space conditioning system requirements. These forms would also need to be updated to include items from the nonresidential code that would be explicitly cited in the CEH section. 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 tool²⁶ that mechanical designers and Title 24 consultants can use to verify compliance with mandatory sizing requirements, as well as requirements for integrated space conditioning systems. The sizing and load calculations are described in detail in the proposed Nonresidential Appendix on Indoor Growing Space Conditioning System Sizing outlined in Section 4.6.4.

The tool includes formulas and checks to simplify the process of verifying that an indoor growing space conditioning system is sized to meet projected loads throughout the grow cycle, and that equipment meets the key performance specifications outlined in the integrated system requirements. Although the tool includes load calculation and sizing

²⁶ Supplemental materials, including the proposed spreadsheet-based tool are available at: <https://title24stakeholders.com/measures/2028-cycle/controlled-environment-horticulture-requirements-for-space-conditioning-systems/>

formulas, the tool is only designed to support compliance with energy code requirements and does not replace professional engineering calculations.

Sizing verification would only be required for indoor growing spaces with at least 5,000 square feet of plant canopy under at least 30W/square foot of plant canopy.

Compliance could be demonstrated using the tool, or by submitting load calculations and equipment performance specifications using an alternate method. Although this code requirement is triggered for facilities with at least 5,000 square feet of plant canopy under high-intensity lighting, calculations are required on a room-by-room basis.

The first step in using the load calculation, sizing, and equipment performance tool would require the designer to identify whether the primary means of space conditioning in the room is an integrated or decoupled HVAC/D system. Separate inputs sheets are provided for each of those two system types. After selecting the system type, the designer would need to provide ambient design conditions based on the facilities location and describe room’s planned operating conditions and plant canopy area, as shown in Figure 2.

Facility Ambient Design Conditions				
				Key
ASHRAE WMO Station:		<input type="text"/>	User Input Value	<input type="text"/>
Summer Design (0.4%)	DB (°F)	<input type="text"/>	Default no value	<input type="text"/>
	MCWB (°F)	<input type="text"/>	Calculated Value	<input type="text"/>
Winter Design (99%):	DB (°F)	<input type="text"/>	Day=Lights On; Night=Lights Off	

Facility Room Details					
Fill out the following for each room/CEH Space					
Room Name:	<input type="text"/>				
Canopy Square Feet:	<input type="text"/>	(Can be multiple rooms of the same size)			
Provide the Design Space Conditions for the four CEH environment operating conditions:					
		Early/Mid Plant Life		Late Plant Life	
		Day	Night	Day	Night
Room Conditions (Setpoints)	DB (°F)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
	WB (°F)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Relative Humidity	%RH	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

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 two 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 4 prescribed conditions:					
		Early/Mid Plant Life		Late Plant Life	
		Day	Night	Day	Night
Horticultural Lighting	(kW)				
Motor Heat (Fan Power)	(kW)				
Standalone Dehu Load	(BTU/hr)	-	-	-	-
Envelope Load (Optional)	(BTU/hr)				
Plant Irrigation (total minus runoff)	(gal/day)				
% of Net Irrigation Transpired					
Day/Night	%				
Hours (Day/Night)	(hrs)				
Sensible Space Load	(BTU/hr)	-	-	-	-
Evapotranspiration Load	(BTU/hr)	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Figure 3: Indoor growing room load inputs and calculations.

Subsequently, the designer would input operating airflows, capacities, and reheat load for each of the two phases in the grow cycle for integrated equipment, as well as cooling staging and recovered heat inputs, as shown in Figure 4.

Mandatory Compliance and Cooling System Operating Performance Information					
Integrated System Equipment Specification					
Input the Primary System Performance Information that corresponds to the ambient and CEH space operating conditions and loads above:					
		Early/Mid Plant Life		Late Plant Life	
		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!
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: Integrated cooling system compliance and operating performance.

For decoupled cooling equipment, the designer would input operating airflows and capacities for each of the two phases in the grow cycle, as well as a description of cooling stages, as shown in Figure 5.

Cooling System Operating Performance Information					
Cooling System Equipment Specification					
Input the Cooling System Performance Information that corresponds to the ambient and CEH space operating conditions and loads above:					
		Early/Mid Plant Life		Late Plant Life	
		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!
Cooling Stages:		#			
Cooling Stage # Type:		Variable or Constant			

Figure 5: Cooling system compliance and operating performance.

Finally, the designer would describe any additional dehumidification or heating equipment, as shown in Figure 6.

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 6: 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 7.

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 7: System summary.

The tool would provide a summary that verifies the inputs meet the mandatory requirements, as shown in Figure 8.

Compliance Summary	
Does this meet mandatory performance requirements?	
Does this meet mandatory sizing requirements?	

Figure 8: Compliance summary.

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

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Appendix A: Assumptions for Cost-effectiveness Analysis

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 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.

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 (W/m^2), cloud cover, and haze patterns via Diffuse Horizontal Irradiance (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 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.

TMY data were sourced from 2028 CEC weather files.

Prototypical Building Types

Prototypical models were developed for the six scenarios, including two facilities and three crop types shown in Table 75, 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 Statewide 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 75: 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

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 (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 76.

Table 76: Indoor CEH Lighting Assumptions

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopi Area per Luminaire (fa ²)	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μmol/m ² /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"

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/m²/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 (ft²):** 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 77.

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 77: Greenhouse CEH Lighting Assumptions

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft ²)	20	24	10	58	56
Photoperiod (hours/day)	12	18	24	18	12
PPFD (μmol/m ² /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

Pending stakeholder input, the Statewide CASE Team has adopted the assumptions from the 2025 CEH CASE Report (Energy Solutions, 2023).

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 before accounting for HVAC interactions.

Indoor (Warehouse)

The installed wattage of CEH lighting per square foot, or LPD, is calculated as follows:

$$LPD = PPF D / PPE \times (0.0929 \text{ m}^2 / \text{ft}^2)$$

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 from the 2025 CASE Report analysis and hourly outside air temperatures sourced from 2028 CEC weather files.

Greenhouse

The installed wattage of CEH lighting per square foot, or LPD, is calculated as follows:

$$LPD = PPF D / PPE \times (0.0929 \text{ m}^2 / \text{ft}^2) \times (\text{mounting height derate factor})$$

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 PPF D change over the luminaire mounting height distance from the plant canopy and calculated as follows:

$$\text{Mounting Height derate factor} = 1 / (PPFD \% + ((1 - PPF D \%) * \text{Diffuse Light Factor}))$$

where diffuse factor is the percentage of diffuse light reaching the canopy surface and PPF D% is the percentage of the PPF D that is reaching the canopy at a given mounting height. At the prototype mounting height of 24 inches, the PPF D% 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.

Cost Effectiveness by Climate Zone and Prototype

The energy impacts of the proposed code change vary by climate zone. The variations for indoor conditions are relatively small because they are 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 78: 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	\$2.70	41
2	\$111.77	\$2.70	41
3	\$111.58	\$2.70	41
4	\$111.74	\$2.70	41
5	\$112.24	\$2.70	42
6	\$111.38	\$2.70	41
7	\$111.36	\$2.70	41
8	\$110.68	\$2.70	41
9	\$113.55	\$2.70	42
10	\$111.29	\$2.70	41
11	\$111.34	\$2.70	41
12	\$112.57	\$2.70	42
13	\$111.89	\$2.70	41
14	\$109.09	\$2.70	40
15	\$116.09	\$2.70	43
16	\$108.64	\$2.70	40

Table 79: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – 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	\$2.70	41
2	\$111.77	\$2.70	41
3	\$111.58	\$2.70	41
4	\$111.74	\$2.70	41
5	\$112.24	\$2.70	42
6	\$111.38	\$2.70	41
7	\$111.36	\$2.70	41
8	\$110.68	\$2.70	41
9	\$113.55	\$2.70	42
10	\$111.29	\$2.70	41
11	\$111.34	\$2.70	41
12	\$112.57	\$2.70	42
13	\$111.89	\$2.70	41
14	\$109.09	\$2.70	40
15	\$116.09	\$2.70	43
16	\$108.64	\$2.70	40

Table 80: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Indoor (Warehouse) Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$39.28	0.00	Not Applicable
2	\$39.70	0.00	Not Applicable
3	\$39.61	0.00	Not Applicable
4	\$40.01	0.00	Not Applicable
5	\$39.70	0.00	Not Applicable
6	\$39.97	0.00	Not Applicable
7	\$40.04	0.00	Not Applicable
8	\$40.86	0.00	Not Applicable
9	\$40.91	0.00	Not Applicable
10	\$40.97	0.00	Not Applicable
11	\$40.28	0.00	Not Applicable
12	\$40.06	0.00	Not Applicable
13	\$40.50	0.00	Not Applicable
14	\$40.66	0.00	Not Applicable
15	\$41.19	0.00	Not Applicable
16	\$39.91	0.00	Not Applicable

Table 81: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Indoor (Warehouse) Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$39.28	0.00	Not Applicable
2	\$39.70	0.00	Not Applicable
3	\$39.61	0.00	Not Applicable
4	\$40.01	0.00	Not Applicable
5	\$39.70	0.00	Not Applicable
6	\$39.97	0.00	Not Applicable
7	\$40.04	0.00	Not Applicable
8	\$40.86	0.00	Not Applicable
9	\$40.91	0.00	Not Applicable
10	\$40.97	0.00	Not Applicable
11	\$40.28	0.00	Not Applicable
12	\$40.06	0.00	Not Applicable
13	\$40.50	0.00	Not Applicable
14	\$40.66	0.00	Not Applicable
15	\$41.19	0.00	Not Applicable
16	\$39.91	0.00	Not Applicable

Table 82: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Indoor (Warehouse) Tomatoes

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$39.15	\$0.31	125
2	\$39.18	\$0.31	125
3	\$39.11	\$0.31	125
4	\$39.10	\$0.31	125
5	\$39.38	\$0.31	126
6	\$38.95	\$0.31	125
7	\$38.93	\$0.31	124
8	\$38.49	\$0.31	123
9	\$39.70	\$0.31	127
10	\$38.72	\$0.31	124
11	\$38.88	\$0.31	124
12	\$39.44	\$0.31	126
13	\$39.07	\$0.31	125
14	\$37.86	\$0.31	121
15	\$40.70	\$0.31	130
16	\$37.82	\$0.31	121

Table 83: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Indoor (Warehouse) Tomatoes

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$39.15	\$0.31	125
2	\$39.18	\$0.31	125
3	\$39.11	\$0.31	125
4	\$39.10	\$0.31	125
5	\$39.38	\$0.31	126
6	\$38.95	\$0.31	125
7	\$38.93	\$0.31	124
8	\$38.49	\$0.31	123
9	\$39.70	\$0.31	127
10	\$38.72	\$0.31	124
11	\$38.88	\$0.31	124
12	\$39.44	\$0.31	126
13	\$39.07	\$0.31	125
14	\$37.86	\$0.31	121
15	\$40.70	\$0.31	130
16	\$37.82	\$0.31	121

Table 84: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Cannabis

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$29.20	\$0.44	66
2	\$23.66	\$0.44	54
3	\$23.04	\$0.44	52
4	\$18.44	\$0.44	42
5	\$18.20	\$0.44	41
6	\$17.80	\$0.44	40
7	\$17.67	\$0.44	40
8	\$17.04	\$0.44	39
9	\$16.58	\$0.44	38
10	\$16.47	\$0.44	37
11	\$23.41	\$0.44	53
12	\$21.45	\$0.44	49
13	\$19.38	\$0.44	44
14	\$15.62	\$0.44	35
15	\$15.65	\$0.44	36
16	\$21.91	\$0.44	50

Table 85: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Cannabis

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$29.20	\$0.44	66
2	\$23.66	\$0.44	54
3	\$23.04	\$0.44	52
4	\$18.44	\$0.44	42
5	\$18.20	\$0.44	41
6	\$17.80	\$0.44	40
7	\$17.67	\$0.44	40
8	\$17.04	\$0.44	39
9	\$16.58	\$0.44	38
10	\$16.47	\$0.44	37
11	\$23.41	\$0.44	53
12	\$21.45	\$0.44	49
13	\$19.38	\$0.44	44
14	\$15.62	\$0.44	35
15	\$15.65	\$0.44	36
16	\$21.91	\$0.44	50

Table 86: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$9.11	\$0.00	Not Applicable
2	\$6.95	\$0.00	Not Applicable
3	\$6.67	\$0.00	Not Applicable
4	\$4.04	\$0.00	Not Applicable
5	\$3.50	\$0.00	Not Applicable
6	\$3.07	\$0.00	Not Applicable
7	\$2.67	\$0.00	Not Applicable
8	\$2.89	\$0.00	Not Applicable
9	\$2.89	\$0.00	Not Applicable
10	\$2.83	\$0.00	Not Applicable
11	\$7.27	\$0.00	Not Applicable
12	\$5.99	\$0.00	Not Applicable
13	\$4.91	\$0.00	Not Applicable
14	\$2.45	\$0.00	Not Applicable
15	\$2.28	\$0.00	Not Applicable
16	\$6.23	\$0.00	Not Applicable

Table 87: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$9.11	\$0.00	Not Applicable
2	\$6.95	\$0.00	Not Applicable
3	\$6.67	\$0.00	Not Applicable
4	\$4.04	\$0.00	Not Applicable
5	\$3.50	\$0.00	Not Applicable
6	\$3.07	\$0.00	Not Applicable
7	\$2.67	\$0.00	Not Applicable
8	\$2.89	\$0.00	Not Applicable
9	\$2.89	\$0.00	Not Applicable
10	\$2.83	\$0.00	Not Applicable
11	\$7.27	\$0.00	Not Applicable
12	\$5.99	\$0.00	Not Applicable
13	\$4.91	\$0.00	Not Applicable
14	\$2.45	\$0.00	Not Applicable
15	\$2.28	\$0.00	Not Applicable
16	\$6.23	\$0.00	Not Applicable

Table 88: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – 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	\$0.31	35
2	\$8.53	\$0.31	27
3	\$8.14	\$0.31	26
4	\$5.51	\$0.31	18
5	\$5.02	\$0.31	16
6	\$4.46	\$0.31	14
7	\$4.11	\$0.31	13
8	\$4.24	\$0.31	14
9	\$4.23	\$0.31	14
10	\$4.15	\$0.31	13
11	\$8.74	\$0.31	28
12	\$7.54	\$0.31	24
13	\$6.33	\$0.31	20
14	\$3.70	\$0.31	12
15	\$3.55	\$0.31	11
16	\$7.80	\$0.31	25

Table 89: 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	\$0.31	35
2	\$8.53	\$0.31	27
3	\$8.14	\$0.31	26
4	\$5.51	\$0.31	18
5	\$5.02	\$0.31	16
6	\$4.46	\$0.31	14
7	\$4.11	\$0.31	13
8	\$4.24	\$0.31	14
9	\$4.23	\$0.31	14
10	\$4.15	\$0.31	13
11	\$8.74	\$0.31	28
12	\$7.54	\$0.31	24
13	\$6.33	\$0.31	20
14	\$3.70	\$0.31	12
15	\$3.55	\$0.31	11
16	\$7.80	\$0.31	25

Daylight Responsive Controls

Key Assumptions for Energy Savings Analysis

Assumptions utilized for the proposed daylighting-responsive controls energy savings analysis are based on Greenhouse Lighting Efficacy assumptions from 2025 CEH CASE Report (Energy Solutions, 2023), market research, and stakeholder input.

