Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

# Controlled Environment Horticulture

Nonresidential Covered Processes
Kyle Booth, Energy Solutions

May 2023
Draft CASE Report

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# Executive Summary

*This is a draft report. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented in this draft report. When possible, provide supporting data and justifications in addition to comments. Suggested revisions will be considered when refining proposals and analyses. The Final CASE Report will be submitted to the California Energy Commission in summer 2023. For this report, the Statewide CASE Team is requesting input on the following:*

1. *Horticultural lighting minimum required efficacy for indoor CEH facilities.*
2. *Horticultural lighting minimum required efficacy for greenhouse CEH facilities.*
3. *Examples of efficient HVAC / dehumidification (HVAC/D) equipment and controls configurations.*
4. *Examples of inefficient HVAC / dehumidification (HVAC/D) equipment and controls configurations.*

*Email comments and suggestions to Kyle Booth at* kbooth@energy-solution.com *and* info@title24stakeholders.com*. Comments will not be released for public review or will be anonymized if shared.*

## Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (CEC's) efforts to update the California Energy Code (Title 24, Part 6) 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 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 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.

The Statewide CASE Team gathered input from stakeholders to inform the proposal and associated analyses and justifications. Stakeholders also provided input on the code compliance and enforcement process.

1. 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.
2. 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.
3. HVAC and Dehumidification (HVAC/D) Industry Working Group Meetings: Multiple 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.
4. Lighting Code Language Review: The California Lighting Technology Center (CLTC) hosted a series of meetings to review existing CEH code language and provide suggestions for refining and clarifying code language.
5. Resilient Harvests Conference: The Statewide CASE Team presented the 2025 CEH proposed code changes at the Resilient Harvests Conference in Long Beach, CA 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.

Significant topics of discussion during stakeholder meetings included light emitting diode (LED) grow light cost, availability, and increase in market adoption since the last code cycle as well as feasibility of an HVAC measure specific to CEH. Key insights from the conversations are listed below:

- LED grow lights 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.
- LED grow light cost has reduced approximately 15 percent per year, as described in Section 2.4.3.
- 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 grow lights 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.

See Appendix F: for a summary of stakeholder engagement.

The goal of this Draft CASE Report is to present a cost-effective code change proposal for horticultural lighting efficacy and HVAC/D equipment and controls integration. The report contains pertinent information supporting the code change.

## Proposal Description – Horticultural Lighting Efficacy

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 indoor and greenhouse facilities from 1.9 to an LED-based efficacy of at least 2.3 μmol/J. This change would require the use of LEDs whereas HPS lamps can meet the existing requirements. The Statewide CASE Team also investigated the potential for requiring controls that operate CEH lighting systems based on Photosynthetic Photon Flux Density (PPFD) and Daily Light Integral (DLI). These controls are still considered emerging technology by the industry, and they were not included in the 2025 CEH code change proposal.

For greenhouses, the Statewide CASE Team is looking into increasing the minimum PPE for luminaires and lamps used for plant growth from 1.7 to 1.9 μmol/J. Double-ended HPS lamps and LED luminaires would be able to meet this proposed level while ceramic metal halides would likely not.

## Proposed Code Change

This proposal would modify the following sections of the California Energy Code as shown below. See Section 4 of this report for marked-up code language.

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

- **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 1.9 Micromoles per Joule from 1.7 Micromoles per Joule.

## Justification and Background Information

The CEH horticultural lighting minimum efficacy requirements was introduced to the 2022 CA 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 a reduction in minimum required efficacy to 1.9 μMol/J PPE.

There has been significant progress in the horticultural lighting industry and with adoption of LED horticultural lighting, indicating a revision is warranted. The Statewide CASE Team estimates 111.2 GWh first-year savings from the proposed horticultural lighting efficacy increase.

## Background Information

In the 2022 code cycle, 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. CEH includes both greenhouses and indoor growing spaces. 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 greenhouses and indoor facilities, but the stringency of the measures would not depend on what crop is being grown.

## Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of standards, Reference Appendices, Alternative Calculation Manual (ACM) Reference

Manuals, and compliance documents that would be modified as a result of the proposed change(s).

