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Final CASE Report- Revised October 11,2023, Controlled Environment Horticulture

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Additional submitted attachment is included below.

Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

Controlled Environment Horticulture

Nonresidential Covered Processes

Kyle Booth, Energy Solutions

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Final CASE Report

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Authors:	Kyle Booth, Jasmine Shepard, Remy Hutheesing (Energy Solutions); Joe Sullivan (Franklin Energy)
Prime Contractor:	Energy Solutions
Project Management:	California Statewide Utility Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company, Sacramento Municipal Utility District, and Los Angeles Department of Water and Power.
Revisions as of 10/6/2023	This document contains the following revisions: 1. Moved the embodied carbon results from the body of the report to Appendix D; 2. Modified language in Section 1 to include a summary of Appendix H and Appendix I.

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Executive Summary

This report presents a cost-effective code change proposal for horticultural lighting efficacy and pertinent information supporting the code change. With an anticipated 111.7 GWh of savings during the first year, this proposal would have one of the highest electricity savings of all proposed changes for the 2025 code cycle. The horticultural lighting proposal is cost effective in both greenhouses and indoor CEH operations for all crop types with benefit-to-cost ratios between 1.96-10.0. The significant potential savings and high cost-effectiveness from the horticultural efficacy lighting proposal make it highly supportive of California's climate and emissions goals, saving approximately 7,845 metric tons of CO_2 emissions. The electricity and GHG reduction of this proposal is equivalent to the annual electricity use of 11,600 CA residences.

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (CEC) efforts to update the California Energy Code (Title 24, Part 6) and to include new requirements or to upgrade existing requirements for various technologies. Three California investor-owned utilities (IOUs)—Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison—and two publicly owned utilities—Los Angeles Department of Water and Power, and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author)—sponsored this effort. The goal of the program is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the CEC, the state agency that has authority to adopt revisions to Title 24, Part 6. The CEC will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The CEC may revise or reject proposals. See the CEC's 2025 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

Proposed Code Change

Currently luminaires or lamps used for plant growth in facilities with more than 40 kW of horticultural lighting load must have a photosynthetic photon efficacy (PPE) of at least 1.9 micromoles per joule (µmol/J) for indoor grow facilities or 1.7 µmol/J for greenhouses (which have access to daylight). Both these requirements can be met by using double-ended high-pressure sodium (HPS) technology, a legacy product that has been in the CEH market for over a decade. The proposed code change would increase the minimum PPE levels to a minimum of 2.3 µmol/J for both indoor grow facilities and greenhouse. This change would require the use of LEDs, as high pressure sodium (HPS) and ceramic metal halides would not be able to meet this PPE level. The proposed code change would apply to additions. Altered lighting systems would also need to comply with the new PPE requirement, but the existing 10 percent alterations trigger would be maintained.

See Section 6 Proposed Revisions to Code Language of this report for marked-up code language. Table 1 summarizes the proposed code changes.

Table 1: Scope of Code Change Proposal for Controlled Environment Horticulture

Type of Requirement	Mandatory
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	120.6(h)2, 120.6(h)6
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	No
Modified Compliance Document(s)	NRCC-PRC-E Process Systems

Cost Effectiveness

The proposed code changes were found to be cost effective in all climate zones. California horticultural businesses would save more money on energy than they would need to spend financing the efficiency measure. As a result, this proposal would leave funds available for discretionary and investment purposes once the initial cost is paid off. The benefit-to-cost (B/C) ratio over the 30-year period of analysis ranges from 1.96-10.0. The methodology, assumptions, and results of the cost-effectiveness analysis are presented in Section 3.4.

The Statewide CASE Team estimates 111.7 GWh first-year savings from the proposed increase in horticultural lighting efficacy, indicating a revision is warranted.

Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed code changes on disproportionately impacted populations. The proposed changes are unlikely to have significant impacts on energy equity or environmental justice. Full details addressing energy equity and environmental justice can be found in Section 2 of this report.

Measures Considered but Not Proposed

The Statewide CASE Team investigated the potential for requiring controls that operate indoor lighting systems based on Photosynthetic Photon Flux Density (PPFD) and Daily Light Integral (DLI). These control systems are still in an early adoption stage and could benefit from further experience and performance validation before considering a mandatory code requirement.

The Statewide CASE Team explored options for proposing requirements for CEH HVAC and dehumidification equipment and controls but found several barriers that prevent the development of a feasible code change proposal for the 2025 code cycle.

Finally, the Statewide CASE Team received significant stakeholder feedback and engagement on the topic of greenhouse envelope, concerning the double-glazing requirement of the 2022 Energy Code for conditioned greenhouses. These comments were collected for consideration in future code cycles. There may be potential paths for alternative compliance; for more details see Section 5 of this report.

1. Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (CEC's) efforts to update California's Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The three California Investor Owned Utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities — Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) — sponsored this effort. The program goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The CEC is the state agency that has authority to adopt revisions to Title 24, Part 6. One of the ways the Statewide CASE Team participates in the CEC's code development process is by submitting code change proposals to the CEC for consideration. CEC will evaluate proposals the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. See the CECs 2025 Title 24 website for information about the rulemaking schedule and how to participate in the process (https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency).

This report presents a code change proposal for horticultural lighting efficacy. When developing the code change proposal and associated technical information, the Statewide CASE Team worked with many industry stakeholders including producers/growers, building officials, manufacturers, designers, horticultural researchers, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on October 25, 2022 (Title24Stakeholders.com; Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential) and February 9, 2023 (CASE, California Statewide Codes and Standards Enhancement Team 2023).

Section 2 – Addressing Energy Equity and Environmental Justice presents the potential impacts of proposed code changes on disproportionately impacted populations (DIPs), as well as a summary of research and engagement methods.

Section 3 addresses the horticultural lighting efficiency proposal. The following is a summary of each subsection:

- Section 3.1 – Measure Description of this Final CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 3.2 – Market Analysis includes a review of the current market structure. Section 3.2.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 3.3 – Energy Savings presents the per-unit energy, demand reduction, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 3.4 – Cost and Cost Effectiveness presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 3.5 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2025 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.

Section 4 addresses HVAC/D equipment and controls integration heat recovery, which the Statewide CASE Team considered for the 2025 code cycle, but is not proposing at this time.

Section 5 discusses feedback the Statewide CASE Team has received on the greenhouse envelope requirements that are in the 2022 code. There are no proposed code changes to the greenhouse envelope requirements at this time.

Section 6 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and <u>underlined</u> (additions) language for the Standards. Generalized proposed revisions to sections are included for the Compliance Manual and compliance forms.

Section 7 – Bibliography presents the resources that the Statewide CASE Team used when developing this report.

Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.

Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.

Appendix C: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).

Appendix D: Environmental Analysis presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.

Appendix E: Discussion of Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.

Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.

Appendix G: Energy Cost Savings in Nominal Dollars presents energy cost savings over the period of analysis in nominal dollars.

Appendix H: CEH Lighting Cost Analysis presents luminaires and lighting costs utilized for greenhouse and indoor CEH facilities.

Appendix I: Greenhouse Lighting Analysis presents an analysis using the proposed PPE of 1.9 μmol/J from the Draft CASE Report.

The California IOUs offer free energy code training, tools, and resources for those who need to understand and meet the requirements of Title 24, Part 6. The program recognizes that building codes are one of the most effective pathways to achieve energy savings and GHG reductions from buildings — and that well-informed industry professionals and consumers are key to making codes effective. With that in mind, the California IOUs provide tools and resources to help both those who enforce the code, as well as those who must follow it. Visit EnergyCodeAce.com to learn more and to access content, including a glossary of terms.

2. Addressing Energy Equity and Environmental Justice

2.1 General Equity Impacts

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in disproportionately impacted populations (DIPs) and the role this history plays in the environmental justice issues that persist today. While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017). Similar to the California Public Utilities Commission (CPUC) definition, DIPs refer to the populations throughout California that “most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease” (CPUC. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[1]

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and facing the unjust legacies of the past all serve as critical steps to achieving energy equity. Recognizing the importance of engaging DIPs and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. A participatory approach allows individuals to address problems, develop innovative ideas, and bring forth a different perspective. Please reach out to Kyle Booth (kbooth@energy-solution.com) and Marissa Lerner (mlerner@energy-solution.com) for further engagement.

Energy equity and environmental justice (EEEJ) is a newly emphasized component of the Statewide CASE Team’s work and is an evolving dialogue within California and

[1] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur in higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

beyond.[2] To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences of proposals on DIPs. The Statewide CASE Team identified potential impacts via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. As the Statewide CASE Team continues to build relationships with CBOs, these partnerships will inform and further improve the identification of potential impacts. The Statewide CASE Team is open to receiving additional peer-reviewed studies that contribute to or challenge the information on this topic presented in this report. The Statewide CASE Team is currently continuing outreach with CBOs and EEEJ partners. Results of that outreach as well as a summary of the 2025 code cycle EEEJ activities will be documented in the 2025 EEEJ Summary Report, that is expected to be published on title24stakeholders.com in the fall of 2023.

2.1.1 Procedural Equity and Stakeholder Engagement

As mentioned, representation from DIPs is crucial to considering factors and potential impacts that may otherwise be missed or misinterpreted. The Statewide CASE Team is committed to engaging with representatives from as many affected communities as possible. This code cycle, the Statewide CASE Team is focused on building relationships with CBOs and representatives of DIPs across California. To achieve this end, the Statewide CASE Team is prioritizing the following activities:

- Identification and outreach to relevant and interested CBOs
- Holding a series of working group meetings to solicit feedback from CBOs on code change proposals
- Developing a 2025 EEEJ Summary Report

In support of these efforts, the Statewide CASE Team is also working to secure funds to provide fair compensation to those who engage with the Statewide CASE Team. While the 2025 code cycle will come to an end, the Statewide CASE Team's EEEJ efforts will continue, as this is not an effort that can be "completed" in a single or even multiple code cycles. In future code cycles, the Statewide CASE Team is committed to furthering relationships with CBOs and inviting feedback on proposed code changes with a goal of

[2] The CEC defines energy equity as "the quality of being fair or just in the availability and distribution of energy programs" (CEC 2018). American Council for an Energy-Efficient Economy (ACEEE) defines energy equity as that which "aims to ensure that disadvantaged communities have equal access to clean energy and are not disproportionately affected by pollution. It requires the fair and just distribution of benefits in the energy system through intentional design of systems, technology, procedures and policies" (ACEEE n.d.). Title 7, Planning and Land Use, of the California Government Code defines environmental justice as "the fair treatment and meaningful involvement of people of all races, cultures, incomes, and national origins, with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies" (State of California n.d.).

engagement with these organizations representing DIPs throughout the code cycle. Several strategies for future code cycles are being considered, including:

- Creating an advisory board of trusted CBOs that may provide consistent feedback on code change proposals throughout the development process
- Establishing a robust compensation structure that enables participation from CBOs and DIPs in the Statewide CASE Team's code development process
- Holding equity-focused stakeholder meetings to solicit feedback on code change proposals that seem more likely to have strong potential impacts

2.1.2 Potential Impacts on DIPs in Nonresidential Buildings

To assess potential inequity of proposals for nonresidential buildings the Statewide CASE Team considered which building types are used by DIPs most frequently and evaluated the allocation of impacts related to the following areas among all populations.

- **Cost:** People historically impacted by poverty and other historic systems of wealth distribution can be affected more severely by the incremental first cost of proposed code changes. Costs can also create an economic burden for DIPs that does not similarly affect other populations. See Section 3.4 for an estimate of energy cost savings from the current proposals.
- **Health:** Any potential health burdens from proposals could more severely affect DIPs that can have limited access to healthcare and reside in areas affected by environmental and other health burdens. Several of the potential negative health impacts from buildings on DIPs are addressed by energy efficiency (Norton 2014 Cluett 2015 Rose 2020). For example, indoor air quality (IAQ) improvements through ventilation or removal of combustion appliances can lessen the incidents of asthma, chronic obstructive pulmonary disease (COPD), and some heart problems. Black and Latinx people are 56 percent and 63 percent more likely to be exposed to dangerous air pollution than white people, respectively (Tessum, et al 2019). Water heating and building shell improvements can reduce stress levels associated with energy bills by lowering utility bill costs. Electrification can reduce the health consequences resulting from NOx, SO_2, and $PM_{2.5}$.
- **Resiliency:** DIPs are more vulnerable to the negative consequences of natural disasters, extreme temperatures, and weather events due to climate change. Black Americans are 40 percent more likely to currently live in areas with the highest projected increases in extreme heat related mortality rates, compared to other groups (EPA 2021). Similarly, natural disasters affect DIPs differently. Race and wealth affect the ability to evacuate for a natural disaster, as evidenced during Hurricane Harvey wherein White and wealthy residents were overrepresented by 19.8 percent among evacuees (Deng, et al 2021). Proposals that improve buildings' resiliency to natural disasters and extreme weather could

positively impact DIPs. For example, buildings with more insulation and tighter envelopes can reduce the health impacts of infiltration of poor quality air, reduce risk of moisture damage and related health impacts (mildew and mold), and help maintain thermal comfort during extreme weather events.

- **Comfort:** Thermal comfort and proper lighting are important considerations for any building where people work, though impacts are not proportional across all populations. Thermal comfort can also have serious health effects as heat related illness is on the rise in California. DIPs are at a greater risk for heat illness due in part to socioeconomic factors. From 2005 to 2015 the number of emergency room visits for heat related illness in California rose 67 percent for Black people, 53 percent for Asian-Americans, and 63 percent for Latinx people (Abualsaud, Ostrovskiy Mahfoud 2019). Studies have shown that not only do the effects of urban heat islands lead to higher mortality during heat waves, but those in large buildings are disproportionately affected (Smargiassi 2008 Laaidi 2012). These residents tend to be the elderly, people of color, and low-income households (Drehobl 2020 Blankenship 2020 IEA 2014). Comfort is not only a nice quality to have in workplaces, schools, etc., but it also has real world health impacts on people's health.

2.2 Specific Impacts of the Proposal

Recognizing the importance of engaging DIPs and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement with stakeholders and gather feedback on the proposed measures. The Statewide CASE Team is seeking input from CBOs, agricultural partners, and potentially other EEEJ stakeholders and will include these findings in the 2025 EEEJ Summary Report. Some of the EEEJ considerations are discussed below.

The Statewide CASE Team is considering how the proposed code changes might impact the health and safety of people who work inside Controlled Environment Horticulture (CEH) facilities including members of DIPs. The California Department of Industrial Relations Division of Occupational Health and Safety (Cal/OSHA) maintains regulations to protect occupational health and safety in all settings including in the cannabis industry. Some hazards that may exist in the cannabis industry and CEH facilities in general include, but are not limited to hazardous indoor air quality, exposure to harmful and/or flammable materials, electrical hazards, and heat illness (California Department of Industrial Relations n.d.). The proposed code changes would not adversely impact occupational health or safety or the ability for CEH facilities to comply with Cal/OSHA requirements.

Another consideration is related to how tax revenue from the cannabis industry benefits DIPs. Historic federal and state drug policies, commonly referred to as the War on Drugs, led to the passage of penalties giving the courts the right to imprison individuals for nonviolent drug offenses and increased the number of primarily Black inmates (St. Mary's College of Maryland 2015). In November 2016 California voters approved Proposition 64 (The Adult Use of Marijuana Act), which allowed people over the age of 21 to possess and use marijuana for recreational purposes. The proposition also created new taxes on the cannabis industry and specified how the new tax revenue be used including directing the Governor’s Office of Business and Economic Development (GO-Biz) to administer the California Community Reinvestment Grants (CalCRG) program. The CalCGR program awards grants to local health departments and qualifying CBOs that offer specific services to DIPs that are “disproportionately affected by past federal and state drug policies.” Grants support activities such as job placement, mental health treatment, substance use disorder treatment, and linkages to medical care (California Governor's Office of Business and Economic Development n.d.). The proposition also directed a portion of tax revenue to support youth programs including drug education, prevention, and treatment. The Youth Community Access Grant Program, for example, applies 60 percent of tax revenue generated by legal recreational cannabis sales to support cultural and natural resources for DIPs (California Natural Resouces Agency 2023). The Statewide CASE Team is investigating whether the proposed code change could affect tax revenue from the cannabis industry and if so whether there would be impacts on the availability of funding to support populations that were disproportionately impacted by historic and federal state drug policies including people of color.

3. Horticultural Lighting Efficacy

3.1 Measure Description

3.1.1 Proposed Code Change

Currently luminaires or lamps used for plant growth in facilities with more than 40 kW of horticultural lighting load must meet differing requirements depending on facility type. The code distinguishes requirements for indoor grow facilities from those for greenhouses (which have access to daylight).

For indoor growing facilities luminaires or lamps must have a photosynthetic photon efficacy (PPE) of at least 1.9 micromoles per joule (µmol/J). For plant growth in greenhouses they must have a PPE of at least 1.7 µmol/J. Both these requirements can be met by using double-ended high-pressure sodium (HPS) technology, a legacy product that has been in the Controlled Environment Horticulture (CEH) market for over a decade. For the 2025 cycle, the Statewide CASE Team analyzed the potential for increasing the minimum PPE levels for luminaires and lamps used to grow plants in both facility types to an efficacy of at least 2.3 µmol/J. This change would require the use of LEDs, as high pressure sodium (HPS) and ceramic metal halides would not be able to meet this PPE.

The Statewide CASE Team also investigated the potential for requiring controls that operate indoor lighting systems based on Photosynthetic Photon Flux Density (PPFD) and Daily Light Integral (DLI). The Team determined that these control systems are still in an early adoption stage and could benefit from further experience and performance validation, which could be achieved through inclusion in an emerging technology program. The Statewide CASE Team is interested in revisiting the potential for this technology for the 2028 code cycle.

This proposal would modify the following sections of the California Energy Code as shown below. See Section 6: Proposed Revisions to Code Language of this report for marked-up code language.

- **Section 120.6(h)2 – Indoor Growing, Horticultural Lighting:** The purpose of this change is to increase the minimum efficacy of indoor horticultural lighting to 2.3 Micromoles per Joule from 1.9 Micromoles per Joule.
- **Section 120.6(h)6 – Greenhouses, Horticultural Lighting:** The purpose of this change is to increase the minimum efficacy of greenhouse horticultural lighting to 2.3 Micromoles per Joule from 1.7 Micromoles per Joule.

- **Additions and Alterations:** Additions and alterations would refer to the new proposed minimum requirements for CEH Lighting Efficacy and would maintain the 10 percent alterations trigger.
- **Updates to Compliance Software:** There would be no updates to compliance software from the proposed code change.
- **Acceptance Tests:** There would be no updates to acceptance tests from the proposed code change.

3.1.2 Justification and Background Information

3.1.2.1 Justification

The CEH horticultural lighting minimum efficacy requirement was introduced to the 2022 California Energy Code as a Covered Process. The measure was initially proposed as a minimum PPE of 2.1 µMol/J for indoor CEH facilities, but stakeholders provided feedback that led to reducing that minimum to 1.9 µMol/J PPE. The measure still provided a first-year electricity savings of 293.9 GWh, making it one of the largest energy saving measures of the 2022 code cycle.

Since that time, the horticultural lighting industry has made significant progress and adoption of LED horticultural lighting has increased. Now there is significant energy savings potential from increasing the minimum required efficacy: the Statewide CASE Team estimates 111.7 GWh first-year savings from this proposal.

3.1.2.2 Background Information

CEH, which includes both greenhouses and indoor growing spaces, is a rapidly growing industry in California. In 2022, the Statewide CASE Team explored numerous CEH-specific Title 24, Part 6 requirements for the first time. The CEC adopted measures to boost the efficacy of lighting used to grow plants, to increase the efficiency of dehumidification systems, and to improve the building envelope for conditioned greenhouses.

To build upon these improvements, the Statewide CASE Team proposes modifying CEH lighting minimum efficacy requirements for the 2025 Title 24, Part 6 cycle. The proposed measures aim to save energy while maintaining crop quality and yield in both greenhouses and indoor grow facilities. The proposed measures may differ between facility types, but the stringency of the measures would not depend on what crop is being grown.

During the previous code cycle, several stakeholders mentioned the wide variation of growing requirements across different crops. The Statewide CASE Team determined that there is no need to differentiate luminaire efficacy requirements per crop type, as there exists a wide range of product lighting intensities with PPE rating at or above the proposed code change values. Thus, including lighting efficacy requirements in the Energy Code would not present a disadvantage to specific crop types.

3.1.2.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance forms would be modified by the proposed change.[3] See Section 6 of this report for detailed proposed revisions to code language.

3.1.2.4 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, and Part 6 as well as the reference appendices to Part 6 are described below. See Section 6.2 of this report for marked-up code language.

Section: **120.6(h)2A**

Specific Purpose: The proposed modification to this section increases the minimum required PPE of indoor CEH lighting to 2.3 micromoles per Joule.

Necessity: The adjustment is necessary to increase energy efficiency via cost-effective building design standards, as mandated by California Public Resource Code, Sections 25213[4] and 25402[5]. If the energy code requirements for photosynthetic photon efficacy of horticultural lighting are not updated to keep pace with currently available products, it would allow a high energy use intensity industry to utilize technologies that use 18 percent more energy than necessary and would misalign with the state's greenhouse gas emission reduction goals.

Section: 120.6(h)6A

Specific Purpose: The proposed modification to this section increases the minimum required PPE of greenhouse CEH lighting to 2.3 micromoles per Joule.