The baseline case assumes CEH luminaires with the proposed 2028 PPE requirement of 2.5 $\mu\text{mol}/\text{J}$ and controlled by automatic scheduling (timeclock) without continuous daylight-responsive dimming. Lighting is assumed to operate at full output during the scheduled crop photoperiod, with no adjustment based on measured canopy light levels. 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.

This baseline was selected consistent with the [2028 CASE Methodology Report](#), which evaluates savings relative to the applicable Energy Code baseline rather than current market practice where existing code requirements apply. The Statewide CASE Team

also vetted this baseline with knowledgeable stakeholders and confirmed that greenhouse lighting controls currently required by Title 24, Part 6 do not require continuous daylight-responsive dimming or DLI-based control.

This analysis distinguishes between (1) the applicable code baseline, (2) current market practice, and (3) the modeled compliance pathway used to estimate savings.

- **Code Baseline:** Consistent with the [2028 CASE Methodology Report](#), the baseline reflects the requirements of the current Energy Code. For greenhouse lighting systems, this baseline consists of luminaires meeting the minimum required efficacy and controlled by automatic scheduling (timeclock) without continuous daylight-responsive dimming. Under this baseline, lighting operates at full output during the scheduled crop photoperiod and does not dynamically adjust based on measured canopy light levels.
- **Common Market Practice:** Field studies and market assessments in California indicate that adoption of advanced greenhouse lighting controls is uneven and often limited to larger or higher-value facilities, with many installations continuing to rely on fixed scheduling strategies (Schimelpfenig, 2025). Even where automated systems are present, lighting operation is often based on fixed schedules rather than continuous daylight-responsive control, resulting in continued over-lighting during periods of high daylight availability.
- **Modeled Compliance Pathway:** For purposes of estimating energy savings, the Statewide CASE Team modeled the Timeclock + PAR sensor control pathway. This approach represents a compliant system that continuously adjusts lighting output based on measured canopy PPFD, including dimming and shutoff capability. The DLI control pathway is expected to provide comparable or greater savings, and therefore the modeled approach is considered conservative for estimating statewide impacts.

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/m²). 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/m²), cloud cover, and haze patterns via DHI (W/m²), 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.

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 75, 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 assumptions 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 ($\mu\text{mol}/\text{m}^2/\text{s}$):** 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 ($2.5 \mu\text{mol}/\text{J}$) 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, $\mu\text{mol}/\text{J}$), driver efficiency, and minimum dimming output (assumed 10 percent)

Table 90 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 90: Greenhouse CEH Lighting Assumptions

Parameter	Cannabis - Flower	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft^2)	20	58	56
Photoperiod (hours/day)	12	18	12
PPFD ($\mu\text{mol}/\text{m}^2/\text{s}$)	600	200	350
Baseline PPE ($\mu\text{mol}/\text{J}$)	2.5	2.5	2.5
Proposed PPE ($\mu\text{mol}/\text{J}$)	2.5	2.5	2.5
Mounting Height Above Canopy (in)	24	24	24

Following stakeholder input, the Statewide CASE Team has continued using the assumptions from the 2025 CEH CASE Report (Energy Solutions, 2023).

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 automatic scheduling/timeclock control, with lights operating at full output during the scheduled crop photoperiod and no continuous dimming in response to measured canopy PPFD. The lights are on at 100 percent 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 is below 10 percent power, the lights are turned off.

The proposed measure allows compliance through either Timeclock + PAR sensor control or DLI-based control. For purposes of this analysis, the Timeclock + PAR sensor pathway was modeled. DLI control systems are expected to achieve equal or greater energy savings because they optimize lighting based on cumulative daily light targets rather than instantaneous PPFD alone.

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 (W/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 ~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:

- $LPD = PPFD/PPE \times (0.0929 \text{ m}^2/\text{ft}^2) \times (\text{mounting height derate factor})$
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.

Cost Effectiveness by Climate Zone and Prototype

The energy impacts of the proposed code change vary by climate zone. The variations for indoors are relatively small because they are 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 91 shows the 30-year cost effectiveness summary per square foot of canopy for new construction for greenhouse cannabis. Table 92 shows the 30-year cost effectiveness summary per square foot of canopy for alterations for greenhouse cannabis. For cannabis greenhouse prototypes, only flowering canopy area was assumed to be impacted. Cost effectiveness for the other prototypes is shown in Table 93 through Table 95.

Table 91: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Cannabis

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$186.59	\$3.76	50
2	\$218.19	\$3.76	58
3	\$221.88	\$3.76	59
4	\$243.99	\$3.76	65
5	\$243.60	\$3.76	65
6	\$244.52	\$3.76	65
7	\$242.21	\$3.76	64
8	\$239.84	\$3.76	64
9	\$250.70	\$3.76	67
10	\$243.57	\$3.76	65
11	\$216.57	\$3.76	58
12	\$233.12	\$3.76	62
13	\$237.29	\$3.76	63
14	\$252.46	\$3.76	67
15	\$258.54	\$3.76	69
16	\$224.62	\$3.76	60

Table 92: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – Greenhouse Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$156.30	\$1.25	125
2	\$168.36	\$1.25	134
3	\$169.68	\$1.25	135
4	\$178.51	\$1.25	142
5	\$180.07	\$1.25	144
6	\$176.06	\$1.25	140
7	\$175.47	\$1.25	140
8	\$173.61	\$1.25	138
9	\$182.09	\$1.25	145
10	\$175.11	\$1.25	140
11	\$166.11	\$1.25	132
12	\$176.42	\$1.25	141
13	\$174.73	\$1.25	139
14	\$175.68	\$1.25	140
15	\$182.98	\$1.25	146
16	\$173.73	\$1.25	139

Table 93: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – Alterations – Greenhouse Leafy Greens

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	\$156.30	\$1.25	125
2	\$168.36	\$1.25	134
3	\$169.68	\$1.25	135
4	\$178.51	\$1.25	142
5	\$180.07	\$1.25	144
6	\$176.06	\$1.25	140
7	\$175.47	\$1.25	140
8	\$173.61	\$1.25	138
9	\$182.09	\$1.25	145
10	\$175.11	\$1.25	140
11	\$166.11	\$1.25	132
12	\$176.42	\$1.25	141
13	\$174.73	\$1.25	139
14	\$175.68	\$1.25	140
15	\$182.98	\$1.25	146
16	\$173.73	\$1.25	139

Table 94: 30-Year Cost-Effectiveness Summary Per Canopy Square Foot – New Construction and Additions – 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	\$2.19	101
2	\$245.48	\$2.19	112
3	\$249.45	\$2.19	114
4	\$268.54	\$2.19	123
5	\$270.00	\$2.19	123
6	\$268.41	\$2.19	122
7	\$267.73	\$2.19	122
8	\$263.86	\$2.19	120
9	\$275.69	\$2.19	126
10	\$266.43	\$2.19	122
11	\$243.44	\$2.19	111
12	\$260.91	\$2.19	119
13	\$262.45	\$2.19	120
14	\$272.68	\$2.19	124
15	\$282.41	\$2.19	129
16	\$253.36	\$2.19	116

Table 95: 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	\$2.19	101
2	\$245.48	\$2.19	112
3	\$249.45	\$2.19	114
4	\$268.54	\$2.19	123
5	\$270.00	\$2.19	123
6	\$268.41	\$2.19	122
7	\$267.73	\$2.19	122
8	\$263.86	\$2.19	120
9	\$275.69	\$2.19	126
10	\$266.43	\$2.19	122
11	\$243.44	\$2.19	111
12	\$260.91	\$2.19	119
13	\$262.45	\$2.19	120
14	\$272.68	\$2.19	124
15	\$282.41	\$2.19	129
16	\$253.36	\$2.19	116

Space Conditioning

Key Assumptions and Inputs for Energy Savings Analysis

Assumptions for the proposed space conditioning measure are based on field data, market research, and stakeholder input. The Statewide CASE Team met with HVAC and dehumidifier manufacturers and distributors, academic researchers, cannabis HVAC/D design professionals, controls providers, and indoor CEH facility operators to review and refine the methodology, key assumptions, and analytical framework.

Since the proposed code changes focus on cannabis flowering rooms with high lighting intensity, the Statewide CASE Team focused on the development of assumptions and modeling inputs to reflect energy use and HVAC/D systems used in those spaces. The team developed a prototype energy model representing all space types in typical cannabis cultivation facility, but aside from the space conditioning systems used in the flower rooms, all other key assumptions used in the energy savings analysis for each the baseline and proposed building configuration are kept constant. The inputs and assumptions in the EnergyPlus model used to calculate energy savings are aligned with

the inputs and assumptions used to calculate incremental first costs and maintenance costs.

The baseline flower room space conditioning system represents a decoupled HVAC/D configuration with thermostat-controlled, single-stage DX cooling sized to the sensible load, electric resistance reheat, constant-volume fans, and humidistat-controlled standalone DX dehumidifiers sized for latent load. The dehumidifiers have efficiency matching the federal minimum.

The proposed system represents an integrated variable-capacity DX HVAC/D system sized to meet both sensible and latent loads, with modulating hot gas reheat capable of recovering up to 90 percent of rejected heat, supplemental electric reheat, and variable air volume fans. Both systems were modeled using the same full-load EER of 11.9, cooling fan efficiency of 0.5, and cooling fan motor efficiency of 0.9.

The dehumidifiers were modeled using the existing EnergyPlus object and control logic, which does not report disaggregated fan and cooling energy. Therefore, both fan and cooling energy for the dehumidifiers used in the baseline decoupled model are reported as “cooling energy”. The EnergyPlus dehumidifier object also represents precise staging of individual dehumidifiers to meet load, a condition reflective of the proposed requirement for individual control and staging of dehumidifiers—not the code minimum baseline condition where multiple dehumidifiers are controlled on a single humidistat. To better reflect the cycling behavior observed in decoupled systems with this type of control, the modeling team also developed a custom EMS (energy management system)-based control reflecting a single control for multiple dehumidifiers. Although this approach better represented this type of cycling behavior, humidity fluctuations exceeded those observed in field studies, so the original EnergyPlus object was used in the final energy savings calculation, reflecting a conservative approach.

EnergyPlus does not have an object reflective of integrated DX HVAC/D systems configured for 100% recirculated air, so custom EMS inputs and controls were developed to reflect the operation of this system type. Standard EnergyPlus inputs limit heat recovery to 30% of condenser heat rejection, so the team developed an EMS input increasing the limit to 90%. Furthermore, EnergyPlus does not offer a native control that allows the user to simulate both latent and sensible control from the same system, so the team developed EMS controls to simulate transitions between sensible-dominated loads and latent dominated loads. The controls logic of the energy model modulates two outputs - supply air mass flow rate (Airflow Program) and cooling coil leaving-air temperature setpoint (Cooling Coil Setpoint Program) - depending on which thermal load is dominant in the space at any given timestep.

The system operates in one of two modes, determined in each timestep by calculating the zone Sensible Heat Ratio (SHR). When sensible loads dominate, the system maximizes airflow and increases supply air temperature to remove heat without over-

drying. When latent loads dominate, airflow is reduced to the minimum needed to remove moisture from plant transpiration, while the coil setpoint is driven toward its dewpoint target to maximize dehumidification efficiency.

At each timestep, the Airflow Program reads the zone sensible cooling load and the zone moisture removal rate. It calculates the latent load equivalent in watts using the latent heat of vaporization at current zone conditions, then computes the zone SHR. A threshold of $SHR = 0.70$ determines which mode is active. At or above this threshold the system enters Sensible Removal Mode. Below it, the system enters Latent Removal Mode.

When the sensible fraction of the total zone load is high - typically during the lights-on period or when envelope gains are elevated - the Airflow Program sets the supply air mass flow to maximum design flow. This maximizes the system capacity to remove sensible heat from the space.

Simultaneously, the Cooling Coil Setpoint Program relaxes the coil leaving-air temperature setpoint toward the supply air temperature setpoint established by the downstream single-zone setpoint manager. This prevents the coil from over-cooling and inadvertently removing latent load when only sensible removal is required. A lower limit of 45 F is enforced at all times.

When the latent fraction is dominant -- primarily driven by plant transpiration - the Airflow Program calculates the supply air mass flow rate required to remove only the moisture present. This approach sizes airflow directly to the latent load, maintaining continuous coil operation without cycling. Flow is bounded at a minimum of 45% of the maximum design flow to preserve adequate air circulation and protect against coil freeze-off and clamped at the maximum if the calculated load would otherwise demand more than full flow.

The coil leaving-air temperature setpoint is computed each timestep by the following sequence:

1. The target humidity ratio setpoint at the coil outlet node is converted to a dewpoint temperature.
2. This coil dewpoint is compared against the supply air temperature setpoint from the downstream setpoint manager.
3. The coil setpoint is assigned to the lower of the two values, whichever is more demanding, moisture removal or temperature control.
4. Exception: if the zone dewpoint is already below the zone dewpoint setpoint (the space is not over-humid), the coil setpoint is relaxed to the supply air temperature setpoint only, avoiding unnecessary latent overcooling.
5. A hard floor of 45°F is enforced at all times to protect the coil from frosting.

This program runs ahead of the main control logic at the beginning of each timestep to establish the zone dewpoint setpoint used by the Cooling Coil Setpoint Program. It reads the zone cooling temperature setpoint and the dehumidification RH setpoint from their respective schedules - both following the 9-week crop cycle -- and converts them to a dewpoint temperature. This dewpoint becomes the reference condition against which the Cooling Coil Setpoint Program determines whether latent removal is actually required. If the zone dewpoint is already below this calculated setpoint, the CC setpoint is relaxed and no additional dehumidification is commanded.