**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 |

## Market Analysis and Regulatory Assessment – Horticultural Lighting Efficacy

The CEH lighting industry consists of different market actors, including:

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

Cost and education were the two barriers mentioned by all of the lighting sales survey respondents for LED horticultural lighting adoption, with cost being the primary barrier of the two. Respondents noting the cost barrier is seen primarily in the upfront cost of lighting purchases. Additionally, many growers require an educational aspect for the ROI and the efficacy of LED lighting when it comes to growing their crops. Many respondents reported that some growers have perfected their craft with a specific type of lighting and are hesitant that LEDs would allow them to continue producing their quality crop. Based on stakeholder conversations and the lighting supply chain survey conducted, cannabis growers are the primary crop type that has preference for specific lighting technologies. LED grow light performance does not seem to be a concern for growers of non-cannabis crops such as produce and flowers.

Resolving these barriers can be accomplished with incentives to help with the cost and education of how to modify growing practices for growing with LEDs. Utility incentive programs have helped reduce the incremental first cost of purchasing LEDs and have been noted by respondents as the most important resolution to the cost barrier. Adoption also requires education on how upgrading to LEDs can require other changes to variables of an operation’s environment such as temperature and watering rates and can affect all crop types. Some crops such as cannabis may have more sensitivity to changes in lighting technology type than others due to the high heat output of baseline efficiency technology and the impacts that heat reduction from more efficient lighting can have on the environmental conditions and the HVAC system. Seminars such as Resource Innovation Institute's Efficient Yields Series[1] are helping to bridge the education gap.

There is no major regulatory overlap or relevant regulations that supersede the proposed code change. The DesignLights Consortium (DLC) publishes a horticultural lighting standard for high efficiency luminaires, and manufacturers can certify their equipment to meet the DLC criteria. On March 31, 2023, DLC's Horticultural Technical Requirements 3.0[2] will be effective. This horticultural lighting standard was utilized as a basis for the proposed minimum efficacy requirement of 2.3 micromoles per Joule for indoor CEH lighting.

## Cost Effectiveness – Horticultural Lighting Efficacy

The proposed code changes were found to be cost effective for all climate zones where it is proposed to be required. The benefit-to-cost (B/C) ratio over the 30-year period of analysis is 3.63 for Indoor CEH Lighting and 4.88 for Greenhouse CEH Lighting. See more details in Section 2.4.[3]

California consumers and businesses would save more money on energy than they would spend to finance the efficiency measure. As a result, over time this proposal would leave more money available for discretionary and investment purposes once the initial cost is paid off.

See Section 2.4 for the methodology, assumptions, and results of the cost-effectiveness analysis.

## Statewide Energy Impacts: Energy, Water, and Greenhouse Gas (GHG) Emissions, and Embodied Carbon Impacts – Horticultural Lighting Efficacy

See Section 2.5 for more details on the first-year statewide impacts. Section 2.3.2 contains details on the per-unit energy savings.

[1] https://catalog.resourceinnovation.org/category/efficient-yields

[2] https://www.designlights.org/our-work/horticultural-lighting/technical-requirements/hort-v3-0/

[3] The benefit-to-cost (B/C) ratio compares the benefits or cost savings to the costs over the 30-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

Avoided GHG emissions are measured in metric tons of carbon dioxide equivalent (metric tons CO2e). Assumptions used in developing the GHG savings are provided in Section a and Appendix C:  of this report. The monetary value of avoided GHG emissions is included in the Long-term Systemwide Cost (LSC) hourly factors provided by CEC and is thus included in the cost-effectiveness analysis.

The proposed horticultural lighting efficacy code change would result in 111.2 GWh first-year savings and a load reduction of 0.08 MW.

The proposed measures are not expected to have any impact on water use or water quality, excluding impacts that occur at power plants. Since the proposed measure requires an increase in efficacy that can be met by air-cooled LEDs, there is no water consumption associated with the proposed measure. Although there are water-cooled LEDs available on the market, minimum efficacy requirements can be met without water-cooled LED technology.