Necessity: The addition is necessary to increase energy efficiency via cost-effective building design standards, as mandated by California Public Resource Code, Sections 25213 and 25402. If the proposed code change did not move forward, it would allow a high energy use intensity industry to utilize technologies that use 11 percent more energy than necessary and would misalign with the state's greenhouse gas emission reduction goals.

[3] Visit EnergyCodeAce.com for trainings, tools and resources designed to help people understand existing code requirements.

[4] https://codes.findlaw.com/ca/public-resources-code/prc-sect-25213/

[5] https://codes.findlaw.com/ca/public-resources-code/prc-sect-25402/

3.1.2.5 Specific Purpose and Necessity of Changes to the Nonresidential ACM Reference Manual

The proposed code change would not modify the ACM Reference Manual.

3.1.2.6 Summary of Changes to the Nonresidential Compliance Manual

The proposed code change would modify Chapter 10 Covered Processes of the Nonresidential Compliance Manual in the CEH facilities section.

3.1.2.7 Summary of Changes to Compliance Forms

The proposed code change would modify the sections of the Nonresidential Compliance Manual below by requiring new PPE thresholds for compliance verification. Examples of the revised forms are presented in Section 6.5.

- NRCC-PRC-E Process Systems
- NRCI-PRC-E Process Systems

3.1.3 Regulatory Context

3.1.3.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

The proposed code change would modify Section 120.6 of the 2022 California Energy Code by increasing the minimum efficacy requirements for CEH lighting in indoor and greenhouse facilities. There are no relevant requirements to the proposed measure on horticultural lighting in other parts of the California Building Code.

The City of Palm Springs is proposing a reach code for CEH lighting that would align with the 2025 proposed code change minimum PPE of 2.3 for indoor CEH lighting. The proposed code change will likely move forward in 2023, resulting in early adoption of the 2025 proposed CEH lighting code change by the City of Palm Springs.

3.1.3.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations related to CEH lighting in indoor and greenhouse facilities.

3.1.3.3 Difference From Existing Model Codes and Industry Standards

There are three relevant industry standards for horticultural lighting efficacy.

The DesignLights Consortium (DLC) published version 3.0 of its technical requirements for horticultural lighting in November 2022. The manual specifies performance requirements, warranty, thermal properties, and output maintenance properties required for listing horticultural lighting products with the DLC. DLC also maintains a qualified product list (QPL) for high-efficiency LED horticultural lighting products. These qualified products requirements form the basis of a voluntary specification that is used in state and utility energy efficiency incentive programs. Lighting devices must have a PPE at or above 2.3 µMol/J to qualify for QPL (Design Light Consortium n.d.). The proposed update for Title 24, part 6, does not require listing in the DLC qualified product database.

Additionally, 2021 International Energy Conservation Code (IECC) adopted code to require at least 95 percent of permanently installed luminaires for plant growth and maintenance to have a PPE of at least 1.6 µMol/J (IECC 2019). The horticultural lighting code language can be found in Section C405.5 of the code.[6]

The ANSI/ASHRAE/IES Standard 90.1-2019 Addendum AR was developed using 2022 California Energy Code as a reference.[7] The addendum requires the same efficacy ratings as the 2022 California Energy Code for horticultural lighting.

3.1.4 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and reduce negative impacts on those involved in the process. This section describes how to comply with the proposed code change and the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The compliance verification activities related to this measure that need to occur during each phase of the project are described below:

- **Design Phase:** An owner, developer, architect, and other team members involved in the design of a CEH facility familiarize themselves with new code requirements and design the facility to meet the requirements. Architectural and basic mechanical systems currently go through plan review, so updating this process to account for new requirements would not be a profound change.
- **Permit Application Phase:** The permit applicant completes a certificate of compliance document and ensures building plans are consistent with the information in the certificate of compliance. A horticulture facility designer or general contractor usually fulfills the role of permit applicant. Plans examiners at an enforcement agency familiarize themselves with new code requirements to determine compliance.
- **Construction Phase:** Field changes resulting in noncompliance require an approval of the revised certificate of compliance document. As needed, the

[6] https://codes.iccsafe.org/content/IECC2021P1/chapter-4-ce-commercial-energy-efficiency#IECC2021P1_CE_Ch04_SecC405

[7] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_ar_20220909.pdf

permit applicant coordinates approval of field changes with the plans examiner at the enforcement agency.

- **Inspection Phase:** An appropriate responsible party completes the certificate of installation document and submits the document to the enforcement agency. A general contractor normally submits the certificate of installation document. Enforcement agency field inspector reviews the certificate of installation and certificate of acceptance documents. The enforcement agency field inspector may conduct a visual inspection of the project upon project completion.

The proposed code change would result in minimal change to existing compliance processes. There should be no significant increased burdens on building officials.

P. CONTROLLED ENVIRONMENT HORTICULTURE

This table documents compliance with mandatory controlled environment horticulture requirements of §120.6(h).

Space Conditioning for Plant Production §120.6(h)1 and 5

01	02	03
System Name/ Description	Dehumidification System for Indoor Grow CEH Compliance Method §120.6(h)1	HVAC System Compliance Method §120.6(h)5

Lighting and Electrical Systems §120.6(h)2, 3 and 6

01	02	03	04	05	06
System Name/ Description	Indoor or Greenhouse Space	Photosynthetic Photon Efficacy (PPE) §120.6(h)2A & 6A	Lighting Controls §120.6(h)2B&C and 6B&C		Electrical System Monitoring Capability §120.6(h)3
			Timeswitch	Multilevel	

Opaque and Non-Opaque Envelopes

This table documents mandatory requirements for envelope assemblies in conditioned greenhouses. Envelope assemblies in Indoor Grow Facilities should be documented on the NRCC-ENV for prescriptive compliance or NRCC-PRF for performance compliance.

01	02	03	04
Tag/Plan Detail ID	Assembly Type	Non-Opaque Envelope Compliance Method §120.6(h)4B	Opaque Envelope Compliance Method §120.6(h)4A

CA Building Energy Efficiency Standards - 2022 Nonresidential Compliance January 2022

Figure 1: 2022 CEH compliance form excerpt

3.2 Market Analysis

3.2.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information about the incremental cost of complying with the proposed measure was gathered. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors, including:

- CEH lighting manufacturers

- CEH lighting distributors
- Online horticultural equipment dealers
- Horticultural equipment dealers with branches in California
- CEH facility design/engineering firms
- CEH facility construction contractors

Key stakeholders include 2022 CEH code cycle stakeholders who provided public comment, lighting manufacturers, dehumidification manufacturers, greenhouse manufacturers, facility designers, and growers.

3.2.1.1 Stakeholder Communications and Survey

In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meetings it held on October 25, 2022 (CASE, California Statewide Utiltiy Codes and Standards Enhancement Team 2022) and February 9, 2023 (CASE, California Statewide Codes and Standards Enhancement Team 2023).

The Statewide CASE Team also presented on November 2, 2022, at the Resilient Harvests industry conference in Long Beach, California. This event brought approximately 200 CEH industry stakeholders together for two days, with field visits on the third day to Glass House Farms and Local Bounti. The conference provided an opportunity for early socialization of the 2025 proposed code change with key CEH industry stakeholders as well as time for in-person discussions to obtain feedback on the proposed code change.

The Statewide CASE Team conducted 30-minute CEH lighting phone interviews with the aim of creating a representative summary of market conditions in California. This survey was designed to reach manufacturers, distributors, installers, and designers through multiple sales channels, and to capture diverse and specialized perspectives. The interviews consisted of the following questions:

- Describe your sales process for horticultural lighting.
- What percent of sales are cannabis vs non-cannabis?
- Do you stock horticultural lighting or is it ordered when purchased?
- What percentage of lighting sales are HID vs LED?
- Have you seen any significant price changes in either technology?
- Have you seen or read any updated research on performance of LEDs vs HID?
- Do you notice any purchasing differences between greenhouse facilities and indoor facilities?
- Do you see any issues for greenhouse facilities if Ceramic Metal Halide (CMH) lighting is no longer qualifying?

- What percent of sales are new construction vs retrofit?
- Are incentives being utilized to help sell LEDs?

The following sections summarize key findings from ten phone surveys conducted between December 2022 and March 2023.

Percent Lighting Type

Most respondents reported that the majority of their CEH lighting sales were LED products. Of the ten respondents, six have either discontinued all other lighting technology types or have only sold LEDs since their company's inception. Two others reported that their LED sales percentage is far greater than HID or other lighting options. Two respondents claimed 20 to 40 percent of their sales are still HID; one of these noted the primary source was coming from greenhouses and cold climate zones where the added heat is important. Five respondents observed a significant increase in LED sales within the last one to four years.

Current Lighting, a horticultural lighting manufacturer that sells through Hort Americas national distribution, provided an overall industry estimate with LEDs being 30 to 50 percent of horticultural lighting sales.

Summary of Cost Info and Trends

All respondents stated the price per watt of LED lighting has fallen every year. A few respondents noted the overall cost of LED luminaires, however, has been increasing slightly over the past two years due to material costs and shipping issues concurrent with COVID19 and other impacts on the industry. One respondent shared, "every year the rule of thumb is either a 10 percent increase in performance for the same price or a 10 percent decrease in price for the LED diodes, and that has been pretty consistent. It is starting to level off now though." Respondents were not well versed in HID cost trends, other than companies lowering the prices to reduce older inventory and move more toward LEDs. Section 3.4.3 provides cost analysis details that show a cost reduction per watt of 16 percent from 2020 to 2023.

Purchasing Habit Differences between Greenhouse and Indoor

A general response, consistent among all respondents, was that indoor lighting requires lighting with greater intensity to provide the sole source of lighting than the intensity needed to provide supplemental lighting in greenhouses. One respondent noted that they generally see ~1,000 micromoles/sec×m2 for indoor CEH facilities and ~500 micromoles/ sec×m2 for greenhouses. Two respondents noted a preference of purchasing full spectrum lights for indoor customers, while greenhouses have more freedom with spectrum and other lighting variables due to sunlight accessibility. Greenhouse customers may choose to use "targeted" spectrum lights which produce only the wavelengths of light most beneficial for plant growth. Targeted spectrum LED light limits the amount of yellow and green light a fixture emits and focuses on the blue part of the spectrum to support vegetative stage and red spectrum for the flowering cycle. The form factor of the luminaire and use of lighting differed between indoor facilities and greenhouses as well. Indoor operations can be single level but since they are usually multi-tiered consisting of racks with multiple levels of plants growing, much of the lighting purchased for indoor operations is designed for multi-level systems. The form factor is more important for greenhouse lighting, as lighting manufacturers try to minimize sunlight shading by using a slim luminaire design.

Stocking Practices

Consistent throughout the ten responses is that there is little to no stocking of CEH lighting products. Due to the custom nature of the industry, almost all products are made-to-order for respondents. Respondents who do stock products carry limited volumes.

Use of Incentives for LEDs

All respondents noted they assist their customers with rebate processes for LED sales. The methods by which they do this include:

- Providing the customer with resources to find LED incentives.
- Observing that the lighting dealer uses the incentive to discount the upfront cost of the lighting.
- Providing resources like a rebate tracker, a member of the team who is a utility relations manager, or a contractor to handle the rebates for the customer.
- Using brokers who take a percentage of the secured incentive.

One respondent mentioned incentives found in California's Market Access Program centered around measured savings, where the incentive program administrator measures power usage over the past 12 months, and then, would provide incentives over the following 12 months based on how much energy is saved. This method can be complex to administer, but it provides accurate savings over time.

Cannabis versus Non-Cannabis Sales

All ten respondents reported there is no clear difference between cannabis and non-cannabis customers in horticultural LED market adoption rate.

The percentage of lighting sales for cannabis growth varied among respondents, with considerations such as sales channels and market trends driving these trends. Seven respondents reported most of their sales (between 70-95 percent) are for cannabis operations. Two respondents reported a 50/50 split between cannabis and non-cannabis horticultural LED sales. One respondent reported significantly more non-cannabis horticultural lighting due to their distributor being more focused on non-cannabis products.

Responses on purchasing differences between cannabis and non-cannabis varied greatly. Respondents all agreed that purchasing for cannabis horticultural lighting has a much higher focus on light intensity, a result of crop requirements and growers pursuing high yields and quality through high light intensity.

New Construction versus Retrofit Sales

Respondents reported varied percentages, but seven of the ten noted more than 70 percent of their sales support new construction and major existing building alteration projects such as repurposing an industrial facility as an indoor CEH facility. Three respondents varied between a 50/50 split and primarily retrofit (relighting) projects. All reported LED is the technology of choice for lighting retrofits.

Some respondents noted cannabis sales typically support new construction and large existing building alteration projects and are smaller in scale compared to non-cannabis.

Barriers Summary

Cost and education were the two barriers mentioned by all respondents for LED horticultural lighting adoption, with upfront cost being the primary barrier. One respondent noted LED costs can be up to four times the amount of HID lighting. Based on the Statewide CASE Team's lighting cost research, first equipment cost can be up to four times as expensive, but that does not factor in the reduction in maintenance costs due to eliminating HPS lamp replacements.

Additionally, many cannabis growers may benefit from access to information on the crop quality and performance of horticultural LEDs as well as the operational cost benefits of LED lighting. Many respondents reported that some growers have perfected their craft with a specific type of lighting and are unsure if LEDs would allow them to continue producing their quality crop. Notably, non-cannabis crops do not have the same level of concern on horticultural LED performance as the cannabis industry.

Utility incentives can assist with overcoming these barriers by covering a significant portion of the incremental equipment cost. Incentives have been used to resolve the first cost of purchasing LEDs and were indicated as the most important resolution to the cost barrier. Adoption also requires continued access to resources and training to understand that upgrading to LEDs is not a simple 1:1 replacement; it requires changes to operational variables such as air temperature and watering rates to produce a high-quality crop. ICF currently implements the statewide Agricultural Energy Efficiency Program that includes incentives for horticultural lighting.[8]

[8] https://caagenergy.com/incentives

3.2.2 Technical Feasibility and Market Availability

In CEH facilities, electric lighting provides plants with the amount and intensity of illumination needed for photosynthesis at each stage of plant development. It is the primary source of energy that plants need for growth.

The most accepted metric for horticultural lighting efficacy is photosynthetic photon efficacy (PPE). This has been discussed and confirmed with several horticultural lighting industry experts, including Ian Ashdown of Suntracker Technologies, the California Lighting Technology Center (CLTC), DesignLights Consortium (DLC), and several horticultural lighting manufacturers. A luminaire or lamp PPE is derived by dividing photosynthetic photon flux by input electric power, measured in micromoles per Joule (μmol/J). The DLC currently employs PPE to qualify products for their horticultural qualified products list. Some industry stakeholders have indicated other metrics to include in efficacy such as ultraviolet and far-red wavelengths, and these may factor into future efficacy calculations. At the time of publication, DLC had seen no manufacturers report optional performance metrics for wider wavelength ranges. Table 2 provides typical efficacy ranges for the common horticultural lighting technology types.

Table 2: Efficacy of Horticultural Lighting Technologies

Technology	Average PPE (micromoles per joule)	Meets proposed minimum PPE greenhouse	Meets proposed minimum PPE indoor
Single-ended 400-W HPS lamp with magnetic ballast	0.9	No	No
Double-ended 1,000-W HPS lamp with electronic ballast[a]	1.7–1.9	No	No
Single-ended HPS[a]	1.0	No	No
Metal halide luminaire[b]	0.8	No	No
Ceramic metal halide luminaire[a]	1.5	No	No
Fluorescent lighting luminaire[a]	0.84–0.95	No	No
LED lighting luminaire[c]	1.9–3.6	Yes	Yes

Sources:

a. (Navigant 2017);
b. (Radetsky 2018);
c. (Radetsky 2018) and (DesignLights Consortium 2019)

3.2.3 Market Impacts and Economic Assessments

3.2.3.1 Impact on Builders

Builders of CEH structures are directly impacted by many of the non-residential measures proposed by the Statewide CASE Team for the 2025 code cycle. These businesses normally adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training to remain compliant with changes to design practices and building codes. The proposed code change in this report would alter the practices of designers and builders, as compliance would involve using LED horticultural lighting instead of HID lighting. Some designers and builders are already familiar with this technology, but others may have to adjust practices if the proposed requirements are adopted.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 3). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction roles (the industrial sector).

Table 3: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establishments	Employment	Annual Payroll (Billions $)
Residential	**All**	**71,889**	**472,974**	**31.2**
Residential	Building Construction Contractors	27,948	130,580	9.8
Residential	Foundation, Structure, & Building Exterior	7,891	83,575	5.0
Residential	Building Equipment Contractors	18,108	125,559	8.5
Residential	Building Finishing Contractors	17,942	133,260	8.0
Commercial	**All**	**17,621**	**368,810**	**35.0**
Commercial	Building Construction Contractors	4,919	83,028	9.0
Commercial	Foundation, Structure, & Building Exterior	2,194	59,110	5.0
Commercial	Building Equipment Contractors	6,039	139,442	13.5
Commercial	Building Finishing Contractors	4,469	87,230	7.4
Industrial, Utilities, Infrastructure, & Other (Industrial+)	**All**	**4,206**	**101,002**	**11.4**
Industrial+	Building Construction	288	3,995	0.4
Industrial+	Utility System Construction	1,761	50,126	5.5
Industrial+	Land Subdivision	907	6,550	1.0
Industrial+	Highway, Street, and Bridge Construction	799	28,726	3.1
Industrial+	Other Heavy Construction	451	11,605	1.4

Source: (State of California n.d.)

The proposed change to CEH Covered Processes would likely affect commercial builders, specifically firms that focus on construction and retrofit of industrial buildings for CEH processes. The effects on the commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 4 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. While CEH facilities typically employ the same types of market actors as commercial construction projects, such as HVAC contractors, equipment distributors, and architects, the individuals involved in constructing CEH facilities typically specialize in this industry. Additionally, indoor grow facilities and greenhouses are considered industrial facilities since a manufacturing process is occurring. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.2.4 Economic Impacts.

Table 4: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2022 (Estimated)

Construction Subsector	Establishments	Employment	Annual Payroll (Billions $)
Commercial Building Construction	4,919	83,028	9.0
Nonresidential Electrical Contractors	3,137	74,277	7.0
Nonresidential plumbing & HVAC contractors	2,346	55,572	5.5
Other Nonresidential equipment contractors	556	9,594	1.0
Other Nonresidential finishing contractors	491	6,549	0.4
Nonresidential site preparation contractors	1,159	18,322	1.6
All other Nonresidential trade contractors	940	18,027	1.6

Source: (State of California n.d.)

3.2.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training to remain compliant with changes to design practices and building codes. This proposal requires minimal paperwork to document compliance as it is a mandatory code change with no measurable monitoring needed.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 5 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the horticultural lighting minimum efficacy proposal to affect firms that focus on nonresidential and industrial construction.

There is no North American Industry Classification System (NAICS)[9] code specific to energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[10] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 5 provides an upper bound indication of the size of this sector in California.

Table 5: California Building Designer and Energy Consultant Sectors in 2022 (Estimated)

Sector	Establishments	Employment	Annual Payroll (Millions $)
Architectural Services [a]	4,134	31,478	3,623.3
Building Inspection Services [b]	1,035	3,567	280.7

Source: (State of California n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings, and structures.

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services

3.2.3.3 Impact on Occupational Safety and Health

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

[9] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[10] Establishments in this sector include businesses primarily engaged in evaluating a building’s structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.2.3.4 Impact on Building Owners and Occupants

Commercial Buildings

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, and mixed-use establishments, and warehouses (including refrigerated) (Kenney 2019). Energy use by occupants of commercial buildings also varies considerably, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating. According to information published in the 2019 California Energy Efficiency Action Plan, there is more than 7.5 billion square feet of commercial floor space in California consuming 19 percent of California's total annual energy use (Kenney 2019). The diversity of building and business types within this sector creates a challenge for disseminating information on energy and water efficiency solutions, as does the variability in sophistication of building owners and the relationships between building owners and occupants.

Estimating Impacts

Building owners and occupants would benefit from lower energy bills. As discussed in Section 3.2.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

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

The Statewide CASE Team's proposed change is not expected to result in economic disruption to any sector of the California economy. The proposed standards represent changes to CEH which would not excessively burden or competitively disadvantage California businesses — nor would it necessarily lead to a competitive advantage for California businesses. The Statewide CASE Team does not foresee any new businesses being created, nor that any existing businesses would be eliminated due to the proposed code changes to the California Energy Code.

3.2.3.6 Impact on Building Inspectors

Table 6 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 6: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Govt.	Establishments	Employment	Annual Payroll (Million $)
Administration of Housing Programs[a]	State	18	265	29.0
	Local	38	3,060	248.6
Urban and Rural Development Admin[b]	State	38	764	71.3
	Local	52	2,481	211.5

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.2.3.7 Impact on Statewide Employment

As described in Sections 3.2.3.1 through 3.2.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.2.4, the Statewide CASE Team estimated the proposed change in horticultural lighting minimum efficacy would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in horticultural lighting minimum efficacy would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software,[11] along with economic information from published sources, and professional judgement to develop estimates of the economic impacts associated with each of the proposed code changes. Conceptually, IMPLAN estimates jobs created as a function of incoming cash flow in different sectors of the economy, due to implementing a code or a standard. The jobs created are typically categorized into direct, indirect, and induced

[11] IMPLAN employs economic data and advanced economic impact modeling to estimate economic impacts for interventions like changes to the California Title 24, Part 6 code. For more information on the IMPLAN modeling process, see www.IMPLAN.com.

employment. For example, cash flow into a manufacturing plant captures direct employment (jobs created in the manufacturing plant), indirect employment (jobs created in the sectors that provide raw materials to the manufacturing plant) and induced employment (jobs created in the larger economy due to purchasing habits of people newly employed in the manufacturing plant). Eventually, IMPLAN computes the total number of jobs created due to a code. The assumptions of IMPLAN include constant returns to scale, fixed input structure, industry homogeneity, no supply constraints, fixed technology, and constant byproduct coefficients. The model is also static in nature and is a simplification of how jobs are created in the macro-economy.

The economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. The IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that the direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspects of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the economic impacts presented below represent lower bound estimates of the actual benefits associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by industrial contractors, architects, energy consultants, and building inspectors. The Statewide CASE Team does not anticipate that money saved by businesses or other organizations affected by the proposed 2025 code cycle regulations would result in additional spending by those businesses.

Table 7: Estimated Impact that Adoption of the Proposed Measure would have on the California Commercial Construction Sector – Indoor CEH New Construction

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	46.1	$3.58	$4.14	$7.01
Indirect Effect (Additional spending by firms supporting Commercial Builders)	11.3	$0.98	$1.53	$2.82
Induced Effect (Spending by employees of firms experiencing “direct” or “indirect” effects)	19.2	$1.31	$2.34	$3.73
Total Economic Impacts	**76.3**	**$5.87**	**$8.01**	**$13.60**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. [12]

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

Table 8: Estimated Impact that Adoption of the Proposed Measure would have on the California Commercial Construction Sector – Indoor CEH Repair & Maintenance

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	8.4	$0.67	1.01	$2.18
Indirect Effect (Additional spending by firms supporting Commercial Builders)	4.9	$0.39	$0.67	$1.17
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	4.5	$0.30	$0.54	$0.87
Total Economic Impacts	**17.8**	**$1.36**	**$2.22**	**$4.22**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. [16]

Table 9: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultants Sectors – Indoor CEH Lighting

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Designers & Energy Consultants)	0.05	$5,339	$5,286	$8,355
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.02	$1,590	$2,210	$3,557
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.03	$1,993	$3,568	$5,679
Total Economic Impacts	**0.10**	**$8,922**	**$11,064**	**$17,591**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. [16]

Table 10: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors – Indoor CEH Lighting

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Inspectors)	0.0	$2,694	$3,194	$3,882
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.0	$249	$389	$677
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.0	$847	$1,518	$2,416
Total Economic Impacts	**0.0**	**$3,791**	**$5,101**	**$6,974**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. [16]

Table 11: Estimated Impact that Adoption of the Proposed Measure would have on the California Commercial Construction Sector – Greenhouse CEH New Construction

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	40.9	$3.18	$3.67	$6.25
Indirect Effect (Additional spending by firms supporting Commercial Builders)	10.0	$0.87	$1.36	$2.50
Induced Effect (Spending by employees of firms experiencing “direct” or “indirect” effects)	17.0	$1.16	$2.08	$3.31
Total Economic Impacts	**67.9**	**$5.20**	**$7.11**	**$12.06**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. 16

Table 12: Estimated Impact that Adoption of the Proposed Measure would have on the California Commercial Construction Sector – Greenhouse CEH Repair and Maintenance

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	18.8	$1.50	$2.25	$4.87
Indirect Effect (Additional spending by firms supporting Commercial Builders)	11.0	$0.86	$1.48	$2.60
Induced Effect (Spending by employees of firms experiencing “direct” or “indirect” effects)	9.9	$0.68	$1.21	$1.93
Total Economic Impacts	**39.7**	**$3.04**	**$4.95**	**$9.40**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. 16

Table 13: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultants Sectors – Greenhouse CEH Lighting

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Designers & Energy Consultants)	0.1	$16,018	$15,858	$25,065
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.1	$4,770	$6,629	$10,671
Induced Effect (Spending by employees of firms experiencing “direct” or “indirect” effects)	0.1	$5,978	$10,704	$17,038
Total Economic Impacts	**0.3**	**$26,765**	**$33,191**	**$52,774**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. 16

Table 14: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors – Greenhouse CEH Lighting

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Inspectors)	0.1	$8,081	$9,583	$11,646
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.0	$748	$1,166	$2,030
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.0	$2,542	$4,553	$7,247
Total Economic Impacts	**0.1**	**$11,372**	**$15,302**	**$20,923**

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. 16

3.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation 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, the estimates of economic impacts discussed in Section 3.2.4 would lead to modest changes in employment of existing jobs.

3.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.2.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to horticultural lighting sales product types in California, which would not excessively burden or competitively disadvantage California businesses—nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

3.2.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state.[13] Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of

[13] 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.

California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

3.2.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[14] As Table 15 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 35 percent in 2019, with an average of 26 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

Table 15: 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)
2017	518.473	1882.460	28
2018	636.846	1977.478	32
2019	690.865	1952.432	35
2020	343.620	1908.433	18
2021	506.331	2619.977	19
5-Year Average	**-**	**-**	**26**

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

The Statewide CASE Team estimates that the sum of proposed code changes in this report would increase investment in California:

- Indoor CEH lighting: Change in Proprietor Income * 0.26 = $403,891
- Greenhouse CEH lighting: Change in Proprietor Income * 0.26 = $456,845.

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team can derive 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

[14] 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.

proprietor income. The Statewide CASE Team used this information to conservatively estimate corporate profits, a portion of which is assumed to be allocated to net business investment.[15]

3.2.4.5 Incentives for Innovation in Products, Materials, or Processes

Based on conversations with the horticultural lighting supply chain in California, the horticultural lighting industry has significantly increased the percentage of horticultural LED luminaire sales over the past three years. This has driven cost down significantly, with an approximate 20 percent reduction in the cost of LED luminaires from the 2022 Energy Code (Califonia Energy Commission 2022). The number of products available on the market has expanded significantly, with DLC's horticultural lighting qualified products list going from ~200 models to over 850 models since the 2022 Energy Code CEH Final CASE Report.

See Section 3.2.1.1 for details and specifically, see the Use of Incentives for LEDs subsection.

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

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

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals. The proposed code change is not anticipated to impact state buildings, as they are unlikely to have commercial CEH operations.

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 re-training is an expense to local governments, it is not an added cost associated with the 2025 code change cycle and would be an easy transition from the 2022 Energy Code

[15] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

minimum requirements (Califonia Energy Commission 2022), requiring updates to greenhouse lighting minimum efficacy and indoor CEH lighting minimum efficacy. 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 3.1.4 and Appendix E, 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.

3.2.4.7 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences. The proposal impacts stakeholders specific to the CEH industry, including growers/farmers, CEH supply chain, and the CEH construction industry. There should be no significant impacts to specific people other than in the CEH industry in general. Refer to Section 2 for more details addressing energy equity and environmental justice.

3.2.5 Fiscal Impacts

3.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts, as the measure affects nonresidential CEH covered processes.

3.2.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts, as the measure affects nonresidential CEH covered processes.

3.2.5.3 Costs or Savings to Any State Agency

There are no costs or savings to any state agencies.

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

There are no added non-discretionary costs or savings to local agencies, as the proposed code change does not require additional local agency funding.

3.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state, as the proposed code change does not require additional state or federal funding.

3.3 Energy Savings

The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. The Statewide CASE Team spoke with CABA Tech, AGxano, Current Lighting, Ian Ashdown, and the California Lighting Technology Center (CLTC) on our proposed savings methodology, and they all validated the general methodology utilized along with key assumptions such as photoperiod, light intensity, and crop lighting requirements.

The savings assumptions were also presented at the stakeholder meeting on February 9, 2023. There were no objections, feedback, or corrections provided during or after the stakeholder meeting related to the energy savings methodology or assumptions. See Appendix F for a summary of stakeholder engagement.

Energy savings benefits may have potential to disproportionately impact DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

3.3.1 Energy Savings Methodology

3.3.1.1 Key Assumptions for Energy Savings Analysis

The California Building Energy Code Compliance (CBECC) Software does not support space functions and conditioning equipment associated with CEH facilities and would not be an appropriate tool to model energy consumption in CEH facilities. Energy savings calculations performed in support of this proposal were estimated using hourly simulation spreadsheets to estimate the impacts of energy efficiency measures implemented in CEH facilities. Market research conducted by the Statewide CASE Team informed the establishment of a baseline of industry-standard practices and equipment to which the proposed measures are compared for estimating the energy savings.

The key assumptions, including photoperiod, used in the energy savings analysis are summarized in Table 16, Table 17, and Table 18.

Table 16: Canopy Area-Cannabis

Facility Type	Flower	Vegetative	Clone
Indoor	83%	15%	2%
Greenhouse	65%	33%	2%

Table 17: Assumptions Used in Indoor Lighting Energy Savings Analysis

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft^2)	20	24	10	58	56
Photoperiod (hours per day)	12	18	24	18	12
PPFD (μMol/m^2/s)	1,000	600	200	200	350
Baseline PPE (μMol/J)	1.9	1.9	1.9	1.9	1.9
Proposed PPE (μMol/J)	2.3	2.3	2.3	2.3	2.3
Baseline Mounting Height Above Canopy	36”	36”	36”	36”	36”
Proposed Mounting Height Above Canopy	24”	24”	24”	24”	24”

Table 18: Assumptions Used in Greenhouse Lighting Energy Savings Analysis

Parameter	Cannabis - Flower	Cannabis - Vegetative	Cannabis - Clone	Leafy Greens	Tomatoes
Canopy Area per Luminaire (ft^2)	20	24	10	58	56
Photoperiod (hours per day)	12	18	24	18	12
PPFD (μMol/m^2/s)	600	400	200	200	350
Baseline PPE (μMol/J)	1.7	1.7	1.7	1.7	1.7
Proposed PPE (μMol/J)	2.3	2.3	2.3	2.3	2.3
Baseline Mounting Height Above Canopy	36”	36”	36”	36”	36”
Proposed Mounting Height Above Canopy	24”	24”	24”	24”	24”

Installed wattage of CEH lighting per square foot, Lighting Power Density (LPD), is calculated as follows:

$$LPD = PPFD / PPE \text{ x } m^2/ft^2 \text{ unit conversion factor x Mounting Height Derate Factor}$$

For the baseline lighting system (double ended high pressure sodium) serving cannabis flower growing with a photosynthetic photon flux density (PPFD) of 1,000 μMol/m^2/s and a light source photosynthetic photon efficacy (PPE) of 1.9 μMol/J, the LPD_b is:

$$LPD_b = \frac{1{,}000\ \mu Mol/m^2 \cdot s}{2.3\ \mu Mol/J} \times 0.0929 \frac{m^2}{ft^2} \times 1.05 = 51.3\ W/ft^2$$

For the proposed lighting system serving cannabis flower growing with the same PPFD but using an improved light source (light emitting diode) with a photosynthetic photon efficacy of 2.3 µMol/J, the LPD_b is 42.4 W/ft^2, which is a reduction of 17 percent of installed power.

Assuming operation of 12 hours per day for 365 days per year, the annual energy savings per square foot for the cannabis flower growing application, ES_{cf} is approximately:

$$ES_{cf} = [51.3\, W/ft^2 - \ 42.4\, W/ft^2] \times 12\frac{h}{d} \times \frac{365d}{yr} \times \frac{0.001kW}{W} = \ 39.1\, kWh/yr \cdot ft^2$$

For each prototype, the savings per square foot are weighted by the area fraction of each application to the statewide population, so that the energy savings value represents the area weighted average controlled environment horticulture application.

The baseline photometric photon efficacy (PPE) is the minimum required efficiency of the 2022 Energy Code. The canopy area per luminaire was calculated using the required PPFD for each crop and the performance of baseline lighting luminaires. The photoperiod includes the time per day that plants require light. For indoor facilities, the entire photoperiod is supplied by luminaires. For greenhouses, the photoperiod does not necessarily correlate to luminaire run hours. Photoperiod estimates were determined by collecting data from informed stakeholders and market research.

The proposed indoor CEH facility minimum PPE of 2.3 µMol/J was determined by surveying existing lighting technologies available, analyzing the DesignLights Consortium (DLC) qualified products list (QPL), and vetting the requirement with lighting technology experts. The primary technology type that meets the PPE requirement is LED lighting technology, but light emitting plasma (LEP) technology may also qualify. Efficacy data provided in PPE for lighting technologies other than LEDs is sparse, and additional test data may prove additional technologies to be eligible. The baseline efficiency for indoor CEH lighting is 1.9 µMol/J, which represents the typical efficacy of double-ended HPS luminaires.

The proposed greenhouse minimum PPE of 2.3 µMol/J represents the typical efficacy of LED luminaires. The costs of LED horticultural lighting luminaires have been dropping while performance has been increasing, so that even with the reduced operating hours in greenhouses, LED lighting is cost-effective. Unlike indoor CEH facilities that utilize supplemental lighting for 100 percent of the crop lighting needs, greenhouse supplement lighting can be used in several different ways. This includes photoperiod extension, daily light integral (DLI) supplementation, and light intensity supplementation. which is typical of double ended high pressure sodium lamps.

3.3.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team measured per unit energy savings expected from the proposed code changes in several ways to quantify key impacts. First, savings are calculated by fuel type. Electricity savings are measured in terms of both energy usage and peak demand reduction. Natural gas savings are quantified in terms of energy usage. Second, the Statewide CASE Team calculated Source Energy Savings. Source Energy represents the total amount of raw fuel required to operate a building. In addition to all energy used from on-site production, source energy incorporates all transmission, delivery, and production losses.

The hourly source energy values provided by CEC are proportional to GHG emissions. Finally, the Statewide CASE Team calculated Long-term Systemwide Cost (LSC) savings, formerly known as Time Dependent Valuation (TDV) energy cost savings. LSC Savings are calculated using hourly LSC factors for both electricity and natural gas provided by the CEC. These LSC hourly factors are projected over the 30-year life of the building and incorporate the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions.[16]

The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 19.

Assumptions for prototypical building models that represent industry-standard indoor, and greenhouse horticultural facilities were developed by the Statewide CASE Team to estimate energy savings. Each building model (i.e., indoor grow and greenhouse) simulated the energy impacts of growing cannabis, tomatoes, and leafy greens in separate facilities. Microgreens and herbs are represented by leafy greens, and vine crops and flowering crops are represented by tomatoes due to similar crop growth requirements. The energy impacts were evaluated on a per square foot basis, and results were weighted to represent the proportion of statewide horticultural facilities dedicated to growing each crop. The weightings are based on data analysis from the 2022 CEH Final CASE Report (California Energy Commission 2022) and can be seen in Table 19. Table 20 shows the estimated crop breakdown for both indoor and greenhouse facility stock.

[16] See Hourly Factors for Source Energy, Long-term Systemwide Cost, and Greenhouse Gas Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

Table 19: Weighting of Crop Area per Prototype and Statewide Covered Construction

Building Type	Crop Type	Percent of Prototype	Percent of Statewide Construction Impacted
Indoor CEH	Cannabis Flower	83	-
	Cannabis Vegetative	15	-
	Cannabis Clone	2	-
	Cannabis Total	**100**	**21**
	Leafy Greens/Microgreens/Herbs	**100**	**1**
	Tomatoes/Flowers/Vine Plants	**100**	**1**
Greenhouse CEH	Cannabis Flower	65	-
	Cannabis Vegetative	33	-
	Cannabis Clone	2	-
	Cannabis Total	**100**	**14**
	Leafy Greens/Microgreens/Herbs	**100**	**14**
	Tomatoes/Flowers/Vine Plants	**100**	**19**

Table 20: Facility Stock Crop Type Breakdown

Building Type	Crop Type	Percent of Facility Stock (%)
Indoor	Cannabis	92
	Leafy Greens/Microgreens/Herbs	5
	Tomatoes/Flowers/Vine Plants	3
Greenhouse	Cannabis	30
	Leafy Greens/Microgreens/Herbs	30
	Tomatoes/Flowers/Vine Plants	40

The Statewide CASE Team estimated energy and demand impacts by simulating the proposed code change using a spreadsheet-based calculation tool specific to CEH facilities. The tool calculates hourly lighting energy based on the parameter assumptions summarized in Table 17 and Table 18. The calculation tool is the same that was used by the Statewide CASE Team for the 2022 code cycle but with updated assumptions and inputs. For indoor CEH facilities, interactive effects on air conditioning equipment caused by reduced cooling loads were estimated assuming minimal compliance with 2022 Title 24, Part 6 efficiency requirements for air conditioners and condensing units (Table 110.2-A). Cooling loads were assumed to decrease due to the use of LED lighting. Gas reheat efficiency was assumed to be 80 percent. Cooling energy savings are calculated using a minimum code level 11-20 ton rooftop unit with an Energy Efficiency Rating (EER) of 10.0 and an Integrated Energy Efficiency Rating (IEER) of 13.2 with a generic DX cooling system performance curve and hourly outside air temperatures sourced from weather files in the 2022 CBECC software. Building envelope for indoor CEH lighting interactive HVAC effects is assumed to be a code minimum non-residential warehouse. Interactive cooling effects were not accounted for in the greenhouse lighting simulation since greenhouses typically vent for the first stage of cooling.

The proposed model was identical to the baseline model in all ways except for the revisions that represent the proposed changes to the code. These baseline assumptions were updated to reflect the proposed code change. The baseline model assumptions are used for both new construction and alterations and are listed in Section 3.3.1.1.

The Statewide CASE Team's spreadsheet tool calculates lighting energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/yr) and Therms per year (Therms/yr). Gas heating load increases are not calculated, as there is an HVAC interactive factor accounted for in electric usage and savings. The spreadsheet tool applies source energy factors to calculate annual energy use in kilo British thermal units per year (kBtu/yr) and annual peak electricity demand reductions measured in kilowatts (kW). Energy cost savings values are measured in 2026 present value dollars (2026 PV$) and nominal dollars were generated.

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 in 2026 PV$ when calculating energy and energy cost impacts.

The per-unit energy impacts for nonresidential buildings are presented in savings per square foot. The annual energy, GHG, and peak demand impacts for each prototype building were translated into impacts per square foot by dividing by the floor area of the prototype building. This step allows for an easier comparison of savings across different building types and enables a calculation of statewide savings using the construction forecast that is published in terms of floor area by building type.

3.3.1.3 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. The Statewide Construction Forecasts estimate new construction/additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The Statewide Construction Forecast did not break out greenhouse and indoor square footage, so the percent of greenhouse and indoor square footage from the 2022 CEH Final CASE Report was utilized, with 68 percent of statewide CEH square footage being greenhouse and 32 percent being indoor CEH square footage. The construction forecast provides construction (new construction/additions and existing building stock) by building type and climate zone, as shown in Appendix A.

Appendix A presents additional information about the methodology and assumptions used to calculate statewide energy impacts.

3.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions are normalized per square foot of growing area and are presented in Table 21 and Table 22. The per square foot energy savings figures do not account for naturally occurring market adoption or compliance rates. The savings vary slightly per climate zone, but the variations are minor. There are no natural gas savings for this measure. The demand reductions are expected to range between 0.00 kW and 0.04 kW per square foot depending on location and climate zone.

New construction and alterations were determined to have the same savings. There are minor variations in savings per climate zone due to interactive HVAC effects and variations in weather conditions, but the savings are shown as a weighted average across all climate zones due to the complexity of the non-CBECC energy model.

Table 21: Per Unit Energy Savings – Indoor Crops

Climate Zone	Cannabis Per Unit Electricity Savings (kWh/square foot)	Greens Per Unit Electricity Savings (kWh/square foot)	Tomatoes Per Unit Electricity Savings (kWh/square foot)
CZ01	60.84	12.42	14.49
CZ02	61.72	14.65	14.65
CZ03	61.45	12.55	14.62
CZ04	61.93	12.53	14.70
CZ05	61.46	12.51	14.60
CZ06	62.04	12.64	14.74
CZ07	61.93	12.65	14.76
CZ08	62.27	12.68	14.80
CZ09	62.33	12.69	14.81
CZ10	62.52	12.71	14.82
CZ11	62.40	12.70	14.82
CZ12	62.10	12.64	14.74
CZ13	62.46	12.72	14.84
CZ14	62.48	12.69	14.81
CZ15	63.91	13.00	15.16
CZ16	61.02	12.46	14.53

Table 22: Per Unit Energy Savings – Greenhouse Crops

Climate Zone	Cannabis Per Unit Electricity Savings (kWh/square foot)	Greens Per Unit Electricity Savings (kWh/square foot)	Tomatoes Per Unit Electricity Savings (kWh/square foot)
CZ01	7.34	12.42	5.92
CZ02	6.09	14.65	4.46
CZ03	6.24	12.55	4.39
CZ04	5.94	12.53	4.07
CZ05	5.85	12.51	3.12
CZ06	6.13	12.64	3.06
CZ07	5.96	12.65	2.66
CZ08	5.97	12.68	3.19
CZ09	5.78	12.69	3.17
CZ10	5.74	12.71	3.07
CZ11	6.02	12.70	4.63
CZ12	6.01	12.64	4.59
CZ13	5.93	12.72	4.43
CZ14	5.20	12.69	2.31
CZ15	5.43	13.00	2.41
CZ16	5.82	12.46	4.17

3.4 Cost and Cost Effectiveness

3.4.1 Energy Cost Savings Methodology

The energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates derived using the methodology described in Section 3.3.1. LSC hourly factors are a normalized metric to calculate LSC savings that account for the variable cost of electricity and natural gas for each hour of the year, as well as how costs are expected to change over the 30-year period of analysis.