This program runs at the end of each system timestep and calculates the quantity of hot gas reheat energy available from the refrigeration circuit. It sums the total cooling energy and compressor electricity energy from the cooling coil to determine total heat rejection. The reheat energy assigned is the lesser of the actual heating coil output or 90% of total heat rejection - the 90% cap preventing the full compressor heat from being claimed as reheat and preserving a margin for condenser heat rejection. This value is reported as an output variable and is used to account for the reheat contribution in the energy balance rather than to directly actuate a component setpoint.

Baseline and proposed HVAC/D systems were sized by SME HVAC/D designers to late flower cycle load conditions, based on the setpoints and loads provided in the subsequent sections of the report. The flower room dimension of 4,165 ft² and 100% canopy area ratio exceeds the size of typical flower rooms found in cannabis facilities, however, loads and equipment sizing are proportional to smaller flower rooms. For the decoupled baseline system, dehumidifiers were sized to 100% of latent loads during late flower cycle, accounting for degraded dehumidifier capacity under those cool/dry conditions. Furthermore, no dehumidification load was assigned to the cooling system due to severely degraded capacity of cooling equipment under the late flower design conditions. Although sizing assumes the cooling system does not contribute to dehumidification in the late flower cycle, the annual model accounts for contributions to dehumidification load from the cooling system during other phases of the flower cycle. Single-stage split cooling equipment was sized to meet sensible load during the first week of the flower cycle, as well as the sensible load created by dehumidifiers during the late flower cycle. The integrated DX system was sized to latent loads in the late flower cycle.

Climate Zones

Although the loads in indoor growing 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 meteorological weather year (TMY) weather data 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 4,165 canopy square feet per room and a maximum lighting intensity of 48.5 W per canopy square foot. The energy impacts were modeled for three flower rooms with staggered flower cycles, using an EnergyPlus model developed by the Statewide CASE Team and evaluated on a per-square-foot basis. For each climate zone, three outputs from the full-facility prototype simulation of three flower rooms with schedules staggered three weeks apart was used to estimate annual and hourly 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 or equal to 30 W per canopy ft²) 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 Baseline and Proposed scenarios used the assumptions in Table 96.

Table 96: Prototype Flower Room Used for Energy, Demand, Cost and Environmental Impacts Analysis

Category	Prototype Variables	Assumptions
Building	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	4,165 square feet per room
Crop	Type	Cannabis: 100% flower, 0% veg, 0% clone
	Room Canopy Area	4,165 canopy square feet, (assumption representing weighted average of single-tier and two-tier facilities to get 100% of room area)
	Maximum evapotranspiration latent cooling load ^a	160 Btuh/ft ² maximum load (room square foot)
	Maximum evapotranspiration sensible heating load ^a	-160 Btuh/ft ² maximum load (room square foot)
	Grow cycle duration	63 days
	Downtime between cycles	4 days

Category	Prototype Variables	Assumptions
Lighting	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 $\mu\text{Mol}/\text{J}$
	Photosynthetic Photon Flux Density	1,200 $\mu\text{Mol}/\text{m}^2/\text{s}$ with dimming

a) British Thermal Units per Hour per square foot

The Proposed Design was identical to the Baseline Design in all ways except for the revisions that represent the proposed changes to the code. Table 97 presents the system specifications used in the Baseline Design and Proposed Design. Specifically, the proposed conditions assume variable-capacity DX equipment with modulating hot gas reheat and adjustable sensible heat ratio.

Table 97: Space Conditioning Equipment Specifications Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Equipment Component	Baseline Design	Proposed Design
Cooling	Thermostat-controlled, single-stage packaged DX sized to sensible load (11.9 EER, 120 tons/room)	Packaged variable-capacity DX sized to both sensible and latent loads (11.9 EER, 160 tons/room)
Dehumidification	Humidistat-controlled standalone DX dehumidifiers (0.64 gallons per kWh, federal minimum) sized for latent load	Integrated with DX system (variable sensible heat ratio)
Reheat	Electric resistance (no hot gas reheat)	Modulating hot gas reheat (90 percent) with supplemental electric resistance
Fan Control	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.

Table 98: Detailed Incremental Cost Estimates: Space Conditioning

1 Flower Room with 4165 sf canopy		Decoupled System			Integrated System		
		Quantity	Cost/Unit	Total Cost	Quantity	Cost/Unit	Total Cost
System Type	DX System	(5-ton split outdoor cooling coil, fan coil indoor)			40-ton integrated DX (packaged)		
	Dehumidifier	710 pint/day dehumidifiers			N/A		
HVAC/D Equipment	Packaged DX unit (per unit)	N/A	N/A	N/A	4	\$140,000	\$560,000
	Packaged DX installation (per unit)	N/A	N/A	N/A	4	\$71,680	\$286,720
	Outdoor DX Unit (per unit)	24	\$2,279.00	\$54,696	N/A	N/A	N/A
	Indoor DX Unit (per unit)	24	\$1,335.00	\$32,040	N/A	N/A	N/A
	Supplemental heating (4kW)	24	\$116.00	\$2,784	N/A	N/A	N/A
	Split DX system installation cost (per unit)	24	\$1,000.00	\$24,000	N/A	N/A	N/A
	Dehumidifiers (per unit)	37	\$7,888.00	\$291,856	N/A	N/A	N/A
	Dehumidifier installation cost (per unit)	37	\$1,000.00	\$37,000	N/A	N/A	N/A
	Total Equipment Cost	\$442,376			\$846,720		

1 Flower Room with 4165 sf canopy		Decoupled System			Integrated System		
		Quantity	Cost/Unit	Total Cost	Quantity	Cost/Unit	Total Cost
Testing & Balancing	Testing, adjusting, and balancing for HVAC (per square foot)	4165	\$1.25	\$5,206	4165	\$1.00	\$4,165
Design	SME to size system (\$300/hr)	N/A	N/A	N/A	18	\$300.00	\$5,400
Acceptance Testing	Controls/HVAC technician (\$110.32/hr)	N/A	N/A	N/A	2	\$110.32	\$221
Sensors	Atmospheric Sensor (Temp / RH)	N/A	N/A	N/A	1	\$358.00	\$358
	Controls cabling	N/A	N/A	N/A	1	\$50.00	\$50
	Total Sensor Cost	N/A			\$408		
Controls	Integrated automation facility controls (per allowance)	N/A	N/A	N/A	1	\$15,000	\$15,000
Electrical	710-pint dehumidifier: 277VAC, 30A breaker each, average 50' panel run to each unit, (per linear foot)	1850	\$30.00	\$55,500	N/A	N/A	N/A
	Fan coil indoor 3kW heat: 208/230VAC, 15Abreaker each (QTY 8 total), average 50' panel run to each, (per linear foot)	1200	\$20.00	\$24,000	N/A	N/A	N/A

1 Flower Room with 4165 sf canopy		Decoupled System			Integrated System		
		Quantity	Cost/Unit	Total Cost	Quantity	Cost/Unit	Total Cost
	Outdoor condenser: 208/230VAC, 30A breaker each (QTY 8 total), assume average 100' panel run, (per linear foot)	2400	\$25.00	\$60,000	N/A	N/A	N/A
	Packaged unit: 480V / 3PH 200A breaker each, average 100' panel run to each unit, (per linear foot)	N/A	N/A	N/A	400	\$135.00	\$54,000
	Total Electrical	\$139,500			\$54,000		
Ductwork	Ductwork: galvanized ductwork (per pound)	12000	\$17.04	\$204,480	12667	\$17.04	\$215,840
	Ductwork: supply diffuser (per unit)	24	\$320.63	\$7,695	56	\$320.63	\$17,955
	Ductwork: return grille (per unit)	24	\$641.25	\$15,390	4	\$641.25	\$2,565
	Ductwork: fire damper (per unit)	N/A	N/A	N/A	4	\$641.25	\$2,565
	Duct insulation: 2" board insulation (per square foot)	N/A	N/A	N/A	2000	\$9.25	\$18,500

1 Flower Room with 4165 sf canopy		Decoupled System			Integrated System		
		Quantity	Cost/Unit	Total Cost	Quantity	Cost/Unit	Total Cost
	Duct insulation: 1-1/2" Thick blanket Insulation, 1.5 lb/ft ³ Density (per square foot)	9600	\$6.39	\$61,344	6000	\$6.39	\$38,340
	Duct insulation: aluminum jacketing (per square foot)	N/A	N/A	N/A	2000	\$8.00	\$16,000
	Total Ductwork Cost	\$288,909			\$311,765		
Condensate Drain and Piping	Condensate drain piping: 1" pipe (per linear foot)	1525	\$64.28	\$98,027	53	\$64.28	\$3,428
	Condensate drain piping: fittings & valves (lump sum)	1	\$32,140.13	\$32,140	1	\$2,389.63	\$2,390
	Condensate drain piping: pipe identification (per linear foot)	1525	\$0.71	\$1,083	53	\$0.71	\$38
	Condensate piping insulation: 1" fiberglass insulation (per linear foot)	1525	\$12.14	\$18,514	N/A	N/A	N/A
	Condensate piping insulation: fittings and valves (lump sum)	1	\$1,516.06	\$1,516	N/A	N/A	N/A
	Total Condensate Drain Piping	\$151,279			\$5,856		

1 Flower Room with 4165 sf canopy		Decoupled System			Integrated System		
		Quantity	Cost/Unit	Total Cost	Quantity	Cost/Unit	Total Cost
Refrigerant Piping	Refrigerant piping: 5/8" pipe (per linear foot)	1200	\$57.54	\$69,048	N/A	N/A	N/A
	Refrigerant piping: 1-1/8" pipe (per linear foot)	1200	\$52.71	\$63,252	N/A	N/A	N/A
	Refrigerant piping: fittings (lump sum)	1	\$11,025.32	\$11,025	N/A	N/A	N/A
	Refrigerant piping: pipe identification (per linear foot)	1200	\$0.71	\$852	N/A	N/A	N/A
	Refrigerant piping insulation: 5/8" pipe (per linear foot)	1200	\$17.74	\$21,288	N/A	N/A	N/A
	Refrigerant piping insulation: 1-1/8" pipe (per linear foot)	1200	\$18.57	\$22,284	N/A	N/A	N/A
	Refrigerant piping insulation: fittings & valves (lump sum)	1	\$4,537.79	\$4,538	N/A	N/A	N/A
	Total Refrigerant Piping	\$192,287			N/A		

Whole Building Prototype

The Statewide CASE Team developed a whole-building EnergyPlus prototype to support the analysis.²⁷ Although the whole-building prototype includes non-flowering indoor growing and support spaces, energy savings for this measure are calculated only for flowering spaces subject to the proposed applicability thresholds and are normalized per canopy square foot. Table 99 shows high-level prototype assumptions.

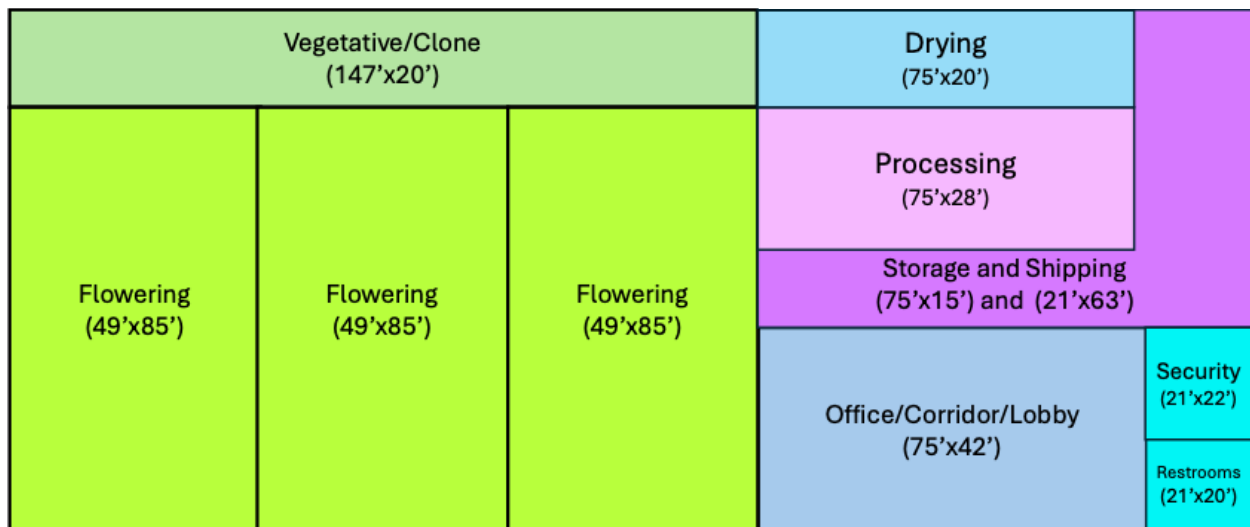
Table 99: CEH Indoor Prototype High Level Assumptions.

Characteristic	Value	Data Sources
Building Type	Indoor Controlled Environment Horticulture - Cannabis	Over 90% of Indoor CEH was estimated to be cannabis in the T24 2025 cycle
Building Category	Nonresidential	
Shape	Rectangle	Indoor CEH Floor plans. Previous T24 CASE work.
Total Floor Area (ft²)	25515 (243 ft x 105 ft)	Based on California Department of Cannabis Control License data by size.
Aspect Ratio	2.3	Based on California Department of Cannabis Control License data by size.
Number of Floors	1	Based on indoor CEH SME input.
Roof type	Flat	Based on indoor CEH SME input.
Window-to-Wall Ratio (WWR)	0.00%	When included, assuming high-security feature in addition to T24-compliant windows; this is still being researched.
Shading Geometry	No Shades	Based on typical indoor horticulture buildings
Floor to floor height (ft)	18	Based on input from SME Kelly Energy Management, confirmed typical by other indoor CEH SMEs.
Floor to ceiling height (ft)	14	Based on input from SME Kelly Energy Management, confirmed typical by other indoor CEH SMEs.

²⁷ Supplemental materials, including the prototype and EnergyPlus model files are available at: <https://title24stakeholders.com/measures/2028-cycle/controlled-environment-horticulture-requirements-for-space-conditioning-systems/>

Characteristic	Value	Data Sources
Glazing sill height (ft)	n/a	Assuming high-security feature in addition to T24-compliant windows; topic still under research. For now, assume 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 applied only in offices areas, not in CEH prototype spaces.

The zones are shown in Figure 9 and are described in Table 100.



,Figure 9: Indoor CEH whole building prototype zones.