The Statewide CASE Team calculated impacts on GHG emissions for these measures associated with embodied carbon. These measures are expected to reduce GHG emissions by 8,374 metric tons $CO_2$e due to embodied carbon impacts. See Section a for more details on the results and Appendix D:  for details on the methodology.

**Table 2: Summary of Impacts for Horticultural Lighting Efficacy**

| Category | Metric | New Construction & Additions | Alterations |
|---|---|---|---|
| Cost Effectiveness | Benefit-Cost Ratio Range (varies by climate zone and building type) | 3.6 (Indoor), 4.9 Greenhouse | 3.6 (Indoor), 4.9 Greenhouse |
| Statewide Impacts During First Year | Electricity Savings (GWh) | 33.77 | 77.42 |
| | Peak Electrical Demand Reduction (MW) | 0.02 | 0.06 |
| | Source Energy Savings (Million kBtu) | 34.90 | 79.99 |
| | LSC Electricity Savings (Million 2026 PV$) | 179.31 | 411.03 |
| | LSC Gas Savings (Million 2026 PV$) | 0.00 | 0.00 |
| | Total LSC Savings (Million 2026 PV$) | 179.31 | 411.03 |
| | Avoided GHG Emissions (Metric Tons CO2e) | 2543.53 | 5830.55 |
| | Monetary Value of Avoided GHG Emissions ($2026) | 313,229 | 718,017 |
| Per square foot Impacts During First Year | Electricity Savings (kWh) | 63.35 | 63.35 |
| | Peak Electrical Demand Reduction (W) | 0.047 | 0.047 |
| | Source Energy Savings (kBtu) | 71.94 | 71.94 |
| | LSC Savings (kBtu) | 332.71 | 332.71 |
| | Avoided GHG Emissions (kg CO2e) | 4.53 | 4.53 |

## Compliance and Enforcement – Horticultural Lighting

### Overview of Compliance Process

The compliance process is described in section 2.1.4. Impacts that the proposed measure would have on market actors is described in Section 2.2.3 and **Error! Reference source not found.**. The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors. There were no significant issues identified for CEH lighting compliance, as the primary change to the existing process is the proposed minimum efficacy.

### Field Verification and Acceptance Testing

The field verification and acceptance testing requirements include a site inspection for certificate of installation. See section 2.1.4 for additional information.

## Proposal Description – HVAC/D Equipment and Controls Integration

### Proposed Code Change

The Statewide CASE Team explored options for proposed CEH HVAC and dehumidification equipment and controls measures. There are several industry barriers that prevented the development of a feasible code change proposal for the 2025 Energy Code. After investigating several different options, the Statewide CASE Team concluded that there are no feasible code change proposals that can be pursued this code cycle.

The following proposed measures were considered:

a. <u>Require modulating capacity dehumidification equipment and controls:</u>

    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 federal preemption for 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.

b. 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.

c. 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.

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. 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 indoor crop cultivation across the country.

## Addressing Energy Equity and Environmental Justice

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. DIPs refer to the areas 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. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[4] 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).

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and grappling with the unjust legacies of the past all serve as critical steps to achieving energy equity. Code change proposals must be developed and adopted with intentional screening for unintended consequences, otherwise they risk perpetuating systemic injustices and oppression.

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time but is open to receiving feedback and data that may prove otherwise. Please reach out to Nancy Metayer (nmetayer@energy-solution.com) and Marissa Lerner (mlerner@energy-solution.com) for further engagement. Full details addressing energy equity and environmental justice can be found in Section 2.6 of this report.

[4] 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 and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

# 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.

The goal of this report is to present a code change proposal for horticultural lighting efficacy and HVAC/D equipment and controls integration.

When developing the code change proposal and associated technical information presented in this report, 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 (CASE, Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential 2022) and February 9, 2023 (CASE, Nonresidential Commercial Kitchens and Controlled Environment Horticulture Utility-Sponsored Stakeholder Meeting 2023).