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2026 PV$. Costs and cost-effectiveness used and 2026 PV$ are presented in Section 3.4 of this report. CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (From 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents energy cost savings results in nominal dollars.

The proposed code change affects both new construction and major additions and alterations. The proposed change and savings are the same for both new construction and major additions and alterations.

3.4.2 Energy Cost Savings Results

The per-unit energy cost savings for newly constructed buildings, additions, and alterations that are realized over the 30-year period of analysis are presented 2026 precent value dollars (2026 PV$) in Table 23 through Table 28. The energy cost savings are presented for both indoor and greenhouse CEH lighting for each prototype (tomatoes, greens, and cannabis).

The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Given that CEH operations are typically running lighting during peak periods, there is a high coincidence of the proposed equipment reducing peak load.

Table 23: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Indoor Tomatoes Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	81.54	0.00	81.54
CZ02	82.42	0.00	82.42
CZ03	82.33	0.00	82.33
CZ04	82.56	0.00	82.56
CZ05	82.18	0.00	82.18
CZ06	83.26	0.00	83.26
CZ07	82.55	0.00	82.55
CZ08	83.39	0.00	83.39
CZ09	83.44	0.00	83.44
CZ10	83.46	0.00	83.46
CZ11	83.24	0.00	83.24
CZ12	82.89	0.00	82.89
CZ13	83.34	0.00	83.34
CZ14	83.31	0.00	83.31
CZ15	85.27	0.00	85.27
CZ16	81.91	0.00	81.91

Table 24: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Indoor Greens Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	69.89	0.00	69.89
CZ02	82.42	0.00	82.42
CZ03	70.60	0.00	70.60
CZ04	70.44	0.00	70.44
CZ05	70.44	0.00	70.44
CZ06	71.36	0.00	71.36
CZ07	70.76	0.00	70.76
CZ08	71.48	0.00	71.48
CZ09	71.52	0.00	71.52
CZ10	71.53	0.00	71.53
CZ11	71.35	0.00	71.35
CZ12	71.05	0.00	71.05
CZ13	71.43	0.00	71.43
CZ14	71.40	0.00	71.40
CZ15	73.09	0.00	73.09
CZ16	70.21	0.00	70.21

Table 25: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Indoor Cannabis Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	305.80	0.00	305.80
CZ02	311.37	0.00	311.37
CZ03	307.21	0.00	307.21
CZ04	308.72	0.00	308.72
CZ05	309.47	0.00	309.47
CZ06	311.90	0.00	311.90
CZ07	318.93	0.00	318.93
CZ08	312.64	0.00	312.64
CZ09	312.57	0.00	312.57
CZ10	313.23	0.00	313.23
CZ11	310.60	0.00	310.60
CZ12	309.69	0.00	309.69
CZ13	311.24	0.00	311.24
CZ14	311.64	0.00	311.64
CZ15	318.93	0.00	318.93
CZ16	305.71	0.00	305.71

Table 26: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Greenhouse Tomatoes Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	33.97	0.00	33.97
CZ02	27.38	0.00	27.38
CZ03	25.68	0.00	25.68
CZ04	23.42	0.00	23.42
CZ05	18.48	0.00	18.48
CZ06	17.49	0.00	17.49
CZ07	15.80	0.00	15.80
CZ08	18.03	0.00	18.03
CZ09	18.03	0.00	18.03
CZ10	17.29	0.00	17.29
CZ11	26.91	0.00	26.91
CZ12	26.92	0.00	26.92
CZ13	25.99	0.00	25.99
CZ14	13.42	0.00	13.42
CZ15	13.74	0.00	13.74
CZ16	23.68	0.00	23.68

Table 27: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Greenhouse Greens Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	69.89	0.00	69.89
CZ02	82.42	0.00	82.42
CZ03	70.60	0.00	70.60
CZ04	70.44	0.00	70.44
CZ05	70.44	0.00	70.44
CZ06	71.36	0.00	71.36
CZ07	70.76	0.00	70.76
CZ08	71.48	0.00	71.48
CZ09	71.52	0.00	71.52
CZ10	71.53	0.00	71.53
CZ11	71.35	0.00	71.35
CZ12	71.05	0.00	71.05
CZ13	71.43	0.00	71.43
CZ14	71.40	0.00	71.40
CZ15	73.09	0.00	73.09
CZ16	70.21	0.00	70.21

Table 28: 2026 Present Value LSC Savings Per Square Foot Over 30-Year Period of Analysis – New Construction, Additions, and Alterations – Greenhouse Cannabis Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	38.07	0.00	38.07
CZ02	33.17	0.00	33.17
CZ03	32.90	0.00	32.90
CZ04	31.08	0.00	31.08
CZ05	31.10	0.00	31.10
CZ06	31.73	0.00	31.73
CZ07	32.41	0.00	32.41
CZ08	30.85	0.00	30.85
CZ09	30.06	0.00	30.06
CZ10	29.82	0.00	29.82
CZ11	31.48	0.00	31.48
CZ12	31.59	0.00	31.59
CZ13	31.14	0.00	31.14
CZ14	27.15	0.00	27.15
CZ15	28.14	0.00	28.14
CZ16	30.78	0.00	30.78

3.4.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices.

The horticulture lighting efficacy measure proposal builds on the 2022 Energy Code minimum requirements (Califonia Energy Commission 2022). The 2022 Energy Code requires a 1.9 micromoles per Joule efficacy for indoor CEH facilities and a 1.7 micromoles per Joule efficacy for greenhouses. The minimum efficacy applies to lamp efficacy for luminaires with removable lamps and a luminaire efficacy for dedicated luminaires.

Retailers such as Grow Ace, Hydrobuilder, and Growers House and manufacturer websites such as MaxLite, Eye Hortilux, and VivoSun listed the prices online for many products. Additionally, the Statewide CASE Team directly reached out to several horticultural lighting manufacturers to obtain price estimates. Some of the major manufacturers included in the cost analysis include: Gavita, Grower's Choice, Phantom, NanoLux, Fluence, Current Lighting, Illuminar, and Photobio.

The cost of luminaires that meet the proposed PPE levels were determined through online searches of the sources listed in the previous paragraph. All luminaires found to meet the proposed standards are LEDs. There may be other technology types that meet the required minimum efficacy, but there was no test data available to verify they can achieve 2.3 μMol/J. The Statewide CASE Team analyzed price points for LED luminaires manufactured by many of the sources listed above, among others. In total, prices for over 60 luminaires and lamps were used to conduct this cost-effectiveness analysis. The specific luminaires and lamps used in the cost analysis were added to Table 67 in Appendix H. An average cost for a combination of ceramic metal halide and double-ended HPS luminaires and lamps was the baseline cost for greenhouse lighting, and the average cost for double-ended HPS luminaires and lamps was the baseline for indoor lighting and also the proposed cost for greenhouse lighting. The average costs for LED luminaires with a PPE at or above 2.3 μMol/J were used for the proposed cost for indoor CEH facilities and for the proposed cost for greenhouses.

There are labor costs associated with this measure due to equipment changes. The labor rate for an electrician to install one luminaire of any light source is $69. The labor rate to replace one lamp or one lamp and a reflector is $16. P.L. Light Systems recommends cleaning reflectors every year. The labor rate to clean one HID reflector is $30 and the labor rate to clean one LED luminaire is $6. A two percent annual lamp failure rate was used for the HID lifecycle cost analysis. For the LED systems, the lifecycle cost analysis includes a sensitivity analysis with one percent failure rates or 25 percent failure rates occurring in year ten. The total payments with both failure rates are shown in the plotted figures; however, the total payments cell in the lifecycle cost analysis summary table shows the cumulative costs with a less conservative one percent assumed failure rate. Incremental costs would not vary between alterations and new construction since the incremental cost is solely dependent on product cost differences in both cases. Table 29 shows the total incremental costs per square foot of canopy for the horticulture lighting measure in both greenhouses and indoor facilities. Maintenance costs are described in Section 3.4.4.

Table 29: 30-Year Lighting Incremental Cost Per Square Foot of Canopy

Building Type	Incremental Equipment Cost	Incremental Maintenance Cost
Indoor Cannabis	$34.88	-$37.76
Indoor Greens	$27.55	-$32.65
Indoor Tomatoes	$34.88	-$35.32
Greenhouse Cannabis	$13.13	-$35.32
Greenhouse Greens	$27.55	-$32.65
Greenhouse Tomatoes	$34.88	-$14.28

For the proposed indoor and greenhouse CEH lighting measures, LED luminaires in the 300-650-watt range were chosen for determining the average proposed equipment cost. This range was chosen, as it correlates with the most common baseline luminaires and their respective range of PPF values. The average proposed indoor CEH lighting equipment cost per luminaire was $1,043, within an average cost per watt of $1.83/W. For comparison, the average cost per watt determined from the 2022 CEH Draft CASE Report was $2.18/W (California Energy Commission 2022). This represents a 16 percent reduction in equipment cost from the 2022 CEH Draft CASE Report data.

For baseline indoor and greenhouse CEH lighting measures, double-ended HPS luminaires in the 600-1000-watt range were chosen for determining average baseline equipment cost, as this covers the most common wattages used in baseline supplemental lighting.

Horticultural luminaires have an expected useful life of approximately ten years. Two luminaire replacements were factored into the 30-year evaluation period.

To determine per canopy incremental cost, average areas per luminaire have been provided by lighting designers, growers, and manufacturers. They are derived from the required PPFD and listed in Table 17 and Table 18. The mounting height used for these calculations assumes a 36-inch mounting height above the canopy for baseline equipment and a 24-inch mounting height for proposed equipment. Incremental equipment cost was derived from subtracting baseline equipment cost from the proposed equipment cost and dividing by the appropriate square footage covered per luminaire.

Incremental costs were calculated in terms of canopy square footage to establish a uniform metric to compare the baseline and proposed scenarios. Based on a cost difference per square foot of canopy, the Statewide CASE Team was able to determine cost savings per square foot of canopy. This metric will allow growers to assess what degree of savings they can expect depending on the size of their operation. The code language was written in terms of total connected lighting load since this is a metric enforceable by building officials and one that can be easily determined by growers. The 40 kW lighting threshold represents (40) 1000W HID luminaires, covering approximately 800-1,000 square feet of canopy.

There was no assumed incremental cost for the requirement to design the electrical power system serving CEH spaces as horticultural lighting loads are separated from other lighting loads and this is common industry practice.

3.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the 30-year period of analysis. The present value of equipment maintenance costs (or savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 LSC hourly factors. The present value of maintenance costs that occurs in the n[th] year is calculated as follows:

$$Present\ Value\ of\ Maintenance\ Cost\ =\ Maintenance\ Cost\ \times\ \left\lfloor\frac{1}{1+d}\right\rfloor^{n}$$

The baseline technology for indoor growing facilities assumed a lamp replacement every year and a luminaire replacement every 10 years for all crop types. The baseline technology for greenhouse growing facilities assumed a lamp replacement every other year and a luminaire replacement every 10 years. The DLC Horticultural QPL (DesignLights Consortium 2019) utilizes 50,000 hours for the expected life of horticultural lighting, as does the California Electronic Technical Reference Manual (eTRM) entry for high- and low-bay LEDs. The California eTRM entry equates this to a 12-year useful life. Given the average daily run time of 12-18 hours per day for horticultural lighting, a 10-year useful life was used instead of 12 years. The proposed measures do not have maintenance costs assumed as there are no lamp replacements associated with horticultural LED luminaires. The lamp costs used in the cost analysis are listed in Appendix H. There was no assumed change in labor for either indoor or greenhouse lighting. The incremental maintenance cost values are included in Table 29.

3.4.5 Cost Effectiveness

This measure proposes a mandatory requirement. As such, a cost analysis is required to demonstrate that the measure is cost effective over the 30-year period of analysis.

The CEC establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with CEC staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The LSC savings from electricity savings were also included in the evaluation. Design costs were not included nor were the incremental costs of code compliance verification.

According to the CEC's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 30 years by the total incremental costs, which includes maintenance costs for 30 years. The B/C ratio was calculated using 2026 Present Value (PV) costs and cost savings.

The proposed measure saves money over the 30-year period of analysis relative to the existing conditions and is cost effective in every climate zone for both greenhouse CEH facilities and indoor CEH facilities. Cost effectiveness for alterations is similar for alterations and major additions to the new construction cost effectiveness. The proposed measure ranges in cost effectiveness from 3.6-10.0 making them highly cost-effective measures.

Table 30 through Table 39 provide the cost effectiveness values for the proposed horticultural lighting efficacy measure. Benefits and costs are defined as follows for these tables:

- **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (California Energy Commission 2022). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of the CASE analysis period.
- **Costs:** Total Incremental Present Valued Costs: Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed

maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the benefit-to-cost ratio is infinite.

Table 30: 30-Year Cost Effectiveness Summary Per Square Foot – Indoor New Construction, Additions, and Alterations - Tomatoes

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	119.30	34.88	3.42
CZ02	120.19	34.88	3.45
CZ03	120.09	34.88	3.44
CZ04	120.32	34.88	3.45
CZ05	119.94	34.88	3.44
CZ06	121.02	34.88	3.47
CZ07	120.32	34.88	3.45
CZ08	121.16	34.88	3.47
CZ09	121.20	34.88	3.47
CZ10	121.22	34.88	3.48
CZ11	121.01	34.88	3.47
CZ12	120.66	34.88	3.46
CZ13	121.10	34.88	3.47
CZ14	121.07	34.88	3.47
CZ15	123.03	34.88	3.53
CZ16	119.68	34.88	3.43
Total	120.67	34.88	3.46

Table 31: 30-Year Cost Effectiveness Summary Per Square Foot – Indoor New Construction & Additions - Greens

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	102.54	27.55	3.72
CZ02	115.08	27.55	4.18
CZ03	103.25	27.55	3.75
CZ04	103.09	27.55	3.74
CZ05	103.09	27.55	3.74
CZ06	104.01	27.55	3.78
CZ07	103.41	27.55	3.75
CZ08	104.13	27.55	3.78
CZ09	104.17	27.55	3.78
CZ10	104.19	27.55	3.78
CZ11	104.00	27.55	3.78
CZ12	103.70	27.55	3.76
CZ13	104.08	27.55	3.78
CZ14	104.06	27.55	3.78
CZ15	105.74	27.55	3.84
CZ16	102.86	27.55	3.73
Total	104.16	27.55	3.78

Table 32: 30-Year Cost Effectiveness Summary Per Square Foot – Indoor Alterations - Greens

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	72.79	11.55	6.30
CZ02	85.32	11.55	7.39
CZ03	73.49	11.55	6.36
CZ04	73.34	11.55	6.35
CZ05	73.33	11.55	6.35
CZ06	74.26	11.55	6.43
CZ07	73.66	11.55	6.38
CZ08	74.38	11.55	6.44
CZ09	74.41	11.55	6.44
CZ10	74.43	11.55	6.44
CZ11	74.25	11.55	6.43
CZ12	73.95	11.55	6.40
CZ13	74.33	11.55	6.44
CZ14	74.30	11.55	6.43
CZ15	75.99	11.55	6.58
CZ16	73.11	11.55	6.33
Total	74.14	11.55	6.42

Table 33: 30-Year Cost Effectiveness Summary Per Square Foot – Indoor New Construction, Additions, and Alterations - Cannabis

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	343.56	34.88	9.85
CZ02	349.14	34.88	10.01
CZ03	344.98	34.88	9.89
CZ04	346.48	34.88	9.93
CZ05	347.23	34.88	9.96
CZ06	349.66	34.88	10.03
CZ07	356.70	34.88	10.23
CZ08	350.41	34.88	10.05
CZ09	350.34	34.88	10.04
CZ10	350.99	34.88	10.06
CZ11	348.36	34.88	9.99
CZ12	347.45	34.88	9.96
CZ13	349.00	34.88	10.01
CZ14	349.40	34.88	10.02
CZ15	356.69	34.88	10.23
CZ16	343.47	34.88	9.85
Total	348.16	34.88	9.98

Table 34: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse New Construction & Additions - Tomatoes

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	48.25	13.13	3.67
CZ02	41.66	13.13	3.17
CZ03	39.95	13.13	3.04
CZ04	37.70	13.13	2.87
CZ05	32.76	13.13	2.49
CZ06	31.76	13.13	2.42
CZ07	30.08	13.13	2.29
CZ08	32.31	13.13	2.46
CZ09	32.31	13.13	2.46
CZ10	31.56	13.13	2.40
CZ11	41.18	13.13	3.14
CZ12	41.20	13.13	3.14
CZ13	40.26	13.13	3.07
CZ14	27.70	13.13	2.11
CZ15	28.02	13.13	2.13
CZ16	37.96	13.13	2.89
Total	37.35	13.13	2.84

Table 35: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse Alterations – Tomatoes

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	66.62	27.55	2.42
CZ02	60.03	27.55	2.18
CZ03	58.33	27.55	2.12
CZ04	56.07	27.55	2.04
CZ05	51.13	27.55	1.86
CZ06	50.14	27.55	1.82
CZ07	48.45	27.55	1.76
CZ08	50.68	27.55	1.84
CZ09	50.68	27.55	1.84
CZ10	49.94	27.55	1.81
CZ11	59.56	27.55	2.16
CZ12	59.57	27.55	2.16
CZ13	58.64	27.55	2.13
CZ14	46.08	27.55	1.67
CZ15	46.39	27.55	1.68
CZ16	56.33	27.55	2.04
Total	54.07	27.55	1.96

Table 36: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse New Construction & Additions - Greens

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	102.54	27.55	3.72
CZ02	115.08	27.55	4.18
CZ03	103.25	27.55	3.75
CZ04	103.09	27.55	3.74
CZ05	103.09	27.55	3.74
CZ06	104.01	27.55	3.78
CZ07	103.41	27.55	3.75
CZ08	104.13	27.55	3.78
CZ09	104.17	27.55	3.78
CZ10	104.19	27.55	3.78
CZ11	104.00	27.55	3.78
CZ12	103.70	27.55	3.76
CZ13	104.08	27.55	3.78
CZ14	104.06	27.55	3.78
CZ15	105.74	27.55	3.84
CZ16	102.86	27.55	3.73
Total	104.16	27.55	3.78

Table 37: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse Alterations - Greens

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	77.81	11.55	6.74
CZ02	90.34	11.55	7.82
CZ03	78.51	11.55	6.80
CZ04	78.36	11.55	6.78
CZ05	78.36	11.55	6.78
CZ06	79.28	11.55	6.86
CZ07	78.68	11.55	6.81
CZ08	79.40	11.55	6.87
CZ09	79.43	11.55	6.88
CZ10	79.45	11.55	6.88
CZ11	79.27	11.55	6.86
CZ12	78.97	11.55	6.84
CZ13	79.35	11.55	6.87
CZ14	79.32	11.55	6.87
CZ15	81.01	11.55	7.01
CZ16	78.13	11.55	6.76
Total	79.16	11.55	6.85

Table 38: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse New Construction & Additions - Cannabis

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot)	Benefit-to-Cost Ratio
CZ01	75.83	34.88	2.17
CZ02	70.93	34.88	2.03
CZ03	70.67	34.88	2.03
CZ04	68.85	34.88	1.97
CZ05	68.86	34.88	1.97
CZ06	69.50	34.88	1.99
CZ07	70.17	34.88	2.01
CZ08	68.61	34.88	1.97
CZ09	67.83	34.88	1.94
CZ10	67.58	34.88	1.94
CZ11	69.24	34.88	1.99
CZ12	69.35	34.88	1.99
CZ13	68.90	34.88	1.98
CZ14	64.91	34.88	1.86
CZ15	65.90	34.88	1.89
CZ16	68.54	34.88	1.97
Total	69.46	34.88	1.99

Table 39: 30-Year Cost Effectiveness Summary Per Square Foot – Greenhouse Alterations - Cannabis

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/square foot)	Costs: Total Incremental PV Costs (2026 PV$/square foot	Benefit-to-Cost Ratio
CZ01	75.83	34.88	2.17
CZ02	70.93	34.88	2.03
CZ03	70.67	34.88	2.03
CZ04	68.85	34.88	1.97
CZ05	68.86	34.88	1.97
CZ06	69.50	34.88	1.99
CZ07	70.17	34.88	2.01
CZ08	68.61	34.88	1.97
CZ09	67.83	34.88	1.94
CZ10	67.58	34.88	1.94
CZ11	69.24	34.88	1.99
CZ12	69.35	34.88	1.99
CZ13	68.90	34.88	1.98
CZ14	64.91	34.88	1.86
CZ15	65.90	34.88	1.89
CZ16	68.54	34.88	1.97
Total	69.12	34.88	1.98

3.5 First-Year Statewide Impacts

3.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per-unit savings, which are presented in Section 3.3.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. The statewide new construction forecast for 2026 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type). As shown in Appendix A, there is 2.08 million square feet per year of newly constructed indoor horticultural spaces and 70 percent or 1.46 million square feet per year of these spaces would be subject to the proposed horticultural lighting requirements. This assumes that 30 percent of the existing building stock has adopted LED horticultural lighting. Of the 1.46 million square feet per year, 68 percent of the square footage is greenhouse and 32 percent is indoor CEH facility space (California Energy Commission 2022).