Table 100: Indoor CEH Whole Building Prototype Zone Description

Space Type	Space/ Thermal Zone	Conditioned (Y/N)	HVAC Zone	Area Fraction	Area (ft ²)	Length (ft)	Width (ft)	Volume (ft ³)	Number of People	People (Persons/ 1,000 ft ²) [T24, 2025, Table 120.1-A]	Canopy Area (ft ²)	Notes
Horticulture_Vegetative	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.
Horticulture_Flowering	Horticulture_Flowering 3 zones	Y	Horticulture_Flowering 3 HVAC zones	49.0%	12,495	85	147	174,930	0	-	12,495	The flowering space type is split into 3 flowering rooms, with shifted schedules (a 9-week grow cycle starting every 3 weeks), each a separate HVAC zone.
Processing Area	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
Horticulture_Drying	Drying room	Y	Horticulture_Drying	5.9%	1,500	20	75	21,000	0	0	N/A	
Storage	Storage and Shipping	Y	Storage	9.6%	2,448	15.0	75.0	34,272	0	0	N/A	
	Storage and Shipping	Y	Storage	9.6%	2,448	63.0	21.0	34,272	0	0	N/A	
Office	Office	Y	Office_Area	12.3%	3,150	42	75	44,100	16	5	N/A	Low-density occupancy relative to office buildings.
Restrooms	Restrooms	Y	Office_Area	1.6%	420	20	21	5,880	1	-	N/A	
Security office	Security office	Y	Office_Area	1.8%	462	22	21	6,468	1	5	N/A	

Space Type	Space/ Thermal Zone	Conditioned (Y/N)	HVAC Zone	Area Fraction	Area (ft ²)	Length (ft)	Width (ft)	Volume (ft ³)	Number of People	People (Persons/ 1,000 ft ²) [T24, 2025, Table 120.1-A]	Canopy Area (ft ²)	Notes
Total (10 Spaces, 8 space types)	Total (10 Thermal Zones)		Total (8 HVAC Zones)	100%	25,515			357,210			12,863	

Prototype envelope assumptions are shown in Table 101 and Table 102.

Table 101: 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
	CEH	Metal Building	Metal surface + Continuous Insulation + Gypsum board	U-factor IP	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
	CEH	Metal Roof	Roof Membrane + Continuous Insulation + Metal Decking	U-factor IP	2022+	2025	Table 140.3-B
Windows	Windows	Fixed Windows	Single Pane (CBECC 2018, ~ 50% of warehouse conversions that were built before 2000 are single pane)	U-factor IP	Pre 2022	2001	Table 1-H
	Windows	Fixed Windows	Double Pane	U-factor IP	2022+	2025	From Medium Office scorecard. Assumed windows only in office areas. This u-factor does not yet include security feature.

Element	Prototype	Assembly Type	Construction	Thermal properties	Vintage	Selected T24	Note
	Windows	Fixed Windows	Single Pane (CBECC 2018, ~ 50% of warehouse conversion that were built before 2000 are single pane)	SHGC	Pre 2022	2001	Table 1-H
	Windows	Fixed Windows	Double Pane	SHGC	2022+	2025	From Medium Office scorecard. Assumed windows only in office areas. This u-factor does not yet include security feature.

Table 102: 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 103 and Table 104.

Table 103: Indoor CEH Whole Building Prototype HVAC Systems, excluding flower rooms. Used for both baseline and proposed case.

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	-
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 with cooling equipment.
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)	-
Security office	Heat Pump	DX (RTU)	CAV	Airside economizers (Integrated)	T24, 2025

Table 104: Indoor CEH Prototype Flower Room HVAC Equipment.

Category	Parameter	Baseline Decoupled	Proposed Integrated
Cooling System / Integrated System	Minimum Supply Air Temperature [F]	55	45
Cooling System / Integrated System	Nominal Cooling Capacity [tons]	120	160
Cooling System / Integrated System	Quantity of individual packaged 5-ton cooling / 40-ton integrated units	24	4
Cooling System / Integrated System	Cooling Supply Air Flow Rate per Unit Cooling Capacity [CFM/ton]	350	300
Cooling System / Integrated System	Total Cooling Airflow	42,000	48,000
Cooling System / Integrated System	Central Cooling Capacity Control Method	CAV	VAV
Cooling System / Integrated System	Compressor Speeds	1	8
Cooling System / Integrated System	Fan Minimum Turndown [%]	100	45
Cooling System / Integrated System	Fan Efficiency	0.5	0.5
Cooling System / Integrated System	Design SHR	1.0	0.6
Heating / Reheat	Heating Source	Electric resistance	Electric resistance / Hot gas reheat
	Efficiency	1.0	1.0 / 0.9
Dehumidifiers	Rated water removal capacity [L/day]	6,549	N/A
Dehumidifiers	Equivalent cooling capacity [tons]	154	N/A
Dehumidifiers	Total quantity of 710 Pints-per-day units	37	N/A
Dehumidifiers	Operating dry bulb range [F]	50 to 90	N/A
Dehumidifiers	Rated energy factor [L/kWh]	2.41	N/A

Ventilation information is in Table 105.

Table 105: Indoor CEH Prototype Outdoor Airflow Rate.

Space/ Thermal Zone	Occupancy Category [T24, 2025, Table 120.1-A]	General Area Required cfm/ft ²	Required Exhaust Rate cfm/unit	Units	Total cfm by area	Total Ventilation	Total Exhaust CFM	Total cfm	Notes
Horticulture_Vegetative	Indoor CEH	0	0	0	0	0	0	0	
Horticulture_Flowering	Indoor CEH	0	0	0	0	0	0	0	
Horticulture_Drying	Indoor CEH	0	0	0	0	0	0	0	
Processing Area	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.
Storage	Warehouse	0.15	0	0	367.2	367.2	0	367.2	
Office	Office	0.15	0	0	472.5	472.5	0	472.5	
Restrooms	All Others	0.15	25	6	63	63	150	0	Transfer Air allowed
Security office	Office / All Others	0.15	0	0	69.3	69.3	0	69.3	

Process lighting is covered in Table 106 and ventilation fan information is shown in Table 107.

Table 106: Indoor CEH Prototype Horticultural Lighting Information

Space	Horticulture Lighting (W/ft ² canopy)	Maximum Dimming %	Source
Horticulture Vegetative	24.24	100	A
Horticulture_Flowering	48.47	60	A
Horticulture_Drying	0.00	100	A
Processing Area	4.42	100	A
Storage	0.0	100	-
Office	0	100	-
Restrooms	0	100	-
Security office	0	100	-

Source A: T24 2025 - Revised indoor 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.

Table 107: Indoor CEH Prototype Ventilation Fan Information

Space	Circulation Fan (W/ft ²)	Fan Efficiency
Horticulture Vegetative	1.00	0.85
Horticulture_Flowering	1.00	0.85
Horticulture_Drying	1.00	0.85
Processing Area	0	N/A
Storage	0	N/A
Office	0	N/A
Restrooms	0	N/A
Security office	0	N/A

Hourly schedules for non-growing areas are in Table 108

Table 108: Indoor CEH Prototype Schedules for Non-Growing Spaces

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
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	0.05	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
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
	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	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

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	
Areas Lighting	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	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	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	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	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	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	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	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	0.05

Table 109: 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
Horticulture Vegetative Horticultural Lighting	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
Horticulture Vegetative 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	0.05	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
Horticulture Flowering 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	0.05	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
Horticulture Flowering Horticultural Lighting - Dimming schedule	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	0.80	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
	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 110: Indoor CEH Prototype Flower Room Evapotranspiration, Temperature Setpoint, Humidity Setpoint, and Dimming Schedule

Schedule	Days	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 Evapo-transpiration 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 111.

Table 111: Indoor CEH Whole Building Prototype Thermostat Setpoints by Zone

Space/ Thermal Zone	Setpoint	CZ 1-16	Source and Note
Office	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	T24 2022 - Appendix 5.4B
	Cooling Setpoint (F)	75	T24 2022 - Appendix 5.4B
	Cooling Setback (F)	80	T24 2022 - Appendix 5.4B
Security	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	T24 2022 - Appendix 5.4B
	Cooling Setpoint (F)	75	T24 2022 - Appendix 5.4B
	Cooling Setback (F)	85	T24 2022 - Appendix 5.4B
Restrooms	Heating Setpoint (F)	70	T24 2022 - Appendix 5.4B
	Heating Setback (F)	60	T24 2022 - Appendix 5.4B
	Cooling Setpoint (F)	75	T24 2022 - Appendix 5.4B
	Cooling Setback (F)	85	T24 2022 - Appendix 5.4B
Storage and Shipping	Heating Setpoint (F)	60	Storage is typically cool and dry to preserve product.
	Heating Setback (F)	60	Storage is typically cool and dry to preserve product.
	Cooling Setpoint (F)	65	Storage is typically cool and dry to preserve product.
	Cooling Setback (F)	75	Storage is typically cool and dry to preserve product.
Processing	Heating Setpoint (F)	70	See note a in table footnote.
	Heating Setback (F)	60	See note a in table footnote.
	Cooling Setpoint (F)	70	See note a in table footnote.
	Cooling Setback (F)	80	See note a in table footnote.
Horticulture _Drying	Heating Setpoint (F)	60	See note b in table footnote.
	Heating Setback (F)	60	See note b in table footnote.
	Cooling Setpoint (F)	60	See note b in table footnote.
	Cooling Setback (F)	60	See note b in table footnote.
Horticulture _Vegetative	Heating Setpoint (F)	n/a	Assume no heating
	Heating Setback (F)	n/a	Assume no heating
	Cooling Setpoint (F)	82	Assume no heating
	Cooling Setback (F)	n/a	Assume no heating
Horticulture _Flowering	Heating Setpoint (F)	n/a	See Latent Load and Setpoint table.
	Heating Setback (F)	n/a	See Latent Load and Setpoint table.
	Cooling Setpoint (F)	Variable	See Latent Load and Setpoint table.
	Cooling Setback (F)	n/a	See Latent Load and Setpoint table.

- a. T24 2022 - Appendix 5.4B. RH is kept below 50% to avoid rehydrating product during trimming and packaging.
- b. Drying room is not typically occupied, kept at 60F and 60%RH to dry plants.

Appendix B: Purpose and Necessity of Proposed Code Changes

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.

Sections 2.6, 3.6, and 4.6 of this report provide 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: 201 [Section: 100.1]

Purpose: The purpose of this change is to improve the clarity, consistency, and enforceability of lighting efficacy requirements for CEH facilities in Title 24, Part 6, Section 908.1.5 by updating the definition of Photosynthetic Photon Efficacy (PPE) to Luminaire Photosynthetic Photon Efficacy (PPE).

Necessity: This change replaces the existing definition of Photosynthetic Photon Efficacy (PPE) to be a definition of Luminaire Photosynthetic Photon Efficacy (PPE) and specifies the applicable wavelength range. These revisions are necessary to ensure consistent measurement of lighting performance at the luminaire level, reduce ambiguity in compliance, and align the definition with industry standards such as ANSI/ASABE S640.

Section: 908.1.5 [Section: 120.6(h)]

Purpose: The purpose of this change is to increase the minimum required luminaire photosynthetic photon efficacy (PPE) for horticultural lighting systems in CEH facilities from 2.3 micromoles per Joule to 2.5 micromoles per Joule.

Necessity: This change is necessary to reduce the energy consumption of CEH facilities by requiring higher-efficiency lighting systems that are already widely available on the market. The proposed threshold aligns with current industry standards, including the DesignLights Consortium requirements, and has been demonstrated to be cost-effective. These adjustments support the statutory requirement to adopt cost-effective energy efficiency standards under Public Resources Code Sections 25213 and 25402.

This change does not expand the scope of regulated systems or introduce new compliance pathways; it modifies the efficiency threshold of an existing mandatory requirement.

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: 201 [Section 100.1]

Purpose: The purpose of this change is to improve the clarity, consistency, and enforceability of daylight-responsive lighting control requirements for CEH facilities by adding definitions for key terms related to lighting measurement and control.

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, and updates existing definitions for Photosynthetic Photon Efficacy (PPE) and Photosynthetic Photon Flux (PPF). These definitions are necessary to ensure consistent interpretation of the proposed lighting control requirements and to align terminology with industry standards such as ANSI/ASABE S640.

Section: 908.1 [Section 120.6(h)]

Purpose: The purpose of this change is to introduce daylight-responsive lighting control requirements for greenhouse horticultural lighting systems and to clarify existing lighting control requirements for indoor growing spaces.

Necessity: This change is necessary to reduce the energy consumption in CEH facilities by preventing over-lighting during periods where sufficient daylight is available. Under current code requirements, greenhouse lighting systems are typically controlled using time-based scheduling without continuous adjustment for available daylight, resulting in unnecessary energy use.

By requiring daylight-responsive controls, this measure ensures that greenhouse lighting systems operate in alignment with actual plant lighting needs and available daylight, improving energy efficiency and supporting California's statutory requirements to adopt cost-effective energy efficiency standards under Public Resources Code 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 installation and functional testing requirements for daylight-responsive horticultural lighting control systems.

Necessity: This change is necessary to ensure that newly required lighting control systems are properly installed, configured, and functioning as intended. Because daylight-responsive controls rely on sensors, calibration, and system integration, verification through acceptance testing is required to ensure that systems respond correctly to daylight conditions and deliver expected energy savings.

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: 200.1 [Section 100.1]

Purpose: The purpose of this change is to support implementation of new space conditioning requirements for indoor growing facilities by adding and revising definitions used in Title 24, Part 6.

Necessity: This change adds definitions for Plant Canopy Area, Commercial Dehumidifier, Consumer Dehumidifier, Indoor Growing Space Conditioning System, Integrated Space Conditioning System, Coordinated Decoupled HVAC/D System, Reheat Capacity, Recovered Heat Capacity Ratio, and Sensible Heat Ratio, and modifies existing definitions for Controlled Environment Horticulture (CEH) Space, Integrated HVAC System, and Process Space. These updates are necessary to clearly distinguish CEH process spaces from conditioned spaces intended for human occupancy and to ensure consistent interpretation and enforcement of the proposed space conditioning requirements.

Section: 401.2.1 [Section 120.1(c)]

Purpose:

The purpose of this change is to establish ventilation requirements specific to CO₂-enriched CEH spaces, recognizing their function as process environments.

Necessity:

This change adds a new category for CO₂-enriched CEH spaces with a minimum outdoor air ventilation rate of zero, aligning Title 24, Part 6 with industry practice and with safety requirements already established in the California Fire Code. This change also adds a requirement for other CEH spaces. This clarification is necessary to resolve inconsistent interpretation and enforcement of ventilation requirements for CEH facilities.