The following is a summary of the contents of this report:

Section 2 – Horticultural Lighting Efficacy

- Measure DescriptionSection 2.1 – Measure Description of this Draft 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 2.2 – Market Analysis includes a review of the current market structure. Section 2.2.2 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 2.3 – 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 2.4 – 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 2.5 – 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 2.6 – 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 – HVAC/D Equipment and Controls Integration

- Section 3.1 – Measure Description of this Draft 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 **Error! Reference source not found.** – 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 **Error! Reference source not found.** – 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 **Error! Reference source not found.** – 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 **Error! Reference source not found.** – 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 4 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards. Generalized proposed revisions to sections are included for the Compliance Manual and compliance forms.

Section 5 – 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 FSummary 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.

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. Horticultural Lighting Efficacy

## 2.1 Measure Description

### 2.1.1 Proposed Code Change

The current code requires luminaires or lamps that are used for plant growth to have a photosynthetic photon efficacy (PPE) of at least 1.9 micromoles per joule (μmol/J) for indoor grow facilities with more than 40 kW of horticultural lighting load. Luminaires or lamps used for plant growth in greenhouses with more than 40 kW of horticultural lighting load must have a PPE of at least 1.7 μmol/J. Both the indoor and greenhouse requirements can be met by double-ended high-pressure sodium (HPS) technology, a legacy product that has been in the 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 indoor and greenhouse facilities from 1.9 to an LED-based efficacy of at least 2.3 μmol/J. This change would require the use of LEDs whereas HPS lamps can only meet the existing requirements. 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).

For greenhouses, the Statewide CASE Team proposes an increase in the minimum PPE for luminaires and lamps used for plant growth from 1.7 to 1.9 μmol/J. Currently available double-ended HPS lamps and LED luminaires would be able to meet this proposed level. Ceramic metal halides would likely not be able to meet this PPE.

This proposal would modify the following sections of the California Energy Code as shown below. See Section 4 of this report for marked-up code language.

- **Section 120.6(h)3 – 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)7 – Greenhouses, Horticultural Lighting:** The purpose of this change is to increase the minimum efficacy of greenhouse horticultural lighting to 1.9 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.

## 2.1.2 Justification and Background Information

### *2.1.2.1 Justification*

The CEH horticultural lighting minimum efficacy requirements was introduced to the 2022 CA 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 a reduction in minimum required efficacy to 1.9 μMol/J PPE. Even with the reduced minimum efficacy, the measure still provided a first-year electricity savings of 293.9 GWh, making it one of the largest energy saving measures of the code cycle.

There has been significant progress in the horticultural lighting industry and with adoption of LED horticultural lighting, and there is significant energy savings potential from increasing minimum required efficacy of horticultural lighting. The Statewide CASE Team estimates 111.2 GWh first-year savings from the proposed horticultural lighting efficacy increase.

### *2.1.2.2 Background Information*

Controlled Environment Horticulture (CEH) 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. CEH includes both greenhouses and indoor growing spaces. 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 greenhouses and indoor facilities, but the stringency of the measures would not depend on what crop is being grown.

Last code cycle, several stakeholders mentioned the wide variation of crop requirements across different crops. It was determined there is no need to differentiate luminaire efficacy requirements per crop type, as there are a wide range of product lighting intensities with PPE rating at or above the proposed code change values. Including lighting efficacy requirements in the Energy Code was determined not to present a disadvantage to specific crop types.

#### 2.1.2.3 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.[5] See Section 4 of this report for detailed proposed revisions to code language.

#### 2.1.2.4 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 4.2 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[6] and 25402[7]. If the proposed code change did not move forward, it would allow a high energy use intensity industry to utilize inefficient technologies 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 1.9 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 inefficient technologies and would misalign with the state's greenhouse gas emission reduction goals.

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

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

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

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

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

#### 2.1.2.6 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.

#### 2.1.2.7 Summary of Changes to Compliance Forms

The proposed code change would modify the sections of the Nonresidential Compliance Manual below. Examples of the revised forms are presented in Section 4.5.

- NRCC-PRC-E Process Systems

### 2.1.3 Regulatory Context

#### 2.1.3.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

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.

The proposed code change would modify Section 120.6 of the 2022 CA 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.

#### 2.1.3.2 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.

#### 2.1.3.3 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 quality product list (QPL) for high-efficiency LED horticultural lighting products. Lighting devices must have a PPE at or above 2.3 μMol/J in order to qualify for QPL (Design Light Consortium n.d.). However, since the QPL is new, many manufacturers are still in the process of listing their products.