For alterations, it is assumed that 8 percent of the building stock (California Energy Commission 2022) meets the Title 24, Part 6 alterations threshold based on equipment useful life for horticultural lighting and would have to comply with the alterations' requirements. As shown in Appendix A, there is 40.2 million square feet of existing indoor horticultural spaces and 8 percent or 3.34 million square feet per year of these spaces would be subject to the proposed horticultural lighting requirements for lighting alterations. The statewide area of greenhouse alterations that that would trigger the lighting alterations requirements in this proposed code change is 3.3 million square feet.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2026. The 30-year energy cost savings represent the energy cost savings over the entire 30-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

Table 40 through Table 51 present the first-year statewide savings estimates for indoor and greenhouses for each crop type. Savings for new construction and additions are shown separately from savings from alterations. Table 52 presents first-year statewide savings from new construction, additions, and alterations for all crop types for both new construction and alterations.

Table 40: Statewide Energy and Energy Cost Impacts - New Construction & Additions - Indoor Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	623	0.01	0.00	-	0.02	$0.05
CZ02	521	0.01	0.00	-	0.01	$0.04
CZ03	2,148	0.03	0.00	-	0.05	$0.18
CZ04	268	0.00	0.00	-	0.01	$0.02
CZ05	1,358	0.02	0.00	-	0.03	$0.11
CZ06	1,732	0.03	0.00	-	0.04	$0.14
CZ07	10	0.00	0.00	-	0.00	$0.00
CZ08	157	0.00	0.00	-	0.00	$0.01
CZ09	175	0.00	0.00	-	0.00	$0.01
CZ10	1,868	0.03	0.00	-	0.05	$0.16
CZ11	2,034	0.03	0.00	-	0.05	$0.17
CZ12	2,052	0.03	0.00	-	0.05	$0.17
CZ13	606	0.01	0.00	-	0.02	$0.05
CZ14	73	0.00	0.00	-	0.00	$0.01
CZ15	322	0.00	0.00	-	0.01	$0.03
CZ16	31	0.00	0.00	-	0.00	$0.00
Total	13,978	0.21	0.02	-	0.35	$1.16

Table 41: Statewide Energy and Energy Cost Impacts – Alterations – Indoor Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	557	0.01	0.00	-	0.01	$0.05
CZ02	364	0.01	0.00	-	0.01	$0.03
CZ03	2,088	0.03	0.00	-	0.05	$0.17
CZ04	854	0.01	0.00	-	0.02	$0.07
CZ05	5,041	0.07	0.01	-	0.12	$0.41
CZ06	6,585	0.10	0.01	-	0.16	$0.55
CZ07	854	0.01	0.00	-	0.02	$0.07
CZ08	591	0.01	0.00	-	0.01	$0.05
CZ09	1,274	0.02	0.00	-	0.03	$0.11
CZ10	2,876	0.04	0.00	-	0.07	$0.24
CZ11	2,002	0.03	0.00	-	0.05	$0.17
CZ12	3,612	0.05	0.01	-	0.09	$0.30
CZ13	4,271	0.06	0.01	-	0.11	$0.36
CZ14	373	0.01	0.00	-	0.01	$0.03
CZ15	513	0.01	0.00	-	0.01	$0.04
CZ16	187	0.00	0.00	-	0.00	$0.02
Total	32,042	0.47	0.05	-	0.80	$2.66

Table 42: Statewide Energy and Energy Cost Impacts - New Construction & Additions - Indoor Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Yeara 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 2026 PV$)
CZ01	311	0.00	0.00	-	0.01	$0.02
CZ02	260	0.00	0.00	-	0.01	$0.02
CZ03	1,074	0.01	0.00	-	0.02	$0.08
CZ04	134	0.00	0.00	-	0.00	$0.01
CZ05	679	0.01	0.00	-	0.01	$0.05
CZ06	866	0.01	0.00	-	0.02	$0.06
CZ07	5	0.00	0.00	-	0.00	$0.00
CZ08	79	0.00	0.00	-	0.00	$0.01
CZ09	88	0.00	0.00	-	0.00	$0.01
CZ10	934	0.01	0.00	-	0.02	$0.07
CZ11	1,017	0.01	0.00	-	0.02	$0.07
CZ12	1,026	0.01	0.00	-	0.02	$0.07
CZ13	303	0.00	0.00	-	0.01	$0.02
CZ14	36	0.00	0.00	-	0.00	$0.00
CZ15	161	0.00	0.00	-	0.00	$0.01
CZ16	16	0.00	0.00	-	0.00	$0.00
Total	6,989	0.09	0.01	-	0.15	$0.50

Table 43: Statewide Energy and Energy Cost Impacts – Alterations - Indoor Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	278	0.00	0.00	-	0.01	$0.02
CZ02	182	0.00	0.00	-	0.00	$0.02
CZ03	1,044	0.01	0.00	-	0.02	$0.07
CZ04	427	0.01	0.00	-	0.01	$0.03
CZ05	2,521	0.03	0.00	-	0.05	$0.18
CZ06	3,292	0.04	0.00	-	0.07	$0.23
CZ07	427	0.01	0.00	-	0.01	$0.03
CZ08	295	0.00	0.00	-	0.01	$0.02
CZ09	637	0.01	0.00	-	0.01	$0.05
CZ10	1,438	0.02	0.00	-	0.03	$0.10
CZ11	1,001	0.01	0.00	-	0.02	$0.07
CZ12	1,806	0.02	0.00	-	0.04	$0.13
CZ13	2,135	0.03	0.00	-	0.05	$0.15
CZ14	186	0.00	0.00	-	0.00	$0.01
CZ15	257	0.00	0.00	-	0.01	$0.02
CZ16	94	0.00	0.00	-	0.00	$0.01
Total	16,021	0.20	0.02	-	0.34	$1.14

Table 44: Statewide Energy and Energy Cost Impacts - New Construction & Additions - Indoor Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	19,093	1.16	0.06	-	1.42	$5.84
CZ02	15,969	0.99	0.05	-	1.20	$4.97
CZ03	65,884	4.05	0.22	-	4.94	$20.24
CZ04	8,214	0.51	0.03	-	0.62	$2.54
CZ05	41,649	2.56	0.14	-	3.12	$12.89
CZ06	53,127	3.30	0.18	-	4.02	$16.57
CZ07	302	0.02	0.00	-	0.02	$0.10
CZ08	4,826	0.30	0.02	-	0.37	$1.51
CZ09	5,370	0.33	0.02	-	0.41	$1.68
CZ10	57,290	3.58	0.19	-	4.35	$17.95
CZ11	62,380	3.89	0.21	-	4.71	$19.38
CZ12	62,916	3.91	0.21	-	4.74	$19.48
CZ13	18,570	1.16	0.06	-	1.40	$5.78
CZ14	2,224	0.14	0.01	-	0.17	$0.69
CZ15	9,884	0.63	0.03	-	0.76	$3.15
CZ16	961	0.06	0.00	-	0.07	$0.29
Total	428,660	26.58	1.42	-	32.34	$133.05

Table 45: Statewide Energy and Energy Cost Impacts – Alterations – Indoor Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	17,075	1.04	0.06	-	1.27	$5.22
CZ02	11,164	0.69	0.04	-	0.84	$3.48
CZ03	64,020	3.93	0.21	-	4.80	$19.67
CZ04	26,195	1.62	0.09	-	1.98	$8.09
CZ05	154,602	9.50	0.51	-	11.59	$47.84
CZ06	201,932	12.53	0.67	-	15.28	$62.98
CZ07	26,195	1.62	0.09	-	1.98	$8.35
CZ08	18,114	1.13	0.06	-	1.37	$5.66
CZ09	39,072	2.44	0.13	-	2.96	$12.21
CZ10	88,187	5.51	0.29	-	6.70	$27.62
CZ11	61,406	3.83	0.20	-	4.64	$19.07
CZ12	110,765	6.88	0.37	-	8.35	$34.30
CZ13	130,973	8.18	0.44	-	9.91	$40.76
CZ14	11,438	0.71	0.04	-	0.86	$3.56
CZ15	15,744	1.01	0.05	-	1.21	$5.02
CZ16	5,740	0.35	0.02	-	0.43	$1.75
Total	982,620	60.97	3.27	-	74.18	$305.61

Table 46: Statewide Energy and Energy Cost Impacts - New Construction & Additions – Greenhouse Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	17,641	0.10	0.01	-	0.20	$0.60
CZ02	14,754	0.07	0.01	-	0.14	$0.40
CZ03	60,871	0.27	0.02	-	0.56	$1.56
CZ04	7,589	0.03	0.00	-	0.07	$0.18
CZ05	38,480	0.12	0.01	-	0.25	$0.71
CZ06	49,085	0.15	0.02	-	0.31	$0.86
CZ07	279	0.00	0.00	-	0.00	$0.00
CZ08	4,459	0.01	0.00	-	0.03	$0.08
CZ09	4,962	0.02	0.00	-	0.03	$0.09
CZ10	52,931	0.16	0.01	-	0.33	$0.91
CZ11	57,634	0.27	0.03	-	0.56	$1.55
CZ12	58,129	0.27	0.03	-	0.57	$1.56
CZ13	17,157	0.08	0.01	-	0.16	$0.45
CZ14	2,054	0.00	0.00	-	0.01	$0.03
CZ15	9,132	0.02	0.00	-	0.05	$0.13
CZ16	888	0.00	0.00	-	0.01	$0.02
Total	396,045	1.57	0.15	-	3.29	$9.14

Table 47: Statewide Energy and Energy Cost Impacts – Alterations – Greenhouse Tomatoes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	15,776	0.09	0.01	-	0.18	$0.54
CZ02	10,315	0.05	0.00	-	0.10	$0.28
CZ03	59,149	0.26	0.02	-	0.54	$1.52
CZ04	24,201	0.10	0.00	-	0.21	$0.57
CZ05	142,838	0.44	0.04	-	0.93	$2.64
CZ06	186,568	0.57	0.06	-	1.18	$3.26
CZ07	24,201	0.06	0.01	-	0.13	$0.38
CZ08	16,736	0.05	0.01	-	0.11	$0.30
CZ09	36,099	0.11	0.01	-	0.24	$0.65
CZ10	81,477	0.25	0.02	-	0.51	$1.41
CZ11	56,733	0.26	0.03	-	0.55	$1.53
CZ12	102,337	0.47	0.05	-	1.00	$2.75
CZ13	121,007	0.54	0.06	-	1.14	$3.14
CZ14	10,568	0.02	0.00	-	0.06	$0.14
CZ15	14,546	0.04	0.00	-	0.08	$0.20
CZ16	5,303	0.02	0.00	-	0.05	$0.13
Total	907,855	3.35	0.32	-	7.01	$19.44

Table 48: Statewide Energy and Energy Cost Impacts - New Construction & Additions – Greenhouse Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	13,230	0.16	0.02	-	0.28	$0.92
CZ02	11,066	0.16	0.02	-	0.27	$0.91
CZ03	45,653	0.57	0.06	-	0.97	$3.22
CZ04	5,692	0.07	0.01	-	0.12	$0.40
CZ05	28,860	0.36	0.04	-	0.61	$2.03
CZ06	36,814	0.47	0.05	-	0.79	$2.63
CZ07	209	0.00	0.00	-	0.00	$0.01
CZ08	3,344	0.04	0.00	-	0.07	$0.24
CZ09	3,721	0.05	0.01	-	0.08	$0.27
CZ10	39,698	0.50	0.06	-	0.85	$2.84
CZ11	43,226	0.55	0.06	-	0.92	$3.08
CZ12	43,597	0.55	0.06	-	0.93	$3.10
CZ13	12,868	0.16	0.02	-	0.28	$0.92
CZ14	1,541	0.02	0.00	-	0.03	$0.11
CZ15	6,849	0.09	0.01	-	0.15	$0.50
CZ16	666	0.01	0.00	-	0.01	$0.05
Total	297,033	3.77	0.42	-	6.38	$21.24

Table 49: Statewide Energy and Energy Cost Impacts – Alterations – Greenhouse Greens

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	11,832	0.15	0.02	-	0.25	$0.83
CZ02	7,736	0.11	0.01	-	0.19	$0.64
CZ03	44,362	0.56	0.06	-	0.94	$3.13
CZ04	18,151	0.23	0.03	-	0.39	$1.28
CZ05	107,129	1.34	0.15	-	2.27	$7.55
CZ06	139,926	1.77	0.20	-	2.99	$9.99
CZ07	18,151	0.23	0.03	-	0.39	$1.28
CZ08	12,552	0.16	0.02	-	0.27	$0.90
CZ09	27,074	0.34	0.04	-	0.58	$1.94
CZ10	61,108	0.78	0.09	-	1.31	$4.37
CZ11	42,550	0.54	0.06	-	0.91	$3.04
CZ12	76,753	0.97	0.11	-	1.64	$5.45
CZ13	90,756	1.15	0.13	-	1.94	$6.48
CZ14	7,926	0.10	0.01	-	0.17	$0.57
CZ15	10,909	0.14	0.02	-	0.24	$0.80
CZ16	3,977	0.05	0.01	-	0.08	$0.28
Total	680,892	8.62	0.97	-	14.57	$48.51

Table 50: Statewide Energy and Energy Cost Impacts - New Construction & Additions – Greenhouse Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	13,230	0.10	0.01	-	0.14	$0.50
CZ02	11,066	0.07	0.00	-	0.10	$0.37
CZ03	45,653	0.28	0.02	-	0.43	$1.50
CZ04	5,692	0.03	0.00	-	0.05	$0.18
CZ05	28,860	0.17	0.01	-	0.25	$0.90
CZ06	36,814	0.23	0.01	-	0.33	$1.17
CZ07	209	0.00	0.00	-	0.00	$0.01
CZ08	3,344	0.02	0.00	-	0.03	$0.10
CZ09	3,721	0.02	0.00	-	0.03	$0.11
CZ10	39,698	0.23	0.01	-	0.34	$1.18
CZ11	43,226	0.26	0.02	-	0.41	$1.36
CZ12	43,597	0.26	0.02	-	0.41	$1.38
CZ13	12,868	0.08	0.01	-	0.12	$0.40
CZ14	1,541	0.01	0.00	-	0.01	$0.04
CZ15	6,849	0.04	0.00	-	0.06	$0.19
CZ16	666	0.00	0.00	-	0.01	$0.02
Total	297,033	1.80	0.11	-	2.72	$9.42

Table 51: Statewide Energy and Energy Cost Impacts – Alterations – Greenhouse Cannabis

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (square feet)	First-Year[a] 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 2026 PV$)
CZ01	11,832	0.09	0.00	-	0.12	$0.45
CZ02	7,736	0.05	0.00	-	0.07	$0.26
CZ03	44,362	0.28	0.02	-	0.42	$1.46
CZ04	18,151	0.11	0.01	-	0.17	$0.56
CZ05	107,129	0.63	0.04	-	0.94	$3.33
CZ06	139,926	0.86	0.05	-	1.24	$4.44
CZ07	18,151	0.11	0.01	-	0.15	$0.59
CZ08	12,552	0.07	0.00	-	0.11	$0.39
CZ09	27,074	0.16	0.01	-	0.24	$0.81
CZ10	61,108	0.35	0.02	-	0.53	$1.82
CZ11	42,550	0.26	0.02	-	0.40	$1.34
CZ12	76,753	0.46	0.03	-	0.72	$2.42
CZ13	90,756	0.54	0.04	-	0.84	$2.83
CZ14	7,926	0.04	0.00	-	0.07	$0.22
CZ15	10,909	0.06	0.00	-	0.09	$0.31
CZ16	3,977	0.02	0.00	-	0.04	$0.12
Total	680,892	4.07	0.25	-	6.14	$21.35

Table 52: Total First-Year Energy Savings

Crop Type	Construction Type	First-Year[a] 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 Energy Cost Savings (PV$ Million)
Cannabis	New Construction & Additions	28.38	1.54	0.00	35.06	142.47
	Alterations	65.05	3.52	0.00	80.32	326.96
Greens	New Construction & Additions	3.86	0.43	0.00	6.53	21.74
	Alterations	8.82	0.99	0.00	14.91	49.65
Tomatoes	New Construction & Additions	1.78	0.17	0.00	3.63	10.30
	Alterations	3.82	0.38	0.00	7.81	22.10
All	Total	**111.71**	**7.03**	**0.00**	**148.26**	**573.22**

3.5.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions associated with energy consumption using the hourly GHG emissions factors that CEC developed along with the 2025 LSC hourly factors and an assumed cost of $123.15 per metric tons of carbon dioxide equivalent emissions (metric tons CO2e).

The 2025 LSC hourly factors used in the lifecycle cost-effectiveness analysis include the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs).[17] The cost-effectiveness analysis presented in Section 3.4 of this report does not include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the other economic impacts. The authors used the same monetary values that are used in the LSC hourly factors.

Table 53 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 8,374 (metric tons CO2e) would be avoided.

[17] The permit cost of carbon is equivalent to the market value of a unit of GHG emissions in the California Cap-and-Trade program, while social cost of carbon is an estimate of the total economic value of damage done per unit of GHG emissions. Social costs tend to be greater than permit costs. See more on the Cap-and-Trade Program on the California Air Resources Board website: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

Table 53: First-Year Statewide GHG Emissions Impacts

Facility	Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (Million Therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced GHG Emissions[a] (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions[b] ($)
Indoor	Cannabis	87.56	5,635.89	0.00	0.00	5,635.89	694,046
	Greens	0.29	26.08	0.00	0.00	26.08	3,211
	Tomatoes	0.68	60.66	0.00	0.00	60.66	7,470
Greenhouse	Cannabis	5.87	468.88	0.00	0.00	468.88	57,742
	Greens	12.39	1,108.24	0.00	0.00	1,108.24	136,477
	Tomatoes	4.92	544.81	0.00	0.00	544.81	67,093
All	All	**111.71**	**7,844.57**	**0.00**	**0.00**	**7,844.57**	**966,039**

a. First-year savings from all buildings completed statewide in 2026.

b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and Source Energy hourly factors by CEC here: https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

c. The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs) derived from the 2022 TDV Update Model published by CEC here: https://www.energy.ca.gov/files/tdv-2022-update-model

3.5.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

3.5.4 Statewide Material Impacts

The material impacts of a PPE level of 2.3 micromoles per Joule for indoor CEH facilities and for greenhouses were analyzed. The material impacts from the indoor CEH lighting proposal would come from the transition of HID lights to LEDs. The Statewide CASE Team assumed the same impacts for CEH facilities and greenhouses because both would switch from HID to LED. It is important to note that indoor CEH facilities baseline is higher (PPE level of 1.9) so there would likely be less impact. However, the same impact was used to simplify the calculation.

The Statewide CASE Team has updated this analysis for the Final CASE Report which differs in methodology and results from the Draft CASE Report. This update is due to additional studies being found to inform the analysis.

The Statewide CASE Team found a comparative lifecycle assessment (LCA) which analyzed LED and HPS specifically for greenhouses. While initially promising, this comparative LCA did not provide enough granular detail on material inputs for both technologies (Hao Zhang 2016). For example, the LED portion included materials like copper and glass, but the HPS portion did not. Likewise, the HPS portion included brass, plastic, and ceramics while the LED portion did not. It is possible that the specific luminaires chosen for the study did not include these same materials but likely the authors did not include each material because as noted in the study, only the major material inputs were listed. Without any of the major materials the Statewide CASE Team was interested in having overlap, ultimately, this study was not used for this analysis. One important note is that the results indicated in this study that the environmental impacts for LEDs were lower than HPS in every impact category listed.[18]

The Statewide CASE Team was attempted to find environmental product declarations (EPDs) that listed materials for grow lights (both LED and HPS) but was only able to locate EPDs for LEDs.[19] None of these EPDs were specifically for grow lights which may have been an issue except the Statewide CASE Team was unable to locate any EPDs for HPS which meant there was nothing to compare the LEDs to.

The Statewide CASE Team found another comparative LCA for HPS and LEDs which did include major materials overlap, so the information from that LCA was used for this analysis (Leena Tahkamo 2014). It's important to note that this LCA was not a perfect match because it compared road lighting luminaires and not luminaires used for CEH facilities. While not a perfect match, the study still provided useful information used to inform this analysis. Overall, using this comparative LCA yielded results that LEDs would have lower material impacts for mercury, copper, and steel. See Table 54 for further details.

Some additional considerations are that more materials were included in the LCA but the Statewide CASE Team focused on these three materials. Additionally, because the LCA focused on road lighting, the luminaires in the study are different than what would typically be found in a CEH facility. Specifically, the luminaires in the study were a 150 watt HPS luminaire and a 117 watt LED luminaire. Typical HPS and LED luminaires for CEH facilities would have significantly higher wattage which would likely have some impacts on the type and amount of materials used to construct the luminaires. Despite these differences, this LCA still provided the information needed to yield results within a reasonable range for the Statewide CASE Team's analysis. Table 54 below shows the combined material use impacts for indoor and greenhouse facilities and across each plant type. See Appendix D for more details.

[18] Impact categories: global warming, acidification, carcinogenics, non-carcinogenics, respiratory effects, eutrophication, ozone depletion, ecotoxicity, smog, and cumulative energy demand (CED).

[19] Example LED EPD: https://resources.z.lighting/object/EPD/EPDGen.aspx?Number=357360&CompanyID=1&Language=EN&CC=COM

Table 54: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per luminaire)	First-Year [a] Statewide Impacts (Pounds)
Mercury	Decrease	0.00	4.44
Lead	N/A	N/A	N/A
Copper	Decrease	0.76	72,959
Steel	Decrease	11.83	1,135,186
Plastic	N/A	N/A	N/A
Arsenic	N/A	N/A	N/A

a. First-year savings from all buildings completed statewide in 2026.