Section: 908.1 [Section 120.6(h)]

Purpose: The purpose of this change is to establish comprehensive mandatory requirements for indoor growing space conditioning systems, including system sizing, equipment characteristics, and integrated control functionality.

Necessity: Existing code requirements primarily address lighting and limited dehumidification provisions and do not adequately regulate the interaction between cooling, dehumidification, and heating systems in indoor growing spaces. These proposed changes establish enforceable requirements for:

- (a) Sizing systems to meet both sensible and latent loads
- (b) Use of integrated or coordinated HVAC and dehumidification systems
- (c) Integrated temperature and humidity controls
- (d) Use of commercial-grade dehumidification equipment

These updates are necessary to reduce energy consumption in high-intensity indoor growing facilities and align with California Public Resources Code, specifically Sections 25213 and 25402, which require cost-effective energy efficiency standards.

Purpose and Necessity of Changes to the Reference Appendices

Section: NA7.X

Purpose: The purpose of this change is to establish acceptance testing requirements for indoor growing space conditioning system controls.

Necessity: Because system performance depends on correct installation and configuration of integrated controls, acceptance testing is necessary to verify that systems operate as required by the code and to support consistent enforcement.

Section: NA9

Purpose: The purpose of these changes is to establish a standardized method for calculating sensible and latent loads and sizing indoor growing space conditioning systems.

Necessity: Conventional HVAC sizing methods do not adequately account for plant-driven latent loads and dynamic operating conditions in indoor growing facilities. This appendix is necessary to ensure systems are properly sized, which is critical for both energy efficiency and proper operation.

Section: JA19

Purpose: The purpose of this change is to establish qualification, testing, and certification requirements for commercial dehumidifiers used in indoor growing applications.

Necessity: Commercial dehumidifiers commonly used in indoor growing facilities are not covered by federal appliance standards. This appendix establishes a California-specific test procedure and certification pathway to ensure that equipment used to comply with indoor growing requirements meets appropriate performance standards.

Appendix C: Assumptions for Statewide Savings Estimates

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 twelve years, so 8.3 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 8.3 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 8.3 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). Therefore, statewide savings and costs were applied to the remaining 38 percent of otherwise affected installations.

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.

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. Tomatoes are used as a proxy for vine and fruiting crops with broadly similar light and temperature requirements. Flowering crops are included in this category for statewide weighting purposes, although individual crop requirements may vary. 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 assumptions and calculations are shown in Table 112 for new construction and Table 113 additions, and for alterations.

Table 112: 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 (%)
Indoor – 32%	Cannabis	92	14.43
	Leafy greens / Microgreens / Herbs	5	0.78
	Tomatoes / Flowers / Vine Plants	3	0.47
Greenhouse – 68%	Cannabis	30	14.28
	Leafy greens / Microgreens / Herbs	30	14.28
	Tomatoes / Flowers / Vine Plants	40	19.04

Note: These values do not account for the market adoption.

Table 113: 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 114 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 115 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2029. The Statewide CASE Team developed these estimates using the methods described in this section. Table represents the assumed percentage of affected floorspace by climate zone. Combining all CEH prototypes, the Statewide CASE Team assumed 12.96 percent of CEH new construction and 0.54 percent of CEH facility stock are impacted annually. When expressed as a percentage of total nonresidential statewide floorspace, the affected shares are shown in Table 116.

Table 114: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2029, 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	0.000008	0.00096	0.00235	0.00074	0.00127	0.00013	0.00136	0.00011	0.00011	0.02034	0.00009	0.00105	0.00042	0.00669	0.00082	0.00104	0.0375
CEH Indoor Leafy Greens	0.000000	0.00005	0.00013	0.00004	0.00007	0.00001	0.00007	0.00001	0.00001	0.00111	0.00000	0.00006	0.00002	0.00036	0.00004	0.00006	0.0020
CEH Indoor Tomatoes	0.000000	0.00003	0.00008	0.00002	0.00004	0.00000	0.00004	0.00000	0.00000	0.00066	0.00000	0.00003	0.00001	0.00022	0.00003	0.00003	0.0012
CEH Greenhouse Cannabis	0.000008	0.00095	0.00233	0.00073	0.00125	0.00013	0.00135	0.00011	0.00011	0.02013	0.00009	0.00104	0.00041	0.00662	0.00082	0.00103	0.0371
CEH Greenhouse Leafy Greens	0.000008	0.00095	0.00233	0.00073	0.00125	0.00013	0.00135	0.00011	0.00011	0.02013	0.00009	0.00104	0.00041	0.00662	0.00082	0.00103	0.0371
CEH Greenhouse Tomatoes	0.000011	0.00127	0.00310	0.00097	0.00167	0.00017	0.00180	0.00015	0.00015	0.02685	0.00011	0.00138	0.00055	0.00882	0.00109	0.00138	0.0495
TOTAL	0.000036	0.00421	0.01031	0.00323	0.00555	0.00056	0.00597	0.00049	0.00049	0.08922	0.00038	0.00459	0.00184	0.02933	0.00361	0.00457	0.1644

Table 115: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2029 (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	0.00278	0.00237	0.01157	0.00339	0.02875	0.03555	0.00456	0.00326	0.00702	0.04335	0.01231	0.02269	0.02362	0.01172	0.00358	0.00204	0.2186
CEH Indoor Leafy Greens	0.00023	0.00019	0.00094	0.00028	0.00234	0.00290	0.00037	0.00027	0.00057	0.00353	0.00100	0.00185	0.00193	0.00096	0.00029	0.00017	0.0178
CEH Indoor Tomatoes	0.00008	0.00007	0.00032	0.00009	0.00080	0.00099	0.00013	0.00009	0.00020	0.00121	0.00034	0.00063	0.00066	0.00033	0.00010	0.00006	0.0061
CEH Greenhouse Cannabis	0.00275	0.00234	0.01145	0.00336	0.02846	0.03519	0.00452	0.00323	0.00695	0.04291	0.01218	0.02246	0.02339	0.01160	0.00354	0.00202	0.2163
CEH Greenhouse Leafy Greens	0.00412	0.00351	0.01718	0.00504	0.04269	0.05279	0.00677	0.00484	0.01043	0.06437	0.01827	0.03369	0.03508	0.01740	0.00532	0.00303	0.3245
CEH Greenhouse Tomatoes	0.00314	0.00268	0.01309	0.00384	0.03253	0.04022	0.00516	0.00369	0.00794	0.04904	0.01392	0.02567	0.02673	0.01326	0.00405	0.00230	0.2473
TOTAL	0.01309	0.01116	0.05454	0.01600	0.13558	0.16765	0.02151	0.01538	0.03311	0.20442	0.05803	0.10698	0.11140	0.05526	0.01688	0.00961	1.0306

Table 116: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2029, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Indoor (Warehouse) Cannabis	0.56%	0.08%
CEH Indoor (Warehouse) Leafy Greens	0.03%	0.01%
CEH Indoor (Warehouse) Tomatoes	0.02%	0.01%
CEH Greenhouse Cannabis	0.55%	0.07%
CEH Greenhouse Leafy Greens	0.55%	0.11%
CEH Greenhouse Tomatoes	0.73%	0.09%
TOTAL	2.44%	0.37%

Table 117: 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	0.006%	0.038%
2	0.103%	0.006%
3	0.051%	0.006%
4	0.024%	0.003%
5	0.309%	0.143%
6	0.004%	0.022%
7	0.057%	0.004%
8	0.002%	0.002%
9	0.002%	0.002%
10	0.535%	0.020%
11	0.010%	0.030%
12	0.025%	0.011%
13	0.030%	0.029%
14	0.766%	0.023%
15	0.167%	0.013%
16	0.348%	0.012%

Table 118: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00001	0.0001	0.00001	N/A	0.0001	\$0.001
2	0.00096	0.0150	0.00114	N/A	0.0138	\$0.107
3	0.00235	0.0366	0.00279	N/A	0.0339	\$0.262
4	0.00074	0.0116	0.00088	N/A	0.0106	\$0.082
5	0.00127	0.0198	0.00150	N/A	0.0182	\$0.142
6	0.00013	0.0020	0.00015	N/A	0.0019	\$0.014
7	0.00136	0.0214	0.00163	N/A	0.0198	\$0.152
8	0.00011	0.0018	0.00013	N/A	0.0016	\$0.012
9	0.00011	0.0018	0.00013	N/A	0.0016	\$0.013
10	0.02034	0.3236	0.02452	N/A	0.2964	\$2.264
11	0.00009	0.0014	0.00010	N/A	0.0013	\$0.010
12	0.00105	0.0165	0.00125	N/A	0.0151	\$0.118
13	0.00042	0.0067	0.00050	N/A	0.0061	\$0.047
14	0.00669	0.1061	0.00795	N/A	0.0965	\$0.729
15	0.00082	0.0134	0.00100	N/A	0.0122	\$0.096
16	0.00104	0.0161	0.00123	N/A	0.0148	\$0.113
Total	0.03747	0.5936	0.04494	N/A	0.5438	\$4.161

Table 119: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Leafy Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.0000004	0.000002	0.0000002	N/A	0.000003	\$0.00002
2	0.0000521	0.000250	0.0000247	N/A	0.000350	\$0.00207
3	0.0001278	0.000613	0.0000606	N/A	0.000863	\$0.00506
4	0.0000401	0.000194	0.0000191	N/A	0.000271	\$0.00160
5	0.0000688	0.000330	0.0000326	N/A	0.000464	\$0.00273
6	0.0000070	0.000034	0.0000033	N/A	0.000047	\$0.00028
7	0.0000739	0.000359	0.0000355	N/A	0.000506	\$0.00296
8	0.0000060	0.000029	0.0000029	N/A	0.000041	\$0.00025
9	0.0000060	0.000029	0.0000029	N/A	0.000041	\$0.00025
10	0.0011054	0.005403	0.0005324	N/A	0.007558	\$0.04529
11	0.0000047	0.000023	0.0000023	N/A	0.000032	\$0.00019
12	0.0000568	0.000275	0.0000272	N/A	0.000385	\$0.00228
13	0.0000228	0.000111	0.0000110	N/A	0.000156	\$0.00092
14	0.0003633	0.001771	0.0001729	N/A	0.002463	\$0.01477
15	0.0000448	0.000224	0.0000219	N/A	0.000311	\$0.00184
16	0.0000566	0.000269	0.0000267	N/A	0.000378	\$0.00226
Total	0.0020366	0.009916	0.0009761	N/A	0.013868	\$0.08276

Table 120: Statewide Energy and LSC Impacts – New Construction and Additions – Indoor (Warehouse) – Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.0000003	0.000001	0.0000001	N/A	0.000001	\$0.00001
2	0.0000313	0.000176	0.0000127	N/A	0.000147	\$0.00123
3	0.0000767	0.000430	0.0000311	N/A	0.000361	\$0.00300
4	0.0000240	0.000137	0.0000098	N/A	0.000113	\$0.00094
5	0.0000413	0.000232	0.0000167	N/A	0.000194	\$0.00162
6	0.0000042	0.000024	0.0000017	N/A	0.000020	\$0.00016
7	0.0000444	0.000252	0.0000182	N/A	0.000211	\$0.00173
8	0.0000036	0.000021	0.0000015	N/A	0.000017	\$0.00014
9	0.0000036	0.000021	0.0000015	N/A	0.000017	\$0.00014
10	0.0006633	0.003804	0.0002727	N/A	0.003155	\$0.02568
11	0.0000028	0.000016	0.0000012	N/A	0.000013	\$0.00011
12	0.0000341	0.000193	0.0000139	N/A	0.000161	\$0.00134
13	0.0000137	0.000078	0.0000056	N/A	0.000065	\$0.00053
14	0.0002180	0.001247	0.0000884	N/A	0.001027	\$0.00825
15	0.0000269	0.000157	0.0000112	N/A	0.000129	\$0.00109
16	0.0000340	0.000189	0.0000136	N/A	0.000158	\$0.00129
Total	0.0012220	0.006977	0.0004997	N/A	0.005789	\$0.04728

Table 121: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00001	0.00003	0.000003	N/A	0.00004	\$0.00024
2	0.00095	0.00266	0.000322	N/A	0.00467	\$0.02246
3	0.00233	0.00616	0.000754	N/A	0.01112	\$0.05361
4	0.00073	0.00158	0.000229	N/A	0.00311	\$0.01346
5	0.00125	0.00269	0.000382	N/A	0.00520	\$0.02280
6	0.00013	0.00026	0.000038	N/A	0.00051	\$0.00226
7	0.00135	0.00286	0.000399	N/A	0.00530	\$0.02379
8	0.00011	0.00023	0.000032	N/A	0.00044	\$0.00187
9	0.00011	0.00022	0.000032	N/A	0.00044	\$0.00182
10	0.02013	0.04012	0.005868	N/A	0.08115	\$0.33154
11	0.00009	0.00025	0.000032	N/A	0.00043	\$0.00201
12	0.00104	0.00273	0.000346	N/A	0.00491	\$0.02220
13	0.00041	0.00096	0.000139	N/A	0.00189	\$0.00804
14	0.00662	0.01232	0.001962	N/A	0.02601	\$0.10335
15	0.00082	0.00148	0.000232	N/A	0.00315	\$0.01277
16	0.00103	0.00292	0.000362	N/A	0.00487	\$0.02260
Total	0.03710	0.07748	0.011131	N/A	0.15324	\$0.64481

Table 122: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Leafy Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00001	0.000008	0.000001	N/A	0.00002	\$0.00007
2	0.00095	0.000688	0.000098	N/A	0.00176	\$0.00660
3	0.00233	0.001547	0.000200	N/A	0.00403	\$0.01553
4	0.00073	0.000309	0.000054	N/A	0.00091	\$0.00295
5	0.00125	0.000465	0.000077	N/A	0.00137	\$0.00438
6	0.00013	0.000038	0.000007	N/A	0.00012	\$0.00039
7	0.00135	0.000373	0.000063	N/A	0.00116	\$0.00359
8	0.00011	0.000034	0.000006	N/A	0.00011	\$0.00032
9	0.00011	0.000034	0.000006	N/A	0.00011	\$0.00032
10	0.02013	0.006027	0.001058	N/A	0.02025	\$0.05704
11	0.00009	0.000070	0.000010	N/A	0.00017	\$0.00062
12	0.00104	0.000687	0.000099	N/A	0.00179	\$0.00620
13	0.00041	0.000215	0.000039	N/A	0.00066	\$0.00204
14	0.00662	0.001656	0.000383	N/A	0.00602	\$0.01620
15	0.00082	0.000184	0.000037	N/A	0.00069	\$0.00186
16	0.00103	0.000762	0.000111	N/A	0.00174	\$0.00642
Total	0.03710	0.013095	0.002250	N/A	0.04091	\$0.12453