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[8] of the code.

The ANSI/ASHRAE/IES Standard 90.1 (2019) Addendum AR[9] was developed using 2022 CA Energy Code as a reference. The addendum requires the same efficacy ratings as the 2022 CA Energy Code for horticultural lighting.

### 2.1.4 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. **Error! Reference source not found.** 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 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

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

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

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**

## 2.2 Market Analysis

### 2.2.1 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 meetings that the Statewide CASE Team held on October 25, 2022 (CASE, Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential 2022) and February 9, 2023 (CASE, Nonresidential Commercial Kitchens and Controlled Environment Horticulture Utility-Sponsored Stakeholder Meeting 2023).

The Statewide CASE Team also presented on November 2, 2022, at the Resilient Harvests industry conference in Long Beach, CA. This event brought approximately 200 CEH industry stakeholder 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 with stakeholders to obtain feedback on the proposed code change. Key stakeholders include 2022 CEH code cycle stakeholders that provided public comment, lighting manufacturers, dehumidification manufacturers, greenhouse manufacturers, facility designers, and growers.

The CEH lighting industry consists of different market actors, including:

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

The Statewide CASE Team conducted CEH lighting phone interview surveys to better understand the market in California. This survey was designed to reach manufacturers, distributors, installers, and designers through multiple sales channels to capture diverse and specialized perspectives with the aim of creating a representative summary of market conditions. The 30-minute survey 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 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 that were conducted between December 2022 and March 2023.

### *Percent Lighting Type*

Most survey 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 options of lights. Two respondents claimed 20 to 40 percent of their sales are still HID, one noting the primary source coming from greenhouses and cold climate zones where the added heat is important. Five respondents noted they observed a significant increase in LED sales within the last one to four years.

Current Lighting, a major horticultural lighting manufacturer, provided an overall industry estimate of 30 to 50 percent of horticultural lighting sales being LEDs.

### *Summary of Cost Info and Trends*

All respondents stated the price per watt of LED lighting has reduced each 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 present with COVID-19 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 get rid of stock to move more toward LEDs. Section 2.4.3 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 indoor lighting requires lighting with greater intensity for sole source than supplemental in greenhouse lighting. One respondent noted that they generally see ~1,000 micromoles for indoor CEH facilities and ~500 micromoles 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.

The shape 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 utilizing a slim fixture 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. Those respondents that do stock products carry a limited stock.

### *Use of Incentives for LEDs*

Among the respondents, there appears to be no shortage of incentives for LED purchasing, and they all noted they assist their customers with rebate processes for LED sales. The methods by which they assist customers with rebates include:

- Provide the customer with resources to find LED rebates.
- Observe the lighting dealer utilize the incentive to discount the upfront cost of the lighting.
- Provide 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.
- Utilize brokers who take a percentage of the secured rebate.

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 based on how much you save, they would give you incentives over the next the following 12 months. This method can be complex to administer, but it provides accurate savings over time.

### *Cannabis vs. Non-Cannabis Sales*

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 grow light sales. One respondent reported significantly non-cannabis grow lighting due to their distributor being more focused on non-cannabis products.

Responses on purchasing differences between cannabis and non-cannabis varied greatly. The one consistent answer was cannabis purchasing has a much higher focus on light intensity due to crop requirements and growers pursuing high yields and quality through high light intensity.

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

### ***New Construction vs. Retrofit Sales***

Percentages varied between respondents, but seven noted a large majority (more than 70 percent) of their sales are for 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 primary technology of choice in 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 up-front 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, although that does not factor in the reduction in maintenance costs due to eliminating HPS lamp replacements.

Additionally, many cannabis growers require education 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 hesitant that LEDs would allow them to continue producing their quality crop. It is noted that non-cannabis crops do not have the same level of concern on LED grow light 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 education on how 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.

### 2.2.2 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. Technologies that meet the proposed greenhouse efficacy levels are widely available and include double-ended HPS and LED luminaires. The required minimum efficacy for indoor facilities is more stringent than greenhouses and requires the use of LED lighting technology by setting efficacy levels that are not capable of being met by less efficacious light sources.