3.5.5 Other Non-Energy Impacts

There are no other quantifiable non-energy impacts for the proposed code change.

4. HVAC/D Equipment and Controls Integration

4.1 Measure Description

4.1.1 Justification and Background Information

4.1.1.1 Justification

The Statewide CASE Team explored mandatory environmental and irrigation controls in indoor horticulture facilities larger than a certain square feet threshold. The controls specify the monitoring parameters specific to plant growth such as temperature, humidity, CO2 levels, as well as parameters specific to plant irrigation such as pressure in irrigation lines.

One major barrier to developing this code change proposal was getting stakeholders to agree on values for environmental parameters such as temperature, humidity, and watering rate. The evaluation considered simple controls such as thermostats, switches, time clocks, irrigation timers, irrigation controllers, pressure sensors for irrigation lines as well as more complex controls that use computerized equipment. Interactions of lighting and HVAC systems were considered.

The objective of the proposed measure was to reduce energy use by requiring the use of more efficient HVAC/D system configurations in indoor growing facilities. These systems utilize site-recovered energy to reheat dehumidified air, have capacity-modulating condensing unit technologies, and have controls that allow systems to modulate with temperature and humidity controls. The Statewide CASE Team found barriers to measure development that resulted in the HVAC/D equipment and controls integration measure to be dropped. After pursuing several different options, it was determined that there are no feasible code change proposals available for this code cycle.

The following proposed measures were considered, but will not be reviewed in the context of this code cycle:

1. **Require modulating capacity dehumidification equipment and controls:**

    This considered measure aimed to save energy by requiring modulating capacity equipment for CEH facilities. Since space conditioning requirements change with plant growth, modulating capacity equipment has the potential to save energy by modulating capacity with the plant growth requirements.

    There were barriers that could not be resolved in this code cycle. One major barrier is possible federal preemption for commercial stand-alone dehumidifiers. This concern was brought up last code cycle, and there has been no change that would allow standards to be set for stand-alone dehumidifiers used in CEH applications. Without this, it would only be possible to increase efficiency of system types other than stand-alone dehumidifiers. This would disproportionately affect dehumidification equipment that is not considered a stand-alone dehumidifier.

Another barrier is the lack of industry test procedures or standards for performance of equipment in CEH facilities. Without these standards, it is difficult to specify capacity modulating technology across the various system types used in CEH facilities.

2. **Require HVAC and dehumidification system commissioning:**

   This considered measure aimed to achieve savings through proper sizing and commissioning of HVAC and dehumidification systems. There are several barriers that could not be resolved during this code cycle. While manufacturers have some commissioning practices, there are no industry-accepted guidelines for commissioning in CEH facilities. It is also difficult to fully model CEH facility performance in commissioning without having plants in the space. This measure would also require the development of a new acceptance test and training to educate acceptance test technicians on how to conduct the test.

3. **Require HVAC and dehumidification load sizing calculations:**

   This measure aimed to save energy by ensuring systems are right sized for CEH applications. The primary barrier facing this option is a lack of industry guidelines for sizing HVAC and dehumidification systems for CEH applications.

4.1.1.2 Background Information

In the 2022 Title 24, Part 6 code cycle, the Statewide CASE Team analyzed the feasibility of an irrigation and environmental control measure. The Statewide CASE Team considered lighting, temperature, humidity, and irrigation controls in indoor horticulture as well as an acceptance test for these controls. Prior to the second stakeholder meeting in March 2020, the Statewide CASE Team dropped this measure to focus on the lighting efficacy effort. Dehumidification manufacturers have recently provided input that there is opportunity for integrated environmental controls, so the measure is being reconsidered for the 2025 code cycle.

During the 2022 Energy Code development cycle, the Energy Commission determined that stand-alone dehumidifiers used for CEH facilities are federally preempted by 10 CFR, Part 430, Subpart B. Industry stakeholders did not agree with this determination, as they have historically not tested their large commercial dehumidifiers to the federal appliance standard. This has led to confusion among stakeholders on how to show compliance for stand-alone dehumidifiers. The Statewide CASE Team engaged with compliance officials to help resolve confusion with compliance and recommended that the Energy Commission provide updated guidance through a blueprint to educate industry stakeholders on compliance requirements.

There are no industry performance standards or test procedures specific to CEH facilities for dehumidification equipment. In 2021, ASABE (American Society of Agricultural and Biological Engineers) and ASHRAE developed a guidance document, ANSI/ASABE/ASHRAE EP653, to provide design considerations for HVAC and dehumidification in indoor growing facilities (ASHRAE 2019). This engineering practice document provides considerations that may be helpful in informing CEH HVAC/D code development, although it does not provide a test procedure for energy performance specific to CEH facilities.

4.2 Market Analysis

4.2.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meeting that the Statewide CASE Team held on October 25, 2022 (CASE, California Statewide Utiltiy Codes and Standards Enhancement Team 2022) and February 9, 2023 (CASE, California Statewide Codes and Standards Enhancement Team 2023). The Statewide CASE Team also presented on November 2, 2022, at the Resilient Harvests industry conference in Long Beach, California.

The HVAC/D (Heating, Ventilation, Air Conditioning, and Dehumidification) market for Controlled Environment Horticulture (CEH) facilities in California is competitive and has constantly evolved over the last 5 years, influenced and driven by advancements in technology and changing economic conditions within the CEH industry as a whole.

The HVAC/D industry for CEH is a specialized sector within the broader HVAC industry. It is structured similarly to the HVAC industry for other commercial and industrial applications, with HVAC & dehumidification companies that specialize in manufacturing, design, and installation of HVAC/D systems for CEH.

HVAC/D systems for CEH can be designed as either a single integrated unit that regulates and controls both temperature and humidity or as two separately controlled units that manage air temperature and dehumidification separately. They can be controlled by wall-mounted thermostats and on-unit humidistats or by a centralized environmental management system. However, regardless of the configuration, it is essential that the equipment is appropriately sized to handle the sensible and latent loads that are unique to each room within a facility and can maintain specific setpoints accurately.

Most large HVAC manufacturers in California sell equipment to CEH operators. Companies such as Trane, Carrier, Lennox, Dakin, LG, and Mitsubishi market their standard commercial HVAC units to growers. Some of these have begun to develop more horticulture focused solutions as of late, however, there are some manufacturers that provide HVAC/D systems which are specifically designed to create and maintain an environment that is conducive to plant growth. These companies provide equipment, components, and controls that cater to the unique needs of growing plants in a controlled environment. Indoor agriculture specialists like this include InSpire Transpiration (headquartered in San Francisco, California), Desert Aire Solutions, Quest Climate, Surna, Cultiva Systems, and AAON. Many of these companies offer more comprehensive solutions that encompass a broader range of services for CEH that includes equipment manufacturing, project management and construction, system design and engineering, and horticultural consulting.

The purchase of HVAC equipment typically includes humidity and thermostatic controls, which can be offered by both major HVAC manufacturers and specialty manufacturers. Controlled Environment Horticulture (CEH) operations can choose to use standard commercial control devices from companies like Honeywell, or they can opt for specialized agricultural control devices like Wadsworth Controls, Argus Controls, Titan Controls, or GrowLink.

Commissioning, calibrating of controls, and load calculations can be provided by a wide array of market actors. It is typically up to the building owner and/or operator where they would like to obtain these services, if at all. Specialized CEH HVAC/D equipment manufacturers may provide all three as a service, however, CEH operators often have an engineer provide load calculations which their HVAC/D systems are designed to. Specialized agricultural control and HVAC/D manufacturers will provide start-up support and equipment calibration as well. However, large HVAC manufacturers and distributors do not always provide start-up support. That responsibility is left to the grower and their mechanical contractor. Operators will collaborate with equipment manufacturers, architects, and engineering firms to ensure their equipment functions and is sized to their unique specification. CEH operators will identify operational parameters, accurately determine the expected sensible and latent loads in each room used for plant production and ensure equipment functions optimally after the building is fully operational.

4.2.2 Technical Feasibility and Market Availability

HVAC/D systems are essential for maintaining optimal growing conditions in plants grown in a controlled environment. There are various strategies that can be employed by operators of controlled environment horticulture (CEH) to manage temperature, humidity, VPD, and air circulation. These systems can be designed as an integrated unit that controls both temperature and humidity or as two separate units for air temperature and dehumidification. They can be controlled using wall-mounted thermostats, on-unit humidistats, or centralized environmental management systems. Based on research and multiple meetings with a group of CEH HVAC/D experts, Statewide CASE Team found several technical barriers that can hinder the proper sizing and commissioning of HVAC/D systems in indoor growing facilities due to variations in system design, configurations, and load calculations.

HVAC/D system design typically starts with the facility operator working with a mechanical design engineer or with the owner reaching out to the manufacturer or sales partner directly. From there, the mechanical designer and manufacturer representatives would coordinate to select and proposed equipment and systems that meets the environmental design conditions provided by the grower. However, growers will typically instruct their HVAC/D to oversize their systems to ensure they have enough capacity. Most growers do not actually calculate sensible or latent loads, they will use a rule-of-thumb based on the number of lights and plants they plan to have when sizing equipment or instruct their HVAC/D to design their systems to peak load. In most nonresidential buildings, HVAC loads are primarily calculated based on sensible loads to determine total loads, airflow, and equipment selection. However, in grow facilities latent loads are the main consideration. Using standard load calculation software tools for grow facilities can yield inaccurate results. As the size of the plants increases, cooling dry-bulb and relative humidity setpoints will change. While some specialized indoor agriculture HVAC/D manufacturers will properly account for the variability of latent and sensible loads as plants move through their lifecycle, many do not. This directly affects the amount of heat and moisture that must be removed to reach desirable environmental set-points when overlooked by engineers and manufacturers.

Both undersized and oversized HVAC/D units may have a negative impact on energy use. If a system is too large for the space it is cooling, it can short cycle frequently, leading to wasted energy and increased wear on the system. Additionally, oversized units may cool air too quickly, causing the temperature and humidity levels to fluctuate in a grow room. If an HVAC/D system is undersized for its grow room, it may operate for longer periods than necessary to achieve the desired temperature and humidity levels. If a system cannot meet the cooling demands of the grow room, it can lead to fluctuations in temperature and humidity levels that can negatively impact the plants' health and yield quality. Oversized and undersized HVAC/D systems can both lead to fluctuations which cause stress to the plants and reduce their overall growth potential.

This submeasure has been proposed to set standards that encourage operators, engineers, and manufacturers to appropriately size their HVAC/D systems to handle both sensible and latent loads and ensure that equipment functions correctly to maintain the required environmental conditions.

The CEH industry in California is currently facing challenges. According to a 2023 article by Reuters, “wholesale prices are reported to have crashed by as much as 95 percent since the state voted to legalize cannabis in 2016.” One stakeholder stated that, “growers in California are just trying to stay in business right now. Proper commissioning and design of HVAC/D systems have increased in states that have booming markets, but not California.” Equipment sizing has a direct impact on the initial cost of mechanical systems. Undersized systems may appear cost-effective in the short term, as they are cheaper to install, but they can lead to an array of problems that directly affect facility yield and profits in the long run. Whereas oversized HVAC/D equipment can lead to higher costs and longer returns on investment throughout the industry. It is crucial to educate designers and manufacturers on the importance of proper sizing and provide them with the tools to effectively communicate this to growers. This will enable them to recommend appropriately sized systems and promote more cost-effective solutions that provide precise environmental control. One stakeholder shared during a working group meeting that, “if you told growers how to find information to make sure their equipment was designed and operated correctly, they would jump all over that.”

Currently, only a few CEH-specific HVAC/D manufacturers provide any type of commissioning. Testing of equipment and controls functionality is typically left up to the mechanical contractor. Once all construction activities are completed and the CEH facility is fully operational, with plants growing throughout, commissioning can begin, and manufacturers and contractors can go through functional testing of equipment, controls, and sensors. The process of commissioning would need to be performed before the CEH building received its certificate of occupancy. However, a CEH building would not be able to put plants in without the certificate of occupancy. All stakeholder feedback indicated there is no way to create false sensible and latent loads to ensure the equipment can function properly without plants being grown in a building. To address the problem of partial loads before commissioning, a functional test could be conducted to confirm that the equipment is properly wired, and the sensors are functioning correctly. This test would be straightforward and would not place an unreasonable burden on the industry before construction. It would be part of the routine start-up testing performed by manufacturers and mechanical contractors and would benefit the building operator, as indicated by feedback from the CEH HVAC/D Stakeholder Working Group.

Currently there are no ASHRAE resources that specifically address commissioning and cooling load calculation processes for CEH buildings. While guidelines developed by the ASHRAE EP653 Development Committee do exist, they are primarily intended to provide foundational information to growers rather than detailed technical guidance – they provide growers with, "the foundational information that will a) facilitate the understanding of HVAC equipment options that can be used to manage the indoor plant environment (IPE) and b) allow the grower to communicate knowledgeably with engineers, contractors, manufacturers, investors, and other growers." That said, there are ASHRAE requirements for commissioning and cooling load calculation in other nonresidential buildings, but these have not yet been extended to CEH buildings. Developing similar guidelines for CEH would significantly enhance technical feasibility and education surrounding HVAC systems for cannabis cultivation across the country. By having clear commissioning guidelines, growers can be confident that their HVAC/D systems would meet industry standards and operate efficiently, which can result in increased crop yields, reduced energy consumption, and improved environmental control and also help prevent equipment failures and reduce maintenance costs over time.

The Statewide CASE Team recommends working with ASHRAE on the development of commissioning and load calculation requirements for HVAC/D systems for the indoor plant environment. It would be a significant step towards advancing the industry throughout the country by improving efficiency, productivity, and quality control.

5. Greenhouse Envelope

Greenhouse envelope was not a proposed measure for the 2025 code cycle, but there was significant stakeholder feedback and engagement with the Statewide CASE Team stemming from the 2022 rulemaking process and implementation of the requirements. The greenhouse industry raised concerns that the 2022 Energy Code requires greenhouses that meet the definition of "conditioned greenhouse" to use double glazing.

The Statewide CASE Team corresponded with Kubo Greenhouses, AB Energy, Borlaug, Windset Farms, Glass House Brands, Svensson, and the National Greenhouse Manufacturer's Association (NGMA) to understand the concerns with the code and understand what potential alternative pathways could work for the industry while maintaining the energy savings related with the code requirement for greenhouse envelope. The major concerns with double glazing are listed below:

- Reduction in visible light transmittance: Compared to single layer glazing, double glazing reduces light transmittance by up to 10 percent. Many growers utilize a rule of thumb that 1 percent reduction in light transmittance equates to 1 percent reduction in yield. Due to the reduced light transmittance, growers would have to supplement daylighting with electric horticultural LEDsgrow lighting.
- Condensation buildup: Double glazing can often lead to condensation buildup. This can lead to mold issues if not treated properly. Single layer greenhouses do not get the same condensation issues.
- No allowance for alternative compliance pathways: Several greenhouse stakeholders are interested in an alternate compliance path that utilizes shade and thermal curtains to achieve equivalent efficiency as a double-glazed building envelope.

The Statewide CASE Team welcomes any information that could help support the alternate compliance pathway for double glazing and show equivalence to the code.

6. Proposed Revisions to Code Language

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 2022 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

6.2 Standards

(h) Mandatory Requirements for Controlled Environment Horticulture (CEH) Spaces

(…)

2. Indoor growing, horticultural lighting. In a building with CEH spaces and with more than 40 kW of aggregate horticultural lighting load, the electric lighting systems used for plant growth and plant maintenance shall meet all of 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 2.3 ~~1.9~~ micromoles per joule~~; or~~

   ii. ~~Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 2.3 1.9 micromoles per joule.~~

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 NA7.6.2.

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

(…)

6. Greenhouses, horticultural lighting. In a greenhouse with more than 40 kW of aggregate horticultural lighting load, 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 2.3 ~~1.7~~ micromoles per joule; or

   ii. ~~Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least 1.7 2.3 micromoles per joule.~~

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 NA7.6.2.

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

6.3 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

6.5 Compliance Forms

Compliance document NRCC-PRC-E Process Systems would need to be revised. The revision would only require updating the minimum efficacy for indoor and greenhouse CEH lighting.

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U.S. BUREAU OF LABOR STATISTICS.

Appendix A: Statewide Savings Methodology

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts that the CEC provided (California Energy Commission 2022). The CEC provided the construction estimates on March 27, 2023, at the Staff Workshop on Triennial California Energy Code Measure Proposal Template.

To calculate first-year statewide savings, the Statewide CASE Team multiplied the per-unit savings by statewide construction estimates for the first year the standards will be in effect (2026). The nonresidential new construction forecast is presented in Table 55 and nonresidential existing statewide building stock is presented in Table 56. The projected nonresidential new construction that will be impacted by the proposed code change in 2026 is presented in Table 55. The projected nonresidential existing statewide building stock that will be impacted by the proposed code change as a result of alterations in 2026 is presented in Table 56. This section describes how the Statewide CASE Team developed these estimates.

The CEC Building Standards Office provided the nonresidential construction forecast, which is available for public review on the CEC's website: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

The construction forecast presents the total floorspace of newly constructed buildings in 2026 by building type and climate zone. The building types included in the CECs' forecast are summarized in Table 55.

The Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 59 presents the assumed percentage of floorspace that would be impacted by the proposed code change by building type. If a proposed code change does not apply to a specific building type, it is assumed that zero percent of the floorspace would be impacted by the proposal. If the assumed percentage is non-zero, but less than 100 percent, it is an indication that some but not all buildings would be impacted by the proposal. Table 55 presents the percentage of floorspace assumed to be impacted by the proposed change by climate zone.

Table 55: Estimated New Nonresidential Construction in 2026, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All CZs
Large Office	0.00	0.00	3.23	1.58	0.00	1.42	0.83	2.29	4.15	0.39	0.11	0.57	0.00	0.20	0.01	0.05	14.84
Medium Office	0.13	0.48	1.37	0.74	0.37	1.20	0.80	1.65	3.18	1.17	0.27	2.80	0.59	0.35	0.26	0.10	15.47
Small Office	0.01	0.44	0.19	0.02	0.06	0.15	0.23	0.16	0.36	0.42	0.09	0.54	0.39	0.04	0.11	0.03	3.24
Large Retail	0.00	0.00	1.10	0.55	0.15	0.70	0.37	0.83	1.66	0.63	0.30	1.30	0.36	0.14	0.18	0.06	8.34
Medium Retail	0.08	0.35	0.79	0.45	0.09	0.60	0.29	0.86	1.42	0.82	0.14	0.63	0.38	0.18	0.12	0.08	7.29
Strip Mall	0.00	0.15	0.50	0.23	0.01	0.56	0.49	0.99	1.07	1.35	0.07	0.59	0.33	0.32	0.10	0.06	6.81
Mixed-use Retail	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
Large School	0.01	0.13	0.88	0.44	0.04	0.59	0.61	0.91	1.42	0.85	0.35	1.15	0.61	0.17	0.09	0.07	8.31
Small School	0.07	0.27	0.46	0.23	0.14	0.32	0.29	0.35	0.66	0.35	0.10	0.78	0.30	0.11	0.04	0.04	4.50
Non-refrigerated Warehouse	0.06	0.37	2.16	1.12	0.18	1.36	0.71	1.95	3.01	1.36	0.63	2.84	0.82	0.36	0.37	0.14	17.44
Hotel	0.04	0.22	1.03	0.53	0.11	0.55	0.48	0.78	1.18	0.57	0.15	0.80	0.26	0.14	0.12	0.04	7.02
Assembly	0.01	0.39	1.58	0.56	0.06	0.79	0.80	1.43	1.82	1.14	0.17	1.41	0.30	0.25	0.12	0.08	10.92
Hospital	0.03	0.17	0.84	0.44	0.08	0.33	0.55	0.44	0.79	0.81	0.15	0.83	0.27	0.14	0.12	0.05	6.03
Laboratory	0.00	0.05	0.63	0.36	0.02	0.07	0.05	0.10	0.12	0.06	0.01	0.05	0.01	0.01	0.01	0.00	1.57
Restaurant	0.01	0.08	0.33	0.17	0.03	0.34	0.20	0.49	0.82	0.41	0.07	0.31	0.14	0.10	0.05	0.03	3.59
Enclosed Parking Garage	0.00	0.01	1.83	1.25	0.00	2.59	0.71	2.27	1.53	0.05	0.00	0.04	0.00	0.02	0.00	0.01	10.29
Open Parking Garage	0.00	0.12	2.47	1.68	0.06	3.65	1.20	3.20	2.16	0.65	0.02	0.53	0.04	0.20	0.05	0.09	16.12
Grocery	0.01	0.05	0.10	0.06	0.01	0.05	0.02	0.05	0.09	0.05	0.01	0.04	0.02	0.01	0.01	0.01	0.58
Refrigerated Warehouse	0.00	0.00	0.06	0.05	0.01	0.02	0.00	0.01	0.01	0.04	0.00	0.07	0.12	0.01	0.01	0.01	0.41
Controlled Environment Horticulture	0.09	0.08	0.32	0.04	0.20	0.26	0.00	0.02	0.03	0.28	0.30	0.31	0.09	0.01	0.05	0.00	2.08
Vehicle Service	0.00	0.08	0.55	0.36	0.03	0.55	0.34	0.80	1.81	0.57	0.02	0.39	0.25	0.20	0.06	0.05	6.05
Manufacturing	0.01	0.13	0.40	0.19	0.06	0.13	0.09	0.11	0.10	0.11	0.06	0.16	0.02	0.02	0.02	0.01	1.62
Unassigned	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
TOTAL	**0.6**	**3.6**	**20.8**	**11.5**	**1.7**	**16.2**	**9.1**	**19.7**	**27.4**	**12.1**	**3.0**	**16.2**	**5.3**	**3.0**	**1.9**	**1.0**	**152.9**