Table 123: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00001	0.000014	0.000002	N/A	0.00002	\$0.0001
2	0.00127	0.001257	0.000139	N/A	0.00232	\$0.0108
3	0.00310	0.002864	0.000305	N/A	0.00542	\$0.0252
4	0.00097	0.000612	0.000086	N/A	0.00135	\$0.0054
5	0.00167	0.000962	0.000141	N/A	0.00213	\$0.0084
6	0.00017	0.000082	0.000013	N/A	0.00020	\$0.0008
7	0.00180	0.000840	0.000122	N/A	0.00194	\$0.0074
8	0.00015	0.000073	0.000011	N/A	0.00017	\$0.0006
9	0.00015	0.000073	0.000011	N/A	0.00017	\$0.0006
10	0.02685	0.012794	0.001889	N/A	0.03212	\$0.1115
11	0.00011	0.000123	0.000014	N/A	0.00022	\$0.0010
12	0.00138	0.001271	0.000146	N/A	0.00238	\$0.0104
13	0.00055	0.000407	0.000060	N/A	0.00091	\$0.0035
14	0.00882	0.003640	0.000652	N/A	0.00981	\$0.0326
15	0.00109	0.000413	0.000071	N/A	0.00116	\$0.0039
16	0.00138	0.001395	0.000164	N/A	0.00230	\$0.0107
Total	0.04946	0.026822	0.003826	N/A	0.06262	\$0.2329

Table 124: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Cannabis

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (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	0.0028	0.043	0.003	N/A	0.04	\$0.31
2	0.0024	0.037	0.003	N/A	0.03	\$0.26
3	0.0116	0.180	0.014	N/A	0.17	\$1.29
4	0.0034	0.053	0.004	N/A	0.05	\$0.38
5	0.0288	0.449	0.034	N/A	0.41	\$3.23
6	0.0356	0.559	0.043	N/A	0.52	\$3.96
7	0.0046	0.072	0.005	N/A	0.07	\$0.51
8	0.0033	0.052	0.004	N/A	0.05	\$0.36
9	0.0070	0.111	0.008	N/A	0.10	\$0.80
10	0.0433	0.690	0.052	N/A	0.63	\$4.82
11	0.0123	0.195	0.015	N/A	0.18	\$1.37
12	0.0227	0.357	0.027	N/A	0.33	\$2.55
13	0.0236	0.375	0.028	N/A	0.34	\$2.64
14	0.0117	0.186	0.014	N/A	0.17	\$1.28
15	0.0036	0.058	0.004	N/A	0.05	\$0.42
16	0.0020	0.031	0.002	N/A	0.03	\$0.22
Total	0.2186	3.448	0.262	N/A	3.17	\$24.40

Table 125: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Leafy Greens

Climate Zone	Statewide Alterations impacted by Proposed Change in 2029 (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	0.00023	0.0011	0.0001	N/A	0.002	\$0.01
2	0.00019	0.0009	0.0001	N/A	0.001	\$0.01
3	0.00094	0.0045	0.0004	N/A	0.006	\$0.04
4	0.00028	0.0013	0.0001	N/A	0.002	\$0.01
5	0.00234	0.0113	0.0011	N/A	0.016	\$0.09
6	0.00290	0.0140	0.0014	N/A	0.020	\$0.12
7	0.00037	0.0018	0.0002	N/A	0.003	\$0.01
8	0.00027	0.0013	0.0001	N/A	0.002	\$0.01
9	0.00057	0.0028	0.0003	N/A	0.004	\$0.02
10	0.00353	0.0173	0.0017	N/A	0.024	\$0.14
11	0.00100	0.0049	0.0005	N/A	0.007	\$0.04
12	0.00185	0.0089	0.0009	N/A	0.013	\$0.07
13	0.00193	0.0094	0.0009	N/A	0.013	\$0.08
14	0.00096	0.0047	0.0005	N/A	0.006	\$0.04
15	0.00029	0.0015	0.0001	N/A	0.002	\$0.01
16	0.00017	0.0008	0.0001	N/A	0.001	\$0.01
Total	0.01782	0.0865	0.0085	N/A	0.121	\$0.72

Table 126: Statewide Energy and LSC Impacts – Alterations – Indoor (Warehouse) – Tomatoes

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (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	0.00008	0.0004	0.00003	N/A	0.0004	\$0.003
2	0.00007	0.0004	0.00003	N/A	0.0003	\$0.003
3	0.00032	0.0018	0.00013	N/A	0.0015	\$0.013
4	0.00009	0.0005	0.00004	N/A	0.0004	\$0.004
5	0.00080	0.0045	0.00033	N/A	0.0038	\$0.032
6	0.00099	0.0056	0.00041	N/A	0.0047	\$0.039
7	0.00013	0.0007	0.00005	N/A	0.0006	\$0.005
8	0.00009	0.0005	0.00004	N/A	0.0004	\$0.004
9	0.00020	0.0011	0.00008	N/A	0.0009	\$0.008
10	0.00121	0.0069	0.00050	N/A	0.0058	\$0.047
11	0.00034	0.0020	0.00014	N/A	0.0016	\$0.013
12	0.00063	0.0036	0.00026	N/A	0.0030	\$0.025
13	0.00066	0.0038	0.00027	N/A	0.0031	\$0.026
14	0.00033	0.0019	0.00013	N/A	0.0015	\$0.012
15	0.00010	0.0006	0.00004	N/A	0.0005	\$0.004
16	0.00006	0.0003	0.00002	N/A	0.0003	\$0.002
Total	0.00611	0.0347	0.00249	N/A	0.0289	\$0.238

Table 127: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Cannabis

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (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	0.0027	0.010	0.001	N/A	0.020	\$0.08
2	0.0023	0.007	0.001	N/A	0.010	\$0.06
3	0.0115	0.030	0.004	N/A	0.050	\$0.26
4	0.0034	0.007	0.001	N/A	0.010	\$0.06
5	0.0285	0.061	0.009	N/A	0.120	\$0.52
6	0.0352	0.073	0.010	N/A	0.140	\$0.63
7	0.0045	0.010	0.001	N/A	0.020	\$0.08
8	0.0032	0.007	0.001	N/A	0.010	\$0.06
9	0.0070	0.014	0.002	N/A	0.030	\$0.12
10	0.0429	0.086	0.013	N/A	0.170	\$0.71
11	0.0122	0.035	0.005	N/A	0.060	\$0.29
12	0.0225	0.059	0.007	N/A	0.110	\$0.48
13	0.0234	0.054	0.008	N/A	0.110	\$0.45
14	0.0116	0.022	0.003	N/A	0.050	\$0.18
15	0.0035	0.006	0.001	N/A	0.010	\$0.06
16	0.0020	0.006	0.001	N/A	0.010	\$0.04
Total	0.2163	0.486	0.068	N/A	0.930	\$4.06

Table 128: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Leafy Greens

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (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	0.004	0.0040	0.0006	N/A	0.009	\$0.04
2	0.004	0.0025	0.0004	N/A	0.007	\$0.02
3	0.017	0.0114	0.0015	N/A	0.030	\$0.11
4	0.005	0.0021	0.0004	N/A	0.006	\$0.02
5	0.043	0.0158	0.0026	N/A	0.047	\$0.15
6	0.053	0.0158	0.0030	N/A	0.052	\$0.16
7	0.007	0.0019	0.0003	N/A	0.006	\$0.02
8	0.005	0.0015	0.0003	N/A	0.005	\$0.01
9	0.010	0.0033	0.0006	N/A	0.010	\$0.03
10	0.064	0.0193	0.0034	N/A	0.065	\$0.18
11	0.018	0.0149	0.0021	N/A	0.036	\$0.13
12	0.034	0.0224	0.0032	N/A	0.058	\$0.20
13	0.035	0.0182	0.0033	N/A	0.055	\$0.17
14	0.017	0.0044	0.0010	N/A	0.016	\$0.04
15	0.005	0.0012	0.0002	N/A	0.005	\$0.01
16	0.003	0.0022	0.0003	N/A	0.005	\$0.02
Total	0.325	0.1408	0.0232	N/A	0.411	\$1.33

Table 129: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Tomatoes

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (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	0.003	0.004	0.0005	N/A	0.007	\$0.03
2	0.003	0.003	0.0003	N/A	0.005	\$0.02
3	0.013	0.012	0.0013	N/A	0.023	\$0.11
4	0.004	0.002	0.0003	N/A	0.005	\$0.02
5	0.033	0.019	0.0027	N/A	0.041	\$0.16
6	0.040	0.020	0.0030	N/A	0.047	\$0.18
7	0.005	0.002	0.0004	N/A	0.006	\$0.02
8	0.004	0.002	0.0003	N/A	0.004	\$0.02
9	0.008	0.004	0.0006	N/A	0.009	\$0.03
10	0.049	0.023	0.0035	N/A	0.059	\$0.20
11	0.014	0.015	0.0018	N/A	0.026	\$0.12
12	0.026	0.024	0.0027	N/A	0.044	\$0.19
13	0.027	0.020	0.0029	N/A	0.044	\$0.17
14	0.013	0.005	0.0010	N/A	0.015	\$0.05
15	0.004	0.002	0.0003	N/A	0.004	\$0.01
16	0.002	0.002	0.0003	N/A	0.004	\$0.02
Total	0.247	0.159	0.0217	N/A	0.344	\$1.37

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 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 percent 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). For statewide savings calculations, only the portion of installations not already using daylight-responsive controls is assumed to achieve incremental savings. Based on an estimated 62 percent existing market adoption, savings are applied to the remaining 38 percent of affected installations. This estimate reflects partial adoption of sensor-based lighting controls across the CEH sector, with higher adoption in large facilities and lower adoption in smaller or retrofit facilities.

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 were confirmed with stakeholder feedback. For cannabis greenhouses, only flowering canopy area was assumed to be impacted, reflecting typical production practices and resulting in a conservative estimate of statewide savings. This assumption reflects greenhouse canopy area breakdown, where cannabis is typically 65 percent flowering, 33 percent vegetative, and 2 percent clone by canopy area; therefore, 65 percent of cannabis canopy square footage was used in the calculations. These assumptions were confirmed by stakeholder feedback. These assumptions are shown in Table 130 for new construction and additions, and Table 131 for alterations.

Percentages shown in Table 130 reflect the portion of CEH floorspace meeting the 40-kW threshold, adjusted for crop distribution and applicability of the measure.

Percentages presented in

Table 131 reflect the share of total nonresidential floorspace impacted annually, not the share of CEH-only floorspace. These values therefore differ from the 8.75 percent CEH-specific turnover estimate described above.

Table 130: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – New Construction & Additions

Greenhouse Prototype	Percent of building type square footage used for crop type (%)	Percent of CEH Statewide New Construction Impacted (%)
Cannabis	30	14.28
Cannabis Flower Only	19.5	9.28
Leafy greens / Microgreens / Herbs	30	14.28
Tomatoes / Flowers / Vine Plants	40	19.04

Table 131: Percent of Statewide Floorspace Impacted per Building Prototype and Crop Type – Alterations

Greenhouse Prototype	Percent of building type square footage used for crop type (%)	Percent of CEH Building Stock Impacted Annually (%)
Cannabis	30	2.55
Cannabis Flower Only	19.5	1.66
Leafy greens / Microgreens / Herbs	30	2.55
Tomatoes/Flowers/ Vine Plants	40	3.40

Table 132 presents the projected nonresidential new construction that the proposed code change will impact in 2029. Table 133 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2029. 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 134 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 135 represents the assumed percentage of affected floorspace by climate zone.

Table 132: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2029, 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	0.00002	0.002	0.005	0.002	0.003	0.0003	0.003	0.0002	0.0002	0.042	0.0002	0.002	0.001	0.014	0.002	0.002	0.077
CEH Greenhouse Leafy Greens	0.00003	0.003	0.007	0.002	0.004	0.0004	0.004	0.0004	0.0004	0.065	0.0003	0.003	0.001	0.021	0.003	0.003	0.119
CEH Greenhouse Tomatoes	0.00003	0.004	0.010	0.003	0.005	0.0005	0.006	0.0005	0.0005	0.086	0.0004	0.004	0.002	0.028	0.003	0.004	0.159
TOTAL	0.00008	0.009	0.022	0.007	0.012	0.0012	0.013	0.0010	0.0010	0.193	0.0008	0.010	0.004	0.063	0.008	0.010	0.355

Table 133: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2029 (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	0.003	0.003	0.014	0.004	0.034	0.042	0.005	0.004	0.008	0.051	0.015	0.027	0.028	0.014	0.004	0.002	0.259
CEH Greenhouse Leafy Greens	0.005	0.004	0.021	0.006	0.052	0.065	0.008	0.006	0.013	0.079	0.022	0.041	0.043	0.021	0.007	0.004	0.398
CEH Greenhouse Tomatoes	0.007	0.006	0.028	0.008	0.070	0.086	0.011	0.008	0.017	0.105	0.030	0.055	0.057	0.028	0.009	0.005	0.531
TOTAL	0.015	0.013	0.063	0.018	0.156	0.193	0.025	0.018	0.038	0.235	0.067	0.123	0.128	0.064	0.019	0.011	1.187

Table 134: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2029, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Greenhouse Cannabis	1.15%	0.09%
CEH Greenhouse Leafy Greens	1.77%	0.14%
CEH Greenhouse Tomatoes	2.36%	0.18%
TOTAL	5.27%	0.41%

Table 135: 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	0.01%	0.04%
2	0.22%	0.01%
3	0.11%	0.01%
4	0.05%	0.00%
5	0.67%	0.16%
6	0.01%	0.02%
7	0.12%	0.00%
8	0.01%	0.00%
9	0.00%	0.00%
10	1.16%	0.02%
11	0.02%	0.03%
12	0.05%	0.01%
13	0.06%	0.03%
14	1.65%	0.03%
15	0.36%	0.01%
16	0.75%	0.01%