The most accepted metric for horticultural lighting efficacy is photosynthetic photon efficacy (PPE). This has been discussed with several horticultural lighting industry experts, including Ian Ashdown, 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 utilizes 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 3 provides typical efficacy ranges for the common horticultural lighting technology types.

**Table 3: 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** | 1.7–1.9 | Yes | 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)

## 2.2.3 Market Impacts and Economic Assessments

### *2.2.3.1 Impact on Builders*

Builders of CEH structures are directly impacted by many of the measures proposed by the Statewide CASE Team for the 2025 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes. The proposed code change would require designers and builders to utilize LED horticultural lighting instead of HID lighting. Some designers and builders are already familiar with this technology, but others may have to adjust practices to the newly proposed requirements.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 4). 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 4: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)**

| Building Type | Construction Sectors | Establish ments | Employ ment | 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 5 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 2.2.4 Economic Impacts.

**Table 5: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2022 (Estimated)**

| Construction Subsector | Establish ments | Employ ment | 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.)

#### *2.2.3.2 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 in order to remain compliant with changes to design practices and building codes.

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 6 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 not a North American Industry Classification System (NAICS) [10] 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

[10] 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.

residential and nonresidential buildings.[11] 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 6 provides an upper bound indication of the size of this sector in California.

**Table 6: 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

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

### 2.2.3.4 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

[11] 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.

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 2.2.4.1, 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.

### 2.2.3.5 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.

### 2.2.3.6 Impact on Building Inspectors

Table 7 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 7: 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.

#### *2.2.3.7 Impact on Statewide Employment*

As described in Sections 2.2.3.1 through 0, 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 2.2.4, 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.

### 2.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[12], 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 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

[12] 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.

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 8: 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) | 34.6 | $2.69 | $3.11 | $5.29 |
| **Indirect Effect** (Additional spending by firms supporting Commercial Builders) | 8.5 | $0.73 | $1.15 | $2.12 |
| **Induced Effect** (Spending by employees of firms experiencing “direct” or “indirect” effects) | 14.4 | $0.98 | $1.76 | $2.80 |
| **Total Economic Impacts** | **57.5** | **$4.41** | **$6.02** | **$10.21** |

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software. [13]

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

**Table 9: 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) | 7.1 | $0.56 | $0.85 | $1.83 |
| **Indirect Effect** (Additional spending by firms supporting Commercial Builders) | 4.1 | $0.33 | $0.56 | $0.98 |
| **Induced Effect** (Spending by employees of firms experiencing "direct" or "indirect" effects) | 3.7 | $0.26 | $0.46 | $0.73 |
| **Total Economic Impacts** | **14.9** | **$1.14** | **$1.86** | **$3.54** |

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software.[14]

**Table 10: 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) | 0.0 | $5,339 | $5,286 | $8,355 |
| **Indirect Effect** (Additional spending by firms supporting Bldg. Designers & Energy Consultants) | 0.0 | $1,590 | $2,210 | $3,557 |
| **Induced Effect** (Spending by employees of firms experiencing "direct" or "indirect" effects) | 0.0 | $1,993 | $3,568 | $5,679 |
| **Total Economic Impacts** | **0.1** | **$8,922** | **$11,064** | **$17,591** |

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

**Table 11: 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.

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

**Table 12: 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) | 9.1 | $0.71 | $0.82 | $1.39 |
| **Indirect Effect** (Additional spending by firms supporting Commercial Builders) | 2.2 | $0.19 | $0.30 | $0.56 |
| **Induced Effect** (Spending by employees of firms experiencing "direct" or "indirect" effects) | 3.8 | $0.26 | $0.46 | $0.74 |
| **Total Economic Impacts** | **15.1** | **$1.16** | **$1.58** | **$2.68** |

Source: The Statewide CASE Team analysis of data from the IMPLAN modeling software.[15]

**Table 13: 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) | 4.6 | $0.36 | $0.55 | $1.18 |
| **Indirect Effect** (Additional spending by firms supporting Commercial Builders) | 2.7 | $0.21 | $0.36 | $0.63 |
| **Induced Effect** (Spending by employees of firms experiencing "direct" or "indirect" effects) | 2.4 | $0.16 | $0.29 | $0.47 |
| **Total Economic Impacts** | **9.6** | **$0.74** | **$1.20** | **$2.28** |

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

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

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

**Table 14: 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.

**Table 15: 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.

#### 2.2.4.1 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 2.2.4 would lead to modest changes in employment of existing jobs.