Source: CEC Measure Proposal Template https://www.energy.ca.gov/media/3538

Table 56: Estimated Existing Floorspace in 2026, by Climate 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 CZs
Large Office	0.13	3.10	139.80	72.35	1.83	99.54	72.71	162.60	303.10	58.48	2.61	78.61	9.26	20.27	4.43	4.66	1033.49
Medium Office	3.38	30.99	78.79	42.28	13.32	47.81	43.87	59.11	86.34	66.69	16.94	101.70	25.18	13.33	10.25	4.06	644.04
Small Office	4.18	12.75	22.19	11.33	7.50	13.22	8.52	13.28	20.88	24.43	10.60	43.94	21.47	4.99	6.18	2.68	228.13
Large Retail	1.00	8.67	58.68	26.90	4.20	31.96	25.34	43.46	66.53	53.31	11.40	58.16	22.51	10.91	9.40	3.21	435.64
Medium Retail	1.18	13.11	44.52	25.74	5.43	44.27	34.66	66.72	108.20	66.89	10.37	60.50	24.15	15.53	8.77	5.17	535.21
Strip Mall	3.34	9.84	37.42	18.43	5.10	40.23	28.29	55.76	83.70	66.92	12.25	48.37	24.18	15.27	8.70	4.59	462.38
Mixed-use Retail	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
Large School	0.76	8.02	34.83	13.95	2.07	28.37	22.54	42.91	73.58	56.01	10.13	53.38	26.41	12.06	7.62	3.59	396.23
Small School	2.23	11.13	25.57	9.98	6.06	25.69	14.96	34.44	54.31	33.03	13.50	42.08	23.44	8.72	4.25	3.65	313.04
Non-refrigerated Warehouse	3.33	20.22	108.30	53.43	9.80	89.98	51.48	128.40	207.30	182.70	33.73	148.30	51.08	38.87	29.05	11.63	1167.60
Hotel	1.77	10.52	48.10	24.73	5.01	30.49	32.66	41.97	66.01	37.09	7.22	40.53	13.08	8.01	5.88	2.44	375.50
Assembly	4.33	18.18	91.34	45.06	6.59	57.25	40.90	89.14	120.20	91.75	16.35	69.72	30.13	18.95	11.83	6.44	718.16
Hospital	1.87	11.09	48.33	24.67	5.06	28.25	27.15	40.77	69.88	39.60	11.11	53.18	22.49	8.80	5.03	3.23	400.51
Laboratory	0.18	4.01	36.93	28.06	1.53	12.21	17.19	15.61	19.31	10.81	0.68	12.14	4.40	1.72	0.39	0.57	165.74
Restaurant	0.61	3.62	14.72	7.49	1.55	16.46	10.73	23.78	40.00	32.41	3.52	16.95	7.74	6.86	3.45	1.90	191.78
Enclosed Parking Garage	0.02	0.54	40.71	30.94	0.30	29.15	20.67	58.41	72.53	2.67	0.35	3.09	0.49	0.85	0.17	0.43	261.32
Open Parking Garage	0.22	7.02	55.03	41.82	3.86	41.14	35.17	82.44	102.40	34.57	4.46	39.96	6.31	11.05	2.16	5.62	473.23
Grocery	0.10	1.70	5.87	3.56	0.75	3.42	2.08	4.01	6.95	4.02	0.65	3.74	1.45	0.93	0.54	0.38	40.15
Refrigerated Warehouse	0.00	0.46	0.91	0.21	0.39	0.46	0.02	0.42	0.79	0.65	0.26	2.15	3.91	0.18	0.19	0.14	11.15
Controlled Environment Horticulture	0.70	0.46	2.62	1.07	6.33	8.26	1.07	0.74	1.60	3.61	2.51	4.53	5.36	0.47	0.64	0.23	40.21
Vehicle Service	0.91	6.18	33.65	15.98	2.97	33.73	23.08	49.52	81.78	56.54	6.30	38.32	18.24	15.09	6.18	3.54	392.01
Manufacturing	4.11	16.89	61.93	79.55	5.59	73.33	33.27	122.70	168.10	49.58	12.86	57.01	25.97	16.98	5.15	9.27	742.28
Unassigned	0.36	6.58	9.03	6.32	0.22	2.58	0.77	3.78	7.87	2.55	3.37	14.35	2.94	0.77	0.40	1.03	62.89
TOTAL	**34.7**	**205.1**	**999.3**	**583.9**	**95.5**	**757.8**	**547.1**	**1140.0**	**1761.4**	**974.3**	**191.2**	**990.7**	**370.2**	**230.6**	**130.7**	**78.5**	**9090.7**

Source: CEC Measure Proposal Template https://www.energy.ca.gov/media/3538

Table 57: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All CZs
CEH Indoor Cannabis	0.02	0.02	0.07	0.01	0.04	0.05	0.00	0.00	0.01	0.06	0.06	0.06	0.02	0.00	0.01	0.00	0.43
CEH Indoor Greens	0.0010	0.0009	0.0036	0.0004	0.0023	0.0029	0.0000	0.0003	0.0003	0.0031	0.0034	0.0034	0.0010	0.0001	0.0005	0.0001	0.0233
CEH Indoor Tomatoes	0.0006	0.0005	0.0021	0.0003	0.0014	0.0017	0.0000	0.0002	0.0002	0.0019	0.0020	0.0021	0.0006	0.0001	0.0003	0.0000	0.0140
CEH Greenhouse Cannabis	0.0132	0.0111	0.0457	0.0057	0.0289	0.0368	0.0002	0.0033	0.0037	0.0397	0.0432	0.0436	0.0129	0.0015	0.0068	0.0007	0.2970
CEH Greenhouse Greens	0.0132	0.0111	0.0457	0.0057	0.0289	0.0368	0.0002	0.0033	0.0037	0.0397	0.0432	0.0436	0.0129	0.0015	0.0068	0.0007	0.2970
CEH Greenhouse Tomatoes	0.0176	0.0148	0.0609	0.0076	0.0385	0.0491	0.0003	0.0045	0.0050	0.0529	0.0576	0.0581	0.0172	0.0021	0.0091	0.0009	0.3960
TOTAL	**0.0656**	**0.0584**	**0.228**	**0.0297**	**0.14**	**0.1773**	**0.0007**	**0.0116**	**0.0229**	**0.1973**	**0.2094**	**0.2108**	**0.0646**	**0.0053**	**0.0335**	**0.0024**	**1.4573**

Table 58: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All CZs
CEH Indoor Cannabis	0.02	0.01	0.06	0.03	0.15	0.20	0.03	0.02	0.04	0.09	0.06	0.11	0.13	0.01	0.02	0.01	0.98
CEH Indoor Greens	0.0009	0.0006	0.0035	0.0014	0.0084	0.0110	0.0014	0.0010	0.0021	0.0048	0.0033	0.0060	0.0071	0.0006	0.0009	0.0003	0.0534
CEH Indoor Tomatoes	0.0006	0.0004	0.0021	0.0009	0.0050	0.0066	0.0009	0.0006	0.0013	0.0029	0.0020	0.0036	0.0043	0.0004	0.0005	0.0002	0.0320
CEH Greenhouse Cannabis	0.0118	0.0077	0.0444	0.0182	0.1071	0.1399	0.0182	0.0126	0.0271	0.0611	0.0426	0.0768	0.0908	0.0079	0.0109	0.0040	0.6809
CEH Greenhouse Greens	0.0118	0.0077	0.0444	0.0182	0.1071	0.1399	0.0182	0.0126	0.0271	0.0611	0.0426	0.0768	0.0908	0.0079	0.0109	0.0040	0.6809
CEH Greenhouse Tomatoes	0.0158	0.0103	0.0591	0.0242	0.1428	0.1866	0.0242	0.0167	0.0361	0.0815	0.0567	0.1023	0.1210	0.0106	0.0145	0.0053	0.9079
TOTAL	**0.0158**	**0.0103**	**0.0591**	**0.0242**	**0.1428**	**0.1866**	**0.0242**	**0.0167**	**0.0361**	**0.0815**	**0.0567**	**0.1023**	**0.121**	**0.0106**	**0.0145**	**0.0053**	**0.9079**

Table 59: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
CEH Indoor Cannabis	20.61 %	2.44 %
CEH Indoor Greens	1.12 %	0.13 %
CEH Indoor Tomatoes	0.67 %	0.08 %
CEH Greenhouse Cannabis	14.28 %	1.69 %
CEH Greenhouse Greens	14.28 %	1.69 %
CEH Greenhouse Tomatoes	19.04 %	2.26 %

Table 60: 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	16.4%	0.1%
2	2.2%	0.0%
3	1.5%	0.0%
4	0.3%	0.0%
5	11.8%	0.3%
6	1.6%	0.1%
7	0.0%	0.0%
8	0.1%	0.0%
9	0.1%	0.0%
10	2.3%	0.0%
11	10.0%	0.1%
12	1.9%	0.0%
13	1.7%	0.1%
14	0.4%	0.0%
15	2.6%	0.0%
16	0.5%	0.0%

Appendix B: Embedded Electricity in Water Methodology

There are no on-site water savings associated with the proposed code change.

Appendix C: California Building Energy Code Compliance (CBECC) Software Specification

There are no recommended revisions to the compliance software as a result of this code change proposal.

Appendix D: Environmental Analysis

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2025 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed standards. A "significant effect on the environment" is "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." (Cal. Code Regs., tit. 14, § 15002(g).)

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 determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

There are significant energy savings and GHG emission reductions from this proposal. There are no water savings associated with this proposal. For more information on energy savings, see Section 3.3.

GHG emissions are calculated using the hourly emissions factors that CEC provided (California Energy Commission 2022).

The material impacts from the lighting proposal come from the transition of HID lights to LEDs. To assess the material impact of this proposal, the Statewide CASE Team analyzed online reports documenting material contents of LED, CFL and incandescent lamps and also conducted general research for the contents of HPS lamps. The reports on LEDs, CFLs, and incandescent lamps provided precise estimates of materials in each type of lamp, while the Statewide CASE Team was unable to find such specific analysis for HPS lamps. However, typical material contents of HPS lamps were determined. While the material content of LED lamps used for indoor lighting may not directly translate to that of horticultural LEDs, it was determined that this was the best available information.

Notably, the Statewide CASE Team expects to see a decrease in mercury since HIDs contain mercury while LEDs do not. One double ended HPS grow lamp contains an estimated 39 mg of mercury (LEDVANCE n.d.). This level was used as an estimation for the typical HPS lamp. When extrapolated out to the estimate statewide canopy stock, mercury content is expected to decrease by approximately 11 pounds in the first year. Based on relevant studies and online research, the Statewide CASE Team does not expect a change in the use of lead, steel, or plastic. According to a study, the LEDs examined did not contain detectable levels of arsenic, so for the proposes of this code proposal, there is no assumed change in arsenic impacts. Similarly, in this study, LED lamps contain levels of copper in between that of CFLs and incandescents, and as mentioned, the Statewide CASE Team, was unable to find specific levels of copper in HPS bulbs, so there was no assumed change in the copper impacts. While the Statewide CASE Team is not aware of information showing precise estimates of copper in HPS lamps, many lamps do contain copper ballasts.

The study mentioned above indicates increases in silver, chromium, and gallium in LEDs compared to incandescents and CFLs. HPS lamps do not typically contain detectable levels of these elements, so increases in these metals are expected.

Direct Adverse Environmental Impacts

There are no identified direct adverse environmental impacts from this code change proposal.

Indirect Environmental Impacts

Indirect Environmental Benefits

There are no identified indirect environmental benefits from this code change proposal.

Indirect Adverse Environmental Impacts

There are no identified indirect adverse environmental impacts from this code change proposal.

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

If an EIR is developed, CEQA requires a lead agency to evaluate reasonable alternatives to proposals that would have a significant adverse effect on the environment, including a “no project” alternative. (Cal. Code Regs. Tit. 14, §15002(h)(4) and 15126.6.)

The Statewide CASE Team has considered alternatives to the proposal and believes that no alternative achieves the purpose of the proposal with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use from the proposed code change.

Embodied Carbon in Materials

Accounting for embodied carbon emissions is important for understanding the full picture of a proposed code change's environmental impacts. The embodied carbon in materials analysis accounts specifically for emissions produced during the "cradle-to-gate" phase: emissions produced from material extraction, manufacturing, and transportation. Understanding these emissions ensures the proposed measure considers these early stages of materials production and manufacturing instead of emissions reductions from energy efficiency alone.

The Statewide CASE Team calculated emissions impacts associated with embodied carbon from the change in materials as a result of the proposed measure. The calculation builds off the materials impacts outlined in Section 3.5.4. See that section for more details on the materials impact analysis.

After calculating the materials impacts, the Statewide CASE Team applied average embodied carbon emissions for each material. The embodied carbon emissions are based on industry-wide environmental product declarations (EPDs).[20, 21] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[22] The Statewide CASE Team chose the industry-wide average for GWP values in the EPDs because the materials accounted for in the statewide calculation will have a range of embodied carbon; i.e. some materials like concrete have a wide range

[20] EPDs are documents which disclose a variety of environmental impacts, including embodied carbon emissions. These documents are based on lifecycle assessments on specific products and materials. Industry-wide EPDs disclose environmental impacts for one product for all (or most) manufacturers in a specified area and are often developed through the coordination of multiple manufacturers and/or associations. A manufacturer specific EPD only examines one product from one manufacturer. Therefore, an industry-wide EPD discloses all the environmental impacts from the entire industry (for a specific product/material) but a manufacturer specific EPD only factors one manufacturer.

[21] An industry wide EPD was not used for mercury, lead, copper, plastics, and refrigerants. Global warming potential values of mercury, lead and copper are based on data provided in a lifecycle assessment (LCA) conducted by Yale University in 2014. The GWP value for plastic is based on a LCA conducted by Franklin Associates, which capture roughly 59 percent of the U.S.' total production of PVC and HDPE production. The GWP values for refrigerants are based on data provided by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

[22] GWP values for concrete and wood were in units of kg CO2 equivalent by volume of the material rather than by weight. An average density of each material was used to convert volume to weight.

of embodied carbon depending on the manufacturer's processes, source of the materials, etc. The Statewide CASE Team assumes that most building projects will not specify low embodied carbon products. Therefore, an average is appropriate for a statewide estimate.

First-year statewide impacts per material (in pounds) were multiplied by the GWP impacts for each material. This provides the total statewide embodied carbon impact for each material. If a material's use is increased, then there is an increase in embodied carbon impacts (additional emissions). If a material's use is decreased, then there is a decrease in embodied carbon impacts (emissions reduced). Table 61 presents estimated first-year GHG emissions impacts associated with embodied carbon.

A comprehensive accounting of buildings' GHG emissions would include operational emissions (e.g., emissions from energy use) and embodied carbon. Title 24, Part 6 addresses energy use in buildings and results in reductions in operational GHG emissions. The Statewide CASE Team has provided embodied carbon impacts of the proposed code changes, which could support an informed dialogue on how operational emissions and embodied emissions be considered together in the future. The information provided in this report is an incomplete accounting of whole-building embodied carbon and does not account for interactive effects that the proposal may have on other elements of the building design or material use. There may be instances where a specific system or component may increase emissions through embodied carbon but enable the building as a whole to have lower total emissions (operational plus building-wide embodied carbon).

Table 61: First-Year Embodied Carbon Emissions Impacts

Material	Impact	First-Year [a] Statewide Impacts (Pounds)	Embodied GHG Emissions Reductions (Metric Tons CO2e)
Mercury	Decrease	4.44	0.02
Copper	Decrease	72,959	93
Steel	Decrease	1,135,186	624
TOTAL	N/A	N/A	**717.02**

a. First-year savings from all buildings completed statewide in 2026.

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

This appendix discusses how the recommended compliance process, which is described in Section 3.1.4, could impact various market actors. Table 62 identifies the market actors who will play a role in complying with the proposed change, the tasks for which they are responsible, how the proposed code change could impact their existing workflow, and ways negative impacts could be mitigated. The information contained in Table 62 is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. Appendix F summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

This code change proposal would largely follow the compliance process laid out in the 2022 Final CASE Report. Completion of compliance documents is an essential step to ensure compliance, and horticulture facility owners, contractors, and designers may need guidance on how to do so. Compliance documents would need to identify relevant lighting and HVAC equipment to document specific technologies used.

To facilitate an efficient compliance process under the proposed code change, collaboration among a variety of individuals is important. General, lighting, and HVAC contractors would need to closely collaborate with the design team and ensure the relevant documents are shared with one another. Field inspectors would need to now work with indoor horticulture permit applicants to ensure the proper parts of the facility are inspected and that the proposed building plans meet Title 24, Part 6 regulations.

On smaller projects, the same person would likely perform multiple functions. For example, a general contractor may design and build lighting, irrigation, and HVAC/dehumidification systems. Large projects would more likely involve specialized vendors for lighting, controls, and HVAC/dehumidification systems.

Since navigating compliance procedures can be a daunting task, industry groups have developed tools to help growers show compliance. The PowerScore developed by Resource Innovation Institute is used by the state of Massachusetts to confirm energy and water performance for grow facilities (Resource Innovation Institute n.d.). Facilities outside of the state can use the free platform to analyze their respective efficiency levels. Energy Code Ace is also developing tools which will assist market actors with compliance, such as their CEH Code Breaker[23] training.

[23] https://energycodeace.com/codebreaker

Table 62 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing workflow, and ways negative impacts could be mitigated.

Table 62: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
CEC	• Luminaires used for plant growth • Dehumidification efficiency standards in CEH facilities	Compliance process would not change for the proposed measure	Update the Nonresidential Compliance Manual and certificate of compliance document (NRCC-PRC-E Process Systems) and the certificate of acceptance document	• The Statewide CASE Team recommends including the following data fields in the certificate of compliance document: • Canopy size. • PPE ratings of lighting luminaires in micromoles per joule. • Type of dehumidification system and its moisture removal efficiency in pounds of moisture per kilowatt-hour. • Type of HVAC system • Yes/no on the use of carbon dioxide.
Indoor Horticulture Facility Designer	• Design facility to the needs and plans of the facility owner. • Comply with relevant non-energy efficiency related building codes.	• Design a facility that meets applicable Title 24, Part 6 requirements and other building standards. • Complete or assist in completing a certificate of compliance document for permit application. • Ensure building plans are consistent with the information in the certificate of compliance. • Would have to document compliance with the proposed requirements.	Compliance process would not change for the proposed measure	• The Statewide CASE Team recommends including the following in the Nonresidential Compliance Manual: • Examples showing facilities that are compliant with Title 24, Part 6. • Examples showing facilities that are not compliant with Title 24, Part 6 with explanations as to why.
Greenhouse Designer	• Design facility to the needs of the owner. • Comply with non-energy standards in Title 24, Part 6. • If a conditioned greenhouse, comply with required nonresidential envelope requirements.	Would have to design HVAC and dehumidification systems that meet the proposed requirements Would have to design lighting systems that meet the proposed requirements	Compliance process would not change for the proposed measure	• The Statewide CASE Team recommends including the following in the Nonresidential Compliance Manual: • Examples showing facilities that are compliant with Title 24, Part 6. • Examples showing facilities that are not compliant with Title 24, Part 6 with explanations as to why.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Lighting Designer	• Identify lighting luminaires and lighting controls that suit the needs of the facility. • Coordinate design with HVAC designers to account for interaction between lighting and HVAC/dehumidification systems. • Serve as an expert in lighting technology.	• Would have to design lighting systems that meet the proposed requirements. • May need to document compliance with the proposed requirements. • Identify lighting luminaires and lighting controls that meet the proposed standards. • Assist in completing or complete a certificate of compliance for permit application.	Compliance process would not change for the proposed measure	The Statewide CASE Team recommends setting a standard that uses metrics that can be met with widely available and familiar technologies.
Mechanical HVAC Designer	Serve as an expert for specifying HVAC / dehumidification system.	• Design a dehumidification system that meets the proposed standards. • Assist in completing or complete a certificate of compliance for permit application	Compliance process would not change for the proposed measure	Support horticulture industry efforts to develop a testing protocol for dehumidification systems.
Enforcement Agency Plans Examiner	Review plans to ensure minimum code compliance is met.	• Would need to verify horticultural lighting load calculations and equipment specifications are compliant with the proposed requirements. • Become aware of relevant code requirements and updated compliance documents. • Review submitted building plans and compliance documents to verify compliance.	Compliance process would not change for the proposed measure	• Develop training for building department officials to handle new code requirements. • Develop compliance document that auto-verifies compliance status of entered data.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
General Contractor	Build the horticulture facility in accordance with the building plans.	• Would have to build a horticulture facility that meets the proposed requirements. • When field changes result in noncompliance, obtain an approval from the enforcement agency of the revised certificate of compliance document. • Complete a certificate of installation document.	Compliance process would not change for the proposed measure	Provide an option to contractors for getting answers related to compliance over the phone.
Lighting Contractor or Electrician	Build lighting system in accordance with the building plans.	Would have to build a lighting system that meets the proposed requirements.	Compliance process would not change for the proposed measure	Provide an option to contractors for getting answers related to compliance over the phone.
Building Automation Controls Contractor	Serve as an expert for selecting, installing, and commissioning environmental and irrigation controls.	Would have to install controls that meet the proposed requirements.	Compliance process would not change for the proposed measure	Provide an option to contractors for getting answers related to compliance over the phone.
Enforcement Agency Field Inspector	• Coordinate final inspection with the permit applicant. • Verify that the horticulture facility is constructed in accordance with the building plans.	Would have to verify compliance with Title 24, Part 6 for horticulture facilities.	Compliance process would not change for the proposed measure	Develop training for building department officials to handle new code requirements.
Energy Consultant	• Coordinate with Lighting and HVAC Designers on specifications of system • Determine efficiency of specified equipment and ensure it meets or exceeds code minimum requirements	Would have to verify compliance with Title 24, Part 6 for horticulture facilities.	Compliance process would not change for the proposed measure	Provide an option to consultants for getting answers related to compliance over the phone.