Table 136: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00002	0.0005	0.00002	N/A	0.0001	\$0.00
2	0.00198	0.0725	0.00353	N/A	0.0195	\$0.43
3	0.00485	0.1814	0.00899	N/A	0.0497	\$1.08
4	0.00152	0.0624	0.00273	N/A	0.0178	\$0.37
5	0.00261	0.1059	0.00471	N/A	0.0314	\$0.64
6	0.00026	0.0109	0.00049	N/A	0.0033	\$0.06
7	0.00281	0.1133	0.00513	N/A	0.0357	\$0.68
8	0.00023	0.0093	0.00042	N/A	0.0028	\$0.05
9	0.00023	0.0095	0.00042	N/A	0.0029	\$0.06
10	0.04199	1.7477	0.07696	N/A	0.5116	\$10.23
11	0.00018	0.0065	0.00029	N/A	0.0018	\$0.04
12	0.00216	0.0830	0.00380	N/A	0.0230	\$0.50
13	0.00086	0.0348	0.00145	N/A	0.0090	\$0.21
14	0.01380	0.5972	0.02548	N/A	0.1783	\$3.48
15	0.00170	0.0732	0.00320	N/A	0.0223	\$0.44
16	0.00215	0.0807	0.00354	N/A	0.0243	\$0.48
Total	0.07736	3.1891	0.14117	N/A	0.9335	\$18.76

Table 137: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Leafy Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00003	0.0006	0.00004	N/A	0.000	\$0.00
2	0.00305	0.0803	0.00455	N/A	0.034	\$0.51
3	0.00747	0.1994	0.01144	N/A	0.086	\$1.27
4	0.00234	0.0652	0.00353	N/A	0.030	\$0.42
5	0.00402	0.1115	0.00600	N/A	0.052	\$0.72
6	0.00041	0.0113	0.00060	N/A	0.005	\$0.07
7	0.00432	0.1192	0.00641	N/A	0.057	\$0.76
8	0.00035	0.0097	0.00052	N/A	0.005	\$0.06
9	0.00035	0.0098	0.00052	N/A	0.005	\$0.06
10	0.06460	1.7987	0.09416	N/A	0.841	\$11.31
11	0.00027	0.0072	0.00039	N/A	0.003	\$0.05
12	0.00332	0.0899	0.00498	N/A	0.039	\$0.59
13	0.00133	0.0366	0.00193	N/A	0.016	\$0.23
14	0.02123	0.6016	0.03139	N/A	0.287	\$3.73
15	0.00262	0.0741	0.00394	N/A	0.036	\$0.48
16	0.00331	0.0885	0.00482	N/A	0.041	\$0.57
Total	0.11901	3.3035	0.17520	N/A	1.536	\$20.84

Table 138: Statewide Energy and LSC Impacts – New Construction and Additions – Greenhouse – Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.00003	0.001	0.0001	N/A	0.0004	\$0.01
2	0.00406	0.163	0.0087	N/A	0.0536	\$1.00
3	0.00995	0.407	0.0221	N/A	0.1370	\$2.48
4	0.00312	0.136	0.0068	N/A	0.0490	\$0.84
5	0.00536	0.233	0.0114	N/A	0.0858	\$1.45
6	0.00054	0.024	0.0012	N/A	0.0089	\$0.15
7	0.00576	0.250	0.0125	N/A	0.0975	\$1.54
8	0.00047	0.020	0.0010	N/A	0.0077	\$0.12
9	0.00047	0.021	0.0010	N/A	0.0078	\$0.13
10	0.08613	3.799	0.1839	N/A	1.4039	\$22.95
11	0.00037	0.015	0.0007	N/A	0.0048	\$0.09
12	0.00443	0.185	0.0095	N/A	0.0633	\$1.16
13	0.00177	0.077	0.0036	N/A	0.0251	\$0.47
14	0.02831	1.284	0.0611	N/A	0.4866	\$7.72
15	0.00349	0.158	0.0077	N/A	0.0609	\$0.99
16	0.00441	0.181	0.0090	N/A	0.0669	\$1.12
Total	0.15869	6.953	0.3402	N/A	2.5594	\$42.20

Table 139: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.0033	0.10	0.005	N/A	0.03	\$0.61
2	0.0028	0.10	0.005	N/A	0.03	\$0.61
3	0.0137	0.51	0.025	N/A	0.14	\$3.04
4	0.0040	0.16	0.007	N/A	0.05	\$0.98
5	0.0340	1.38	0.061	N/A	0.41	\$8.29
6	0.0421	1.73	0.078	N/A	0.53	\$10.29
7	0.0054	0.22	0.010	N/A	0.07	\$1.31
8	0.0039	0.16	0.007	N/A	0.05	\$0.93
9	0.0083	0.35	0.015	N/A	0.10	\$2.08
10	0.0513	2.14	0.094	N/A	0.62	\$12.49
11	0.0146	0.53	0.023	N/A	0.14	\$3.15
12	0.0268	1.03	0.047	N/A	0.29	\$6.26
13	0.0280	1.13	0.047	N/A	0.29	\$6.63
14	0.0139	0.60	0.026	N/A	0.18	\$3.50
15	0.0042	0.18	0.008	N/A	0.06	\$1.10
16	0.0024	0.09	0.004	N/A	0.03	\$0.54
Total	0.2586	10.41	0.463	N/A	3.01	\$61.81

Table 140: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Leafy Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.0051	0.12	0.007	N/A	0.05	\$0.79
2	0.0043	0.11	0.006	N/A	0.05	\$0.73
3	0.0211	0.56	0.032	N/A	0.24	\$3.57
4	0.0062	0.17	0.009	N/A	0.08	\$1.10
5	0.0523	1.45	0.078	N/A	0.67	\$9.43
6	0.0647	1.80	0.095	N/A	0.85	\$11.40
7	0.0083	0.23	0.012	N/A	0.11	\$1.46
8	0.0059	0.16	0.009	N/A	0.08	\$1.03
9	0.0128	0.36	0.019	N/A	0.17	\$2.33
10	0.0789	2.20	0.115	N/A	1.03	\$13.82
11	0.0224	0.59	0.032	N/A	0.25	\$3.72
12	0.0413	1.12	0.062	N/A	0.49	\$7.29
13	0.0430	1.18	0.062	N/A	0.51	\$7.52
14	0.0213	0.60	0.032	N/A	0.29	\$3.75
15	0.0065	0.18	0.010	N/A	0.09	\$1.19
16	0.0037	0.10	0.005	N/A	0.05	\$0.64
Total	0.3979	10.95	0.586	N/A	4.99	\$69.76

Table 141: Statewide Energy and LSC Impacts – Alterations – Greenhouse – Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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	0.007	0.25	0.013	N/A	0.08	\$1.49
2	0.006	0.23	0.012	N/A	0.08	\$1.41
3	0.028	1.15	0.062	N/A	0.39	\$7.00
4	0.008	0.36	0.018	N/A	0.13	\$2.21
5	0.070	3.03	0.149	N/A	1.12	\$18.84
6	0.086	3.78	0.187	N/A	1.42	\$23.16
7	0.011	0.48	0.024	N/A	0.19	\$2.96
8	0.008	0.35	0.017	N/A	0.13	\$2.09
9	0.017	0.75	0.037	N/A	0.28	\$4.70
10	0.105	4.64	0.225	N/A	1.72	\$28.04
11	0.030	1.20	0.060	N/A	0.39	\$7.27
12	0.055	2.30	0.118	N/A	0.79	\$14.37
13	0.057	2.47	0.117	N/A	0.81	\$15.05
14	0.028	1.29	0.061	N/A	0.49	\$7.76
15	0.009	0.39	0.019	N/A	0.15	\$2.45
16	0.005	0.20	0.010	N/A	0.08	\$1.25
Total	0.531	22.88	1.128	N/A	8.24	\$140.07

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. Building square footage estimates are converted to canopy square footage using assumptions about canopy density and floorplan allocation described below. Total statewide electricity savings are calculated by multiplying per-unit savings (kWh per canopy square foot) by the estimated impacted canopy square footage.

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 growing floor area. Therefore, the proportions from the 2022 CEH Final CASE Report were applied, assuming 32 percent of statewide CEH square footage is indoor growing (Energy Solutions, 2023). These assumptions were vetted with stakeholders this code cycle.

The Statewide CASE Team assumed that 92 percent of the indoor facilities are cannabis (Energy Solutions, 2023), and that 87 percent of cannabis indoor growing facilities have over 5,000 canopy square feet (California Department of Cannabis Control, n.d.). Approximately 58 percent of indoor cannabis facility floor area is allocated to flowering space. To align with the per-unit analysis, this floor area is converted to canopy area using an assumed weighted average canopy ratio of 100 percent (reflecting a mix of single-tier and multi-tier cultivation) (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 58 percent (portion of the building square footage that is cannabis flower) = 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 indoor 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 indoor CEH HVAC/D equipment replaced each year) = 1.0 percent of existing CEH square footage statewide. The assumed 12-year replacement cycle reflects industry practice observed by subject matter experts,

including system replacement due to changes in lighting technology, increased canopy density, or desired environmental control performance. These factors frequently trigger full system upgrades rather than incremental component replacement, aligning with the applicability thresholds defined in the proposed code.

Additionally, the statewide energy and cost savings estimates take the current market share rate into account. The Statewide CASE Team estimates current market adoption of systems meeting the proposed requirements at approximately 25 percent. This estimate was based on analysis of data from the Title 24 compliance database, and was confirmed based on stakeholder feedback, including polling results from the September 24, 2025 Utility-Sponsored Stakeholder Meeting, and is consistent with broader market characterization indicating limited but growing adoption of integrated and coordinated HVAC/D systems in California indoor CEH facilities. A Cannabis Business Times nationwide survey indicated that 34% of growers use integrated HVAC/D systems to control humidity in their space (Cannabis Business Times, 2022). Statewide savings estimates account for current market adoption, with savings applied only to the portion of the market not already using systems that meet the proposed requirements.

The Statewide CASE Team modeled the prototype for cannabis flower 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 with stakeholder feedback. These assumptions are shown in Table 142 for new construction and additions, and Table 143 for alterations.

Table 142: 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	14.86	13.67

Table 143: 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 Existing Stock Impacted (%)
Cannabis	92	1.24	1.14

Table 144: Estimated Nonresidential Construction Impacted by Proposed Code Change in 2029, by Climate Zone – CEH Indoor Cannabis (Million Square Feet)

Climate Zone	New Construction (Million Square Feet)	Alterations (Million Square Feet)
1	0.0001	0.0048
2	0.0062	0.0041
3	0.0151	0.0199
4	0.0047	0.0058
5	0.0081	0.0495
6	0.0008	0.0612
7	0.0088	0.0079
8	0.0007	0.0056
9	0.0007	0.0121
10	0.1309	0.0746
11	0.0006	0.0212
12	0.0067	0.0391
13	0.0027	0.0407
14	0.043	0.0202
15	0.0053	0.0062
16	0.0067	0.0035
Total	0.2412	0.3763

Table 145: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2029, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Indoor Cannabis	3.58%	0.13%
TOTAL	3.58%	0.13%

Table 146: 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	0.0087%	0.0137%
2	0.1516%	0.0020%
3	0.0754%	0.0020%
4	0.0355%	0.0010%
5	0.4539%	0.0519%
6	0.0062%	0.0077%
7	0.0838%	0.0014%
8	0.0035%	0.0005%
9	0.0023%	0.0007%
10	0.7856%	0.0071%
11	0.0151%	0.0109%
12	0.0369%	0.0039%
13	0.0438%	0.0105%
14	1.1240%	0.0083%
15	0.2457%	0.0044%
16	0.5110%	0.0043%

Appendix D: Environmental Analysis

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 proposal modifies horticultural lighting efficacy requirements only and does not change irrigation systems, water treatment systems, crop production practices, or other systems affecting water use or water quality. Therefore, the Statewide CASE Team determined the proposal comes with no impacts on 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-response controls prevents the operation of horticultural lighting when sufficient daylight is available to meet plant lighting requirements. By dynamically adjusting lighting output in response to real-time daylight conditions, the measure reduces unnecessary energy use and associated greenhouse gas emissions from electricity generation. These reductions are particularly impactful during daylight hours when lighting would otherwise operate at full output despite available solar radiation.

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 did not identify any reasonable alternative that would achieve comparable reductions in greenhouse lighting energy consumption with fewer or less severe environmental impacts.

Water Use and Water Quality Impacts Methodology

The proposal modifies lighting control strategies only and does not affect irrigation systems, water delivery, or water treatment processes. Therefore, the Statewide CASE Team determined that the proposal would have no impact on water use or water quality.

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 is poorly equipped to deal with typical CEH space conditioning requirements. The proposed measure would improve the efficiency of space conditioning systems in indoor CEH facilities by requiring systems that better match highly variable sensible and latent loads, reduce simultaneous heating and cooling, and increase the use of recovered

heat for reheat. These improvements would reduce electricity consumption and reduce associated GHG emissions.

Section 4.5.1 discusses 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 proposal includes establishing new minimum outdoor air ventilation rate of 0 CFM for CO₂-enriched spaces. CO₂ enrichment systems used in indoor agriculture facilities are designed to monitor maintain a specific CO₂ level to support plant growth, so any outdoor air exchange will exhaust CO₂ from the space, wasting concentrated CO₂, and contributing to ambient outdoor CO₂ levels. Setting the ventilation rate to 0 will reduce CO₂ emissions from this source.

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 indoor growing space conditioning energy consumption.

Water Use and Water Quality Impacts Methodology

The Statewide CASE Team determined the proposal comes with no impacts on water quality or water use.

Appendix E: Summary of Stakeholder Engagement

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. 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 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.

Lighting Efficacy

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity for stakeholders to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals 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 two stakeholder meetings for CEH Lighting Efficacy via webinar, as described in Table 147, including 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; Hathaway, Controlled Environment Horticulture: Lighting Efficacy slides, 2026), proposal summaries with code language, and meeting notes (California Energy Codes & Standards, 2025; California Energy Codes & Standards, 2026), are included in the bibliography section of this report.

Table 147: 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	Wednesday September 24, 2025	<ul style="list-style-type: none"> • Impacts of lighting efficacy requirements on lighting spectrum, and whether the spectral needs of all crop types can be met at higher PPE. • Increase in lighting intensity with increasing PPE for some crop types. • Compliance verification for lighting efficacy. • Modeling of energy savings from lighting efficacy • Market adoption rates for CEH lighting with PPE of 2.5 and above.
Second Round of Utility-Sponsored Stakeholder Meeting	Thursday March 5, 2026	<ul style="list-style-type: none"> • Incremental first costs • Incremental maintenance costs • Market share • Assumptions used for per unit energy savings calculations • Per Unit Energy Savings • Assumptions used for Statewide Energy Savings calculations • Proposed code triggers for alterations

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 2028 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 stakeholder meetings introduced results of energy, cost-effectiveness, and incremental cost analyses and solicited 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.