#### 2.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 2.2.4.1, 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.

#### 2.2.4.3 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. [17] 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 California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

#### 2.2.4.4 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).[18] As Table 16 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 16: 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.)

[17] 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.

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

The 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 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.[19] The estimated investment in CA due to the proposed code change is $415,756.

#### 2.2.4.5 Incentives for Innovation in Products, Materials, or Processes

Based on conversations with the horticultural lighting supply chain in CA, the horticultural lighting industry has significantly increased the percentage of LED grow light 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 2.2.2 for details and specifically Use of Incentives for LEDs.

#### 2.2.4.6 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

[19] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 16.

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 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 2.1.4 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.

#### *2.2.4.7 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 2.6 for more details addressing energy equity and environmental justice.

### 2.2.5 Fiscal Impacts

#### *2.2.5.1 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.

#### *2.2.5.2 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.

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

There are no costs or savings to any state agencies.

#### *2.2.5.4 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.

#### *2.2.5.5 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.

## 2.3 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 2.6 for more details addressing energy equity and environmental justice.

### 2.3.1 Energy Savings Methodology

#### *2.3.1.1 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 industry-standard practices and equipment. The industry-standard practices and equipment serve as the baseline condition to which the proposed measures are compared for estimating the energy savings. The proposed measure is a mandatory measure, but future code cycles would benefit from prescriptive and performance paths. A CBECC prototype would open the opportunity for prescriptive and performance approaches.

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

**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 |

**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)** | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |

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. Photoperiod shows 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 qualifies is LED lighting technology, but light emitting plasma (LEP) technology may also qualify. Efficacy data listed as PPE for lighting technologies other than LEDs is sparse, and additional test data may prove additional technologies to be eligible. 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 1.9 μMol/J represents the typical efficacy of double-ended HPS luminaires. The minimum requirement allows double-ended HPS and LED luminaires to qualify. Proposed greenhouse CEH lighting efficacy is lower than indoor CEH lighting efficacy due to the wide range of use cases for supplemental lighting in greenhouses. 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. Use cases such as photoperiod extension may not have cost effective results due to the lower operating hours and light intensity. Baseline efficiency for greenhouse CEH lighting is 1.7 μMol/J, which represents a blend of the typical efficacy of double-ended HPS luminaires and ceramic metal halide luminaires.

#### 2.3.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team measured per unit energy savings expected from the proposed code changes in several ways in order 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 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 $CO_2$ emissions.[20] More information on source energy and LSC factors is available in the March 2020 CEC Staff Workshop on Energy Code Compliance Metrics and the July 2022 CEC Staff Workshop on Energy Code Accounting for the 2025 Building Energy Efficiency Standards.

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)

[20] 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

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

| Prototype Name | Crop Type |
|---|---|
| **Indoor (Warehouse)** | Cannabis: 83% flowering growth stage, 15% vegetative growth stage, 2% clone growth stage |
| **Indoor (Warehouse)** | Leafy greens |
| **Indoor (Warehouse)** | Tomatoes |
| **Greenhouse** | Cannabis: 83% flowering growth stage, 15% vegetative growth stage, 2% clone growth stage |
| **Greenhouse** | Leafy greens |
| **Greenhouse** | Tomatoes |

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. Cooling energy savings are calculated using a generic DX cooling coil performance curve and hourly outside air temperatures sourced from weather files in the 2022 CBECC software. 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 2.3.1.1.

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). It then 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 LCCHF factors in 2026 PV$ when calculating energy and energy cost impacts.

Per-unit energy impacts for nonresidential buildings are presented in savings per square foot. 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.

#### *2.3.1.3 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 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.