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders who might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to identify and address issues associated with the proposed code changes so that the proposals presented to the CEC in this Final CASE Report are generally supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption, including cost effectiveness, market barriers, technical barriers, compliance and enforcement challenges, or 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 that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of stakeholder 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 provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asks for feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results for analyses
- Data to support assumptions
- Compliance and enforcement, and
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for CEH via webinar described in Table 63. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

Table 63: Utility-Sponsored Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
Utility-Sponsored Stakeholder Welcome Meeting	Tuesday, October 25, 2022	https://title24stakeholders.com/event/welcome-to-the-2025-energy-code-cycle-stakeholder-meeting-nonresidential/
Nonresidential Covered Process Utility-Sponsored Stakeholder Meeting	Thursday, February 9, 2022	https://title24stakeholders.com/event/nonresidential-commercial-kitchens-and-controlled-environmental-horticulture-utility-sponsored-stakeholder-meeting/

The welcome meeting for the utility-sponsored stakeholder meetings occurred on October 25, 2022 (CASE, California Statewide Utiltiy Codes and Standards Enhancement Team 2022) and was important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued by the Statewide CASE Team. The objectives of the stakeholder welcome meeting were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers.

The second round of utility-sponsored stakeholder meetings occurred on February 9, 2023 (CASE, California Statewide Codes and Standards Enhancement Team 2023) and provided updated details on proposed code changes. The second round of meetings introduced early results of energy, cost-effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com One email was sent to the entire Title 24 Stakeholders listserv, totaling over 3,000 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page (and cross-promoted on the CEC LinkedIn page) two weeks before each meeting to reach out to individuals and larger organizations and 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 into the listserv. Exported webinar meeting data captured attendance numbers and individual comments, and recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

Lighting Supply Chain Surveys

Surveys were conducted with multiple market actors across the horticultural lighting supply chain to understand key aspects of the horticultural lighting industry in California. Ten detailed surveys were conducted. The following stakeholders participated in the interviews: CABA Tech, TSR Grow, Illuminar Lighting, California LightWorks, Cultivation Warehouse, Current Lighting, Hummert International, Acuity Brands, and Shine Retrofits.

Key Stakeholder Meetings

The Statewide CASE Team met with key stakeholders that commented in the previous code cycle such as Seinergy, Mark Lefsrud of McGill University, DesignLights Consortium (DLC), Hawthorne Gardening Company, Fluence, and Agnetix to provide opportunity for input on the proposed code change.

Key insights from the conversations are listed below:

- Horticultural LEDs have increased market share significantly in the past three years, with an estimated increase of 15-20 percent from the 2022 CEH Final CASE Report.
- Horticultural LED cost has reduced approximately 16 percent from 2020 to 2023, as described in Section 3.4.3.
- Current Lighting and Gavita are transitioning to all LED product lines and discontinuing their HID (high intensity discharge) product lines. These are two major horticultural lighting manufacturers that originally started with HID horticultural LEDs as their primary horticultural lighting products.
- There is a lack of standards, sizing guides, and test procedures specific to the CEH HVAC industry. Industry development of these types of resources would support future CEH HVAC code development.
- A performance building model for CEH would expand opportunities for proposed CEH HVAC measures. Without this model, it will be difficult to define new code change proposals for CEH HVAC measures. Due to the development time and effort required, developing a CEH prototype in the 2025 code cycle is not feasible. It could be feasible for future code cycles though and would expand opportunities for CEH Energy Code measures.

HVAC and Dehumidification (HVAC/D) Industry Working Group Meetings

Three focus group meetings were held with industry experts to help refine the measure development for CEH HVAC/D. The group outlined barriers to developing a measure for the 2025 code cycle and explored potential options such as acceptance test development, commissioning requirements specific to CEH, and load sizing calculation requirements.

Lighting Code Language Review

The California Lighting Technology Center (CLTC) hosted a series of meetings to review existing CEH code language as part of a code "clean up" initiative, supported by SCE and in collaboration with the California Energy Alliance, and provide suggestions for refining and clarifying code language.

Resilient Harvests Conference

The Statewide CASE Team presented the 2025 CEH proposed code changes at the Resilient Harvests Conference in Long Beach, California on November 2, 2022. Several key CEH stakeholders were in attendance, and the Statewide CASE Team was able to socialize the code change proposal with them and receive in-person feedback from several key stakeholders. Greenhouse envelope concerns on the 2022 Energy Code surrounding the double glazing requirement were a specific topic of stakeholder feedback.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 64.

Table 64: Engaged Stakeholders

Contact	Organization	Date of Outreach	Method of Outreach	Topic
Andrew Gustafson	TRC	6/17/2022	Meeting	General
Andrew Horowitz	Kubo Greenhouses	10/28/2022	Meeting	Greenhouse Envelope
Andrew Horowitz	Kubo Greenhouses	10/31/2022	Meeting	Greenhouse Envelope
Dan Dettmers	Quest Climate	11/2/2022	Meeting	HVAC/D
Keith Coursin	Desert Aire	11/2/2022	Meeting	HVAC/D
Brian Kammers	Desert Aire	11/2/2022	Meeting	HVAC/D
Adrian Giovenco	Inspire Transpiration Solutions	11/2/2022	Meeting	HVAC/D
Rupal Choksi	Madison Indoor Air Quality	11/2/2022	Meeting	HVAC/D
Nicole Hathaway	CLTC (California Lighting Technology Center)	11/15/2022	Meeting	Lighting
Dick Kramp	AB Energy	11/15/2022	Meeting	Greenhouse Envelope

Contact	Organization	Date of Outreach	Method of Outreach	Topic
Kurt Parbst	Borlaug	11/15/2022	Meeting	Greenhouse Envelope
Garth Torvestad	2050 Partners	11/16/2022	Meeting	HVAC/D
Aaron Hodgson	Glass House	11/21/2022	Meeting	Greenhouse Envelope
Jeremy Yon	Current lighting	12/2/2022	Meeting	Lighting
Nicole Hathaway	CLTC	12/13/2022	Meeting	Lighting
Corinne Wilder	Fluence	12/13/2022	Email	Lighting
Ihor Lys	Agnetix	12/13/2022	Email	Lighting
Andrew Horowitz	Kubo Greenhouses	12/13/2022	Meeting	Greenhouse Envelope
Joji Singh	Inspire Transpiration Solutions	12/14/2022	Email	HVAC/D
Robert Hanifin	Svensson	12/19/2022	Meeting	Greenhouse Envelope
Tony Vilgiate	CABA Tech	12/20/2022	Meeting	Lighting
Ryan Doyle	Agxano	12/20/2022	Meeting	Lighting
Tom Roth	Hawthorne Gardening Company	12/20/2022	Meeting	Lighting
Bob Gunn	Seinergy	12/20/2022	Meeting	Lighting
HVAC Working Group	Quest Climate, Desert Aire, Inspire, TRC, McHugh Energy, Franklin Energy	1/4/2023	Meeting	HVAC/D
HVAC Working Group	Quest Climate, Desert Aire, Inspire, TRC, McHugh Energy, Franklin Energy	1/24/2023	Meeting	HVAC/D
Ted Tiffany	Guttmann Blaevoet	1/13/2023	Meeting	Compliance
Tony Vilgiate	CABA Tech	1/12/2023	Meeting	Lighting
Ryan Doyle	Agxano	1/12/2023	Meeting	Lighting
HVAC Working Group	Quest Climate, Desert Aire, Inspire, TRC, McHugh Energy, Franklin Energy	2/13/2023	Meeting	HVAC/D
David Morrison	NGMA	4/25/2023	Meeting	Greenhouse Envelope
Jeff Nall	G Gro Horticulture	6/1/2023	Meeting	Lighting

Appendix G: Energy Cost Savings in Nominal Dollars

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2026 PV$. Costs and cost effectiveness using and 2026 PV$ are presented in Section 3.4 of this report. This appendix presents energy cost savings in nominal dollars.

Table 65: Nominal LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Alterations – Indoor CEH Lighting

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Natural Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
All	$659.73	-	$659.73

Table 66: Nominal LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Alterations – Greenhouse CEH Lighting

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Natural Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
All	$91.36	-	$91.36

Appendix H: CEH Lighting Cost Analysis

Table 67 and Table 68 provide details of the luminaires and lighting costs utilized in the CEH lighting cost analysis for both greenhouse and indoor CEH facilities.

Table 67: Lamp Cost per Model

Fixture Type	Manufacturer	Lamp Cost	Lamp Wattage
DE HPS	Gavita	$126.20	1000
DE HPS	Philips	$74.75	1000
DE HPS	Ushio	$99.00	1000
DE HPS	Grower's Choice	$59.00	600
DE HPS	Agrosun	$59.62	1000
DE HPS	Phantom	$50.12	1000
DE HPS	Interlux	$45.00	1000
DE HPS	Efinity	$37.50	1000
DE HPS	Nanolux	$44.00	600
DE HPS	Ushio	$102.06	1150
DE HPS	Iluminar	$31.20	600
DE HPS	Ushio	$21.98	600
DE HPS	Optilume	$95.00	1000
DE HPS	Plantmax	$60.00	1000
DE HPS	Xtrasun	$81.00	1000
DE HPS	Iluminar	$75.00	750
DE HPS	Xtrasun	$74.00	600
DE HPS	GE Lucalux	$62.00	400
DE HPS	Ushio	$76.00	400
CMH	Growers Choice	$69.00	315
CMH	Eye Hortilux	$85.84	315
CMH	Dimlux	$81.60	315
CMH	Growers Choice	$109.00	500
CMH	Iluminar	$84.00	630
CMH	Phantom	$15.90	315
CMH	Plantmax	$46.67	315
CMH	Iluminar	$73.29	315
CMH	Luxx	$93.40	630
CMH	Gavita	$77.33	600
CMH	Max Par	$83.59	315

Table 68: Luminaire Cost per Model

Fixture Type	Manufacturer	Model	Fixture Cost	PPF	Fixture Wattage
DE HPS	Hydro Crunch	Double ended HPS bulb	$264	N/A	1000
DE HPS	Yield Lab HPS	Double ended HPS bulb	$261	N/A	1000
DE HPS	Agrolux	Agrolux ALF1000 Optimal 1000W Double Ended Horticultural LED, 240/277 Volt / SKU: HT101206	$467	2100	1000
DE HPS	DimLux	DimLux Expert Series 1000 Watt Double Ended HPS/MH Horticultural LED with 2,000K Bulb/SKU #: DL-ES-DE-1000W	$465	2470	1000
DE HPS	Gavita	Gavita Pro Classic 1000W DE Fixture/SKU #: GVTA-PRO-DE-1000W	$222	2100	1000
DE HPS	Growers Choice	Growers Choice Master Pursuit 1000 Watt Double Ended HPS/MH Horticultural LED / SKU #: GC-1000WMPDEFSHP	$349	2100	1000
DE HPS	Iluminar	Iluminar 1000 Watt Double Ended Horticultural LED with HPS Bulb, 120-240 Volt / SKU #: ILUM-DE-N1K	$265	2100	1000
DE HPS	Iluminar	Iluminar 600/750 Watt Double Ended Horticultural LED with HPS Bulb, 120-240 volt / SKU #: ILUM-DE-N756-24	$259	1407	750
DE HPS	NanoLux	Nanolux Summit Series Modular Horticultural LED System/SKU #: NL-SUMMIT-SERIES	$441	1027.8	600
DE HPS	NanoLux	Nanolux Summit Series Modular Horticultural LED System/SKU #: NL-SUMMIT-SERIES	$441	2034.6	1000
DE HPS	Phantom	Phantom 50 Series 750W Double Ended Open Lighting System with USB Interface, 120/240V / SKU #: PHDEOK72	$165	1450	750
DE HPS	Phantom	Phantom Low Profile 1000 Watt Enclosed Double Ended Horticultural LED, 120-240 Volt / SKU #: PHDESK12L	$268	2100	1000
LED	Horticulture Lighting Group	HLG300 V2	$379	660	275
LED	The Green Sunshine Co	ES300-V2	$595	600	300
LED	SpectrumKing	SK402 LED Horticultural LED 120º	$749	644	460
LED	Growers Choice	ROI-680	$750	1700	680
LED	Black Dog	PhytoMAX-2 PM-2-400	$979	641	420
LED	SpectrumKing	Spectrum King SK603 Full Spectrum LED Horticultural LED	$997	1430.5	650
LED	Gavita	Pro 1700e	$938	1700	646
LED	Photobio	Photobio.M	$1,300	1500	600
LED	KindLED	K5 Series XL750	$1,245	458 (PPFD)	430
LED	Photobio	Photobio.M	$1,400	1260	600
LED	NextLight	NL-MEGA	$922	1400	650
LED	Black Dog	PhytoMAX-2 1000 Horticultural LEDs	$1,700	1602	1050

Fixture Type	Manufacturer	Model	Fixture Cost	PPF	Fixture Wattage
LED	HLG	Horticulture Lighting Group HLG Scorpion Diablo 650 Watt LED Horticultural LED SKU 22968	$1,399	1900	650
LED	HLG	Horticulture Lighting Group HLG 350R LED Horticultural LED 120 Volt SKU 72162	$599	911	350
LED	Iluminar	Iluminar iLogic 9 LED Full Spectrum 1000 Watt 120-277 Volt Fixture SKU 30433	$1,200	2800	1000
LED	Iluminar	Iluminar iL1 2.6 660 Watt 120/277 Volt Single Grid SUP LED Bar/FS Grow SKU 72193	$1,000	1716	660
LED	Iluminar	Iluminar iLogic 8 LED UV and Far-Red 630 Watt 120-277 Volt Fixture SKU 26727	$1,099	1800	630
LED	Iluminar	Iluminar iLogic 6 LED Full Spectrum 330 Watt 120-277 Volt Fixture SKU 30402	$699	924	330
LED	ION	Ion LED XR 830w PRO 120v-277v SKU 26986	$1,299	2410	830
LED	ION	Ion LED 720w 120-277v SKU 19879	$825	1800/1944	720
LED	ION	Ion 320w Veg Horticultural LED SKU 23635	$599	800	320
LED	Growers Choice	Grower's Choice ROI-E200 Horticultural LED System SKU 23640	$350	500	200
LED	PHOTOBIO	PHOTOBIO T LED, 330W, 100-277V S4, (10' Leads Cord) SKU 72245	$600	858	330
LED	Phantom	Phantom PHENO 440 LED, 440W, 100-277V, MP Spectrum SKU 21925	$600	1100	440
LED	Fluence	Fluence SPYDR 2x 345 Watt Horticultural LED SKU 13990	$880	860	345
LED	Nextlight	NextLight Mega PRO 645w LED SKU 26628	$1,295	N/A	645
LED	Kind	Kind LED X2 Commercial Horticultural LED (750w)-240v SKU K-X2-240	$1,695	1650	750
LED	Gavita	Gavita Pro RS 2400e LED SKU HGC906052	$1,465	2400	800
LED	Gavita	Gavita UVR LED 120-240V Stand Alone or Boost SKU HGC906425	$136	N/A	645
LED	Gavita	Gavita CT 1930e 780 Watt Horticultural LED, 208/240 Volt / SKU #: CT1930E -240V	$1,517	1930	780
LED	Gavita	Gavita Pro 900e 345 Watt Horticultural LED with LED Adapter/SKU #: GAVITA-900E	$879	900	345
LED	Sun System	Sun System RS 1850 720 Watt Horticultural LED	$765	1850	720
LED	Efinity	Efinity Ecogrow 630 Watt Horticultural LED / SKU #: EFINITY-ECOGROW	$675	1701	630
LED	Covert	Covert PRO 630 Watt Full-Spectrum Horticultural LED / SKU #: CT-LED-PRO-630	$850	1750	630
LED	Covert	Covert LED-X 500 Watt Full-Spectrum Horticultural LED / SKU #: CT-LEDX-500	$499	1050	500
LED	ChilLED Tech	ChilLED Growcraft X6 Mini 330 Watt Horticultural LED / SKU #: GC-COM-330-X6M	$649	N/A	330
LED	ChilLED Tech	ChilLED Growcraft X3 500 Watt Horticultural LED / SKU #: GC-COM-500-X3	$769	N/A	500
LED	ChilLED Tech	ChilLED Growcraft X6 600 Watt Horticultural LED / SKU #: GC-COM-600-X6	$1,249	N/A	600
LED	ChilLED Tech	ChilLED Growcraft X6 1000 Watt Horticultural LED / SKU #: GC-COM-1000-X6	$1,549	N/A	1000
LED	California LightWorks	California Lightworks SolarSystem SS275 200 Watt Full Spectrum Horticultural LED/SKU #: SS275	$515	350	200
LED	California LightWorks	California Lightworks SolarSystem SS550 400 Watt Full Spectrum Horticultural LED / SKU #: CLW-SS550	$849	888	400

Fixture Type	Manufacturer	Model	Fixture Cost	PPF	Fixture Wattage
LED	California LightWorks	California Lightworks SolarSystem 550 Watt Horticultural LED with Controller / SKU #: SS550-BUNDLE	$1,038	888	550
LED	California LightWorks	California Lightworks Solar System SS1100 800 Watt Full Spectrum Horticultural LED / SKU #: CLW-SS1100	$1,699	1730	800
LED	Black Dog LED	Black Dog PhytoMAX-3 8SC 410 Watt Horticultural LED / SKU #: BD-PM3-8SC	$1,314	N/A	410
LED	Black Dog LED	Black Dog PhytoMAX-3 12SC 615 Watt Horticultural LED / SKU #: BD-PM3-12SC	$1,714	N/A	615
LED	Black Dog LED	Black Dog PhytoMAX-3 16SC 815 Watt Horticultural LED / SKU #: BD-PM3-16SC	$2,214	N/A	815
LED	Black Dog LED	Black Dog PhytoMAX-3 20SC 1020 Watt Horticultural LED / SKU #: BD-PM3-20SC	$2,614	N/A	1020
LED	Current Lighting	GE Current L1000 Greenhouse Horticultural LED Gen1	$995	2250	600
CMH	Arc	CMH Arc Lighting System GL-CMH-ARC33 315w 208v-240v 3100K	$415	598	315
CMH	DimLux	DimLux Expert Series 315 Watt CMH Horticultural LED with 3,100K Bulb, 277 Volt/SKU #: DL315FS277	$433	706	315
CMH	NanoLux	Nanolux Summit Series Modular Horticultural LED System/SKU #: NL-SUMMIT-SERIES	$441	1842.5	1063
CMH	NanoLux	CMH 630 Watt DE Fixture with 3K lamp	$441	932.7	667.5

Appendix I: Greenhouse Lighting Analysis with 1.9 PPE

This section details the results of the greenhouse lighting analysis using the proposed PPE of 1.9 µmol/J from the Draft CASE Report instead of the current proposed PPE of 2.3 µmol/J.

Table 69: Weighted Average Per Square Foot Savings – CEH Lighting

Prototype	First- Year Electricity Savings (kWh) Per Square Foot	Per Unit Peak Demand Reduction (Watts/unit)	Per Unit Natural Gas Savings (kBtu/unit)	Per Unit Source Energy Savings (kBtu/unit)
Greenhouse	6.94	0.003	N/A	0.69

Table 70: 2026 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Alterations– Greenhouse CEH Lighting

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
All	40.46	N/A	40.46

Table 71: 30-Year Lighting Incremental Cost Per Square Foot of Canopy

Building Type	Incremental Equipment Cost	Incremental Maintenance Cost	Total Incremental Cost
Greenhouse	$9.15	-$4.20	$4.95

Table 72: 30-Year Lighting Incremental Cost Per Luminaire

Building Type	Baseline Equipment Cost	Code Efficiency Equipment Cost
Greenhouse	$261.33	$322.25

Table 73: Statewide Energy and Energy Cost Impacts Indoor – New Construction, Additions, and Alterations Greenhouse

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 Energy Cost Savings (PV$ Million)
New Construction & Additions	6.7	0.0	N/A	0.7	38.9
Alterations	15.3	0.0	N/A	1.5	89.1
Total	**22.0**	**0.0**	N/A	**2.2**	**128.0**

Table 74: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings (GWh/yr)	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Natural Gas Savings (Million Therms/yr)	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	22.0	2,410	N/A	N/A	2,410	296,846

Table 75: 30-Year Cost-Effectiveness Summary Per Square Foot – Greenhouse CEH Lighting New Construction/Additions and Alterations

Plant Type	Benefits LSC Savings + Other PV Savings (2026 PV$)	Costs Total Incremental PV Cost (2026 PV$)	Benefit-to-Cost Ratio
Cannabis	41.66	4.26	9.77
Greens	$270.97	$17.10	15.84
Tomatoes	$344.33	$17.10	20.13