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. Webinar data, including data attendance, comments, and poll responses were used to 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 148 lists key organizations and individuals engaged during the proposal development process.

Key Themes from Stakeholder Feedback

Key themes from stakeholder feedback included confirmation of widespread market availability of luminaires meeting 2.5 µmol/J, confirmation that spectral performance can be achieved at proposed efficacy levels, and general support for aligning Title 24 requirements with DLC Horticultural Technical Requirements. Stakeholders also provided input on modeling assumptions, incremental costs, and compliance verification approaches, which informed updates to the analysis.

Table 148: Engaged Stakeholders

Organization / Individual	Market Role	Referenced in CASE Report Sections
DesignLights Consortium (Kasey Holland)	Qualified Product List Provider / Nonprofit	Provided input on PPE thresholds, product performance, and DLC alignment. Technical specifications referenced; product trend data used for EUL and far-red analysis
California Farm Bureau (Karen Mills)	Agricultural Industry Association	Provided input on agricultural lighting market characteristics

Organization / Individual	Market Role	Referenced in CASE Report Sections
Matt Golden	Energy Modeling Expert	Provided input on best practices for energy modeling
Argus Controls (Justin Jacobs)	Manufacturer – Horticultural Control Systems	Provided feedback on typical light fixtures specified with Argus controls, control system configurations, and capabilities
University of California, Davis (Shamim Ahamed)	Academic Research Institution	Contributed insights on controlled environment horticulture and lighting system design
Autogrow (Kelley Nicholson)	Manufacturer – Horticultural Control Systems	Discussed the integration of lighting systems and environmental control platforms
University of Arizona (Gene Giacomelli)	Academic Research Institution	Provided context on greenhouse lighting and plant response studies
Energy Resources Integration (Gretchen Schimelpfenig)	Energy Engineer / Technical Expert	Provided background on emerging control strategies, energy modeling inputs, and recent publications.
Amber Jamieson (EPIC)	Energy Efficiency	Provided support for the proposed updates and efficiency improvements for CEH.
Nevada Country Cannabis Alliance	Grower Organization	Provided contacts to other grower organizations.
Alex Cardenas (Willdan)	Energy Efficiency Programs	Suggested adjusting definitions of greenhouse, indoor growing.

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 two stakeholder meetings for the CEH Daylight Responsive Controls measure via webinar, as described in Table 149. Table 149 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; Hathaway, Controlled Environment Horticulture: Daylight Responsive Controls for Greenhouses, 2026), proposal summaries with code language, and meeting notes (California Energy Codes & Standards, 2026; California Energy Codes & Standards, 2025), are included in the bibliography section of this report.

Table 149: 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	Wednesday September 24, 2025	<ul style="list-style-type: none"> • Scope and justification for the proposed code change for daylight-responsive controls in greenhouse • Definition of two compliance pathways proposed • Estimated energy savings potential for the measure • Interaction of lighting controls with cooling loads and grid demand
Second Round of Utility-Sponsored Stakeholder Meeting	Thursday March 5, 2026	<ul style="list-style-type: none"> • Incremental first costs • Incremental maintenance costs • Market share • Assumptions used for per unit energy savings calculations • Energy Savings methodology • Assumptions used for Statewide Energy Savings calculations • Proposed code triggers for alterations

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 2028 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 stakeholder meetings introduced results of energy, cost-effectiveness, and incremental cost analyses and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings are open to the public. For each stakeholder meeting, two promotional emails were distributed from 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 targeted 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 targeted outreach through email, videoconference, and phone conversations with stakeholders including control system manufacturers, greenhouse designers, agricultural consultants, and researchers. These discussions informed key assumptions related to market adoption, control system capabilities, and implementation practices.

Table 150 lists key organizations and individuals engaged during the proposal development process.

Table 150: Engaged Stakeholders

Organization / Individual	Market Role	Referenced in CASE Report Sections
DesignLights Consortium (Kasey Holland)	Qualified Product List Provider / Nonprofit	Technical specifications referenced; product trend data used for EUL and far-red analysis
California Farm Bureau (Karen Mills)	Agricultural Industry Association	Provided input on agricultural lighting market characteristics
Matt Golden	Energy Modeling Expert	Provided input on best practices for energy modeling
Argus Controls (Justin Jacobs)	Manufacturer – Horticultural Control Systems	Provided feedback on typical light fixtures specified with Argus controls, control system configurations, and capabilities
University of California, Davis (Shamim Ahamed)	Academic Research Institution	Contributed insights on controlled environment horticulture and lighting system design
University of Arizona (Gene Giacomelli)	Academic Research Institution	Provided context on greenhouse lighting and plant response studies
Energy Resources Integration (Gretchen Schimelpfenig)	Energy Engineer / Technical Expert	Provided background on emerging control strategies, energy modeling inputs, and recent publications.
MicroGrow/AutoGrow Kelley Nicholson	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, and the integration of lighting systems with environmental control platforms.
Amber Jamieson (EPIC)	Energy Efficiency	Provided support for the proposed updates and efficiency improvements for CEH.
Nevada Country Cannabis Alliance	Grower Organization	Provided contacts to other grower organizations.
Alex Cardenas (Willdan)	Energy Efficiency Programs	Suggested adjusting definitions of greenhouse, indoor growing.
Evan Gutierrez (TRC)	Energy Efficiency Programs and Research	Seasonal operation of greenhouse supplemental lighting

Key themes from stakeholder feedback included strong support for requiring daylight-responsive controls, confirmation of widespread availability of PAR sensor-based and DLI control systems, and input on cost, commissioning complexity, and control system

integration. Stakeholders emphasized the importance of providing a lower-cost compliance pathway, which led to the inclusion of the timeclock + PAR sensor option alongside DLI controls. Feedback also informed assumptions related to energy savings, market adoption, and acceptance testing requirements.

Stakeholders represented a range of perspectives including manufacturers, agricultural operators, researchers, and energy efficiency professionals.

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 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:

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 two stakeholder meeting for the CEH Space Conditioning measure via webinar, along with an additional webinar to review the prototype used for energy savings analysis, as outlined in Table 151. This table displays dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations (Torvestad, Controlled Environment Horticulture (CEH) Space Conditioning, 2025; Torvestad, Controlled Environment Horticulture (CEH) Space Conditioning, 2026; Torvestad, CEH Prototype Workshop, 2025), proposal summaries with code language, and meeting notes (California Energy Codes & Standards, 2026; California Energy Codes & Standards, 2025; California Energy Codes and Standards, 2025), are included in the bibliography section of this report.

Table 151: 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	Wednesday September 24, 2025	<ul style="list-style-type: none"> • Scope and justification for the proposed code change • Market share for the measure • Estimated energy savings potential for the measure • Energy Savings Methodology
Indoor CEH Prototype Workshop	Wednesday December 10, 2025	<ul style="list-style-type: none"> • Assumptions in the indoor CEH prototype • Proposed user inputs vs. fixed assumptions
Second Round of Utility-Sponsored Stakeholder Meeting	Thursday March 5, 2026	<ul style="list-style-type: none"> • Measure updates based on stakeholder feedback • CEH prototype and savings methodology • Cost-effectiveness approach, assumptions, and results • Proposed compliance process (load/sizing calculations and prototype use)

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 2028 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 stakeholder meetings introduced results of energy, cost-effectiveness, and incremental cost analyses and solicited feedback on refined draft code language. Additionally, a prototype workshop was held to present the assumptions used for modeling energy savings for the CEH Space Conditioning proposal.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the 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 targeted 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 152 summarizes key stakeholders engaged during the proposal development process and their contributions to the analysis and code development.

Table 152: Engaged Stakeholders

Organization / Individual	Market Role	Topics
Anden / Randy Lenz	Manufacturer, Standalone Dehumidifier	Staging of dehumidifiers
DesertAire / Brian Kammers, Craig Burg, Chip Seidel	Manufacturer, Integrated DX/DOAS	Incremental cost, Compliance and enforcement
UCDavis/Shamim Ahamed	Academic Researcher	Prototype assumptions
InSpire/Adrian Giovenco	Manufacturer/Designer, Integrated DX/DOAS	Integrated DX/DOAS equipment background
Anvil Agrinomics / Jim Megerson	Designer, Cannabis Space Conditioning Equipment	Incremental Cost
Rhythm CSS / Cale Winters	Manufacturer, CEH Controls	Integrated controls for HVAC and dehumidifiers
Rupp Air / Rex Mustain	Sales Representative, Cannabis Space Conditioning Equipment	Sizing and design approaches
Agxano / Jim Doyle	Manufacturer, CEH Controls	Integrated controls for HVAC and dehumidifiers

Organization / Individual	Market Role	Topics
University of Wyoming	Academic Researcher, Modeling	Prototype assumptions
Mojave / Zachary Jenkins	Manufacturer, Liquid Desiccant Integrated system	Background
Energy 350 / Meg Waltner, Justin Hovland	Energy Policy	Background, Prototype feedback
Resource Innovation Institute	Industry Group	
Harvest Integrated / Jesse Porter	Cannabis Climate Control Service Provider	Incremental cost, prototype feedback
Accelerated Growth Solutions / Conor Guckian	Distributor/Designer, Cannabis Space Conditioning Equipment	Incremental cost, maintenance cost
ERI/Gretchen Schimelpfenig, Eric Noller	Programs	Prototype feedback
Higher Yields Consulting	Consultants	Incremental cost
Cannabis Grower (anonymous)	Grower	EULs, market share
Duane Jonlin	Energy Policy	
Kevin Muldoon (KCC MFG)	Manufacturer	
Walter Stark	Manufacturer	
Ian Atkins (Greenzone)	Designer	Energy Modeling
John Hammond and Lavanya Jakka (Airgreen)	Manufacturer	Liquid desiccant
Amber Jamieson (EPIC)	Energy Policy	
Nevada County Cannabis Alliance	Grower Coalition	
Alex Cardenas (Willdan)	Programs	Proposed Code Language
Madison Air	Manufacturer	Proposed Code Language, Background, Market, Incremental Cost
Clear Result	Programs	
Eric Sturm (Trane)	Manufacturer	Sizing, background, model inputs
Mechanical Environments	Maintenance	Background, incremental costs
Leizig	Manufacturer	Dehumidifier performance, proposed code language
Intellicon Electronics	Manufacturer	Dehumidifier performance, proposed code language

Key Stakeholder Takeaways and Resulting Revisions

Stakeholder engagement informed several key aspects of the proposed measure:

- **System flexibility:** Stakeholders emphasized that multiple system configurations (integrated and coordinated decoupled systems) must be allowed. In response, the proposal was revised to establish mandatory requirements applicable to both system types rather than favoring a single prescriptive pathway.
- **Feasibility and enforceability:** Stakeholders expressed concerns about the feasibility of performance-based compliance given current modeling limitations. The proposal was revised to a mandatory-only framework with clearly defined functional requirements and acceptance testing.
- **Sizing methodology:** Feedback highlighted the lack of standardized sizing approaches. This informed development of Nonresidential Appendix NA9 to provide a consistent and enforceable sizing methodology.
- **Controls integration:** Stakeholders confirmed that integrated controls are commercially available but emphasized the importance of clear sequencing requirements. The proposal includes explicit control requirements and acceptance testing to ensure proper operation.
- **Incremental cost assumptions:** Manufacturers, designers, and operators provided input on equipment and installation costs, the appropriate number of systems in a grow room, and effective use life of equipment, which were used to refine incremental cost estimates and confirm that integrated systems can be cost-effective when properly sized.
- **Commercial dehumidifier framework:** Stakeholders supported distinguishing commercial from consumer dehumidifiers and developing a California-specific qualification pathway, which is reflected in Joint Appendix JA19.

The Statewide CASE Team also engaged with stakeholders to vet the prototype and model used for per unit energy savings estimates to ensure the prototype reasonably represents real-world CEH operation and can support defensible savings estimates. The prototype assumptions were posted, and a public meeting was held on December 10, 2025 to obtain feedback from the public. The prototype was updated based on stakeholder input. The model was vetted with the CalBEM working group 3 and was posted publicly to obtain technical feedback on modeling assumptions and improve transparency and credibility of the analysis. The model was updated based on stakeholder feedback.

Appendix F: Non-restructured Language

The language below is from the Draft CASE Report and in the non-restructured 2025 Title 24 Part 6 Code Language. The code language recommended by the Statewide CASE Team in the Final CASE Report is in Sections 2.6.3, 3.6.3, and 4.6.3.

Lighting Efficacy Non-Restructured Language

The language below is from the Draft CASE Report, published in April, 2026 in the non-restructured 2025 Title 24 Part 6 Code Language. The code language recommended by the Statewide CASE Team in the Final CASE Report, in the restructured code format, is in Section 2.6.3.

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.

Greenhouse Daylight Responsive Controls Non-Restructured Language

The language below is from the Draft CASE Report, published in April 2025, and in the non-restructured 2025 Title 24 Part 6 Code Language. The code language recommended by the Statewide CASE Team in the Final CASE Report, in the restructured code format, is in Section 3.6.3.

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/m²/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 $\mu\text{mol/s}$, 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 ($\mu\text{mol/m}^2/\text{s}$), 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 ($\mu\text{mol/m}^2/\text{s}$) 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:
 - A. Control up to 40 kW of connected lighting per control zone,
 - B. Be capable of automatically dimming lighting continuously from 100% to 10% of full power based on available PPFD,
 - C. Turn off the electric lighting when daylight PPFD exceeds the crop’s target user-defined PPFD, and
 - D. A single sensor may serve multiple control zones if each zone has separately configured calibration settings.
 - 2. Greenhouse Daily Light Integral (DLI) control. Control shall:
 - E. Be capable of dimming electric lighting between 100% and 10% of full power and turning lighting off.
 - F. Automatically dim the electric lighting based on user-defined DLI from both daylight and electric light.
 - G. Each control zone may include up to 40 kW of connected lighting load.
 - H. A 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.

Space Conditioning Non-Restructured Language

The language below is from the Draft CASE Report published in April 2026 and in the non-restructured 2025 Title 24 Part 6 Code Language. The code language recommended by the Statewide CASE Team in the Final CASE Report, in the restructured format, is in Section 4.6.3.

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-ft², or mechanical cooling that has a capacity exceeding 5 Btu/hr-ft². 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 $\text{Sensible Heat Capacity} / \text{Total Heat Capacity}$.

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 ²)	Area-based Minimum Ventilation Ra (cfm/ft ²)	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
<u>Controlled Environment Horticulture Spaces with Carbon Dioxide Enrichment</u>	<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).