### 2.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 20. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per-unit savings for the first year have an average of 56.89 kWh per square foot weighted for construction by climate zone. Savings do vary slightly per climate zone, but the variations are minor. There are no natural gas savings for this measure. Demand reductions are expected to range between 0.00 kW and 0.04 kW per square foot depending on location and climate zone.

**Table 20: 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) |
|---|---|---|---|---|
| **Indoor** | 56.89 | 0.04 | N/A | 71.25 |
| **Greenhouse** | 6.94 | 0.003 | N/A | 0.69 |

## 2.4 Cost and Cost Effectiveness

### 2.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 2.3.1. LSC hourly factors are a normalized metric to calculate LSC savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with 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 2.4 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. **Error! Reference source not found.** 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.

### 2.4.2 Energy Cost Savings Results

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 **Error! Reference source not found.**.

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.

**Error! Reference source not found.** and Table 22 provide details of the per-unit lifecycle cost savings associated with the proposed measure for both indoor and greenhouse CEH lighting.

**Table 21: 2026 PV 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 (2026 PV$) | 30-Year LSC Natural Gas Savings (2026 PV$) | Total 30-Year LSC Savings (2026 PV$) |
|---|---|---|---|
| **All** | 292.25 | N/A | 292.25 |

**Table 22: 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 |

### 2.4.3 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 43 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 double-ended HPS luminaires were used for the proposed cost for greenhouses.

There was no assumed increase in labor costs with this measure due to equipment changes, as the proposed measure can replace the baseline technology on a one-for-one basis. 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 23 shows the total incremental costs per square foot of canopy for the horticulture lighting measure in both greenhouses and indoor facilities. Table 24 presents the incremental cost data per luminaire. Maintenance costs are described in Section 2.4.4.

**Table 23: 30-Year Lighting Incremental Cost Per Square Foot of Canopy**

| Building Type | Incremental Equipment Cost | Incremental Maintenance Cost | Total Incremental Cost |
|---|---:|---:|---:|
| **Indoor** | $108.06 | -$100.50 | $7.56 |
| **Greenhouse** | $9.15 | -$4.20 | $4.95 |

**Table 24: 30-Year Lighting Incremental Cost Per Luminaire**

| Building Type | Baseline Equipment Cost | Code Efficiency Equipment Cost |
|---|---:|---:|
| **Indoor** | $322.25 | $1,042.65 |
| **Greenhouse** | $261.33 | $322.25 |

For indoor lighting, 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. Indoor CEH baseline luminaire cost

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

Horticultural luminaires have an expected useful life of approximately 10 years. Two luminaire replacements were factored into the 30-year evaluation period.

In order to determine per canopy incremental cost, it was assumed that each luminaire illuminates 20 square feet of canopy space. These average areas per fixture have been provided by lighting designers, growers, and manufacturers and are derived from the required PPFD and listed in Table 17 and Table 18. The highest energy intensity requirements were used to ensure the incremental cost accounted for the highest energy density applications. 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. In getting a cost difference per square foot of canopy, the Statewide CASE Team was able to determine cost savings per square foot of canopy. This will allow growers to assess what degree of savings they can expect depending on the size of their operation. 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 so horticultural lighting loads are separated from other lighting loads since this is common industry practice.

### 2.4.4 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:

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

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 DLC Horticultural QPL (DesignLights Consortium 2019) utilizes 50,000 hours for the expected life of horticultural lighting, as does the CA Electronic Technical Reference Manual (eTRM) entry for high- and low-bay LEDs (California Technical Form n.d.). The CA 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 indoor standard did not have maintenance costs assumed as there is no lamp replacement associated with horticultural LED luminaires.

A baseline maintenance cost of $2,011 per luminaire was assumed for indoor CEH lighting over the 30-year period of analysis. There is no proposed maintenance cost due to no lamp replacements necessary with LED grow lights. These figures were derived from the replacement cost of a double-ended lamp every year. Thus, the indoor LED proposal would save $2,011 in maintenance cost over 30 years; the $2,011 savings translates to a reduction in maintenance cost of $100.53 per canopy square foot using the assumption of 20 square feet per luminaire for indoor grows. Lamp costs used in the cost analysis are listed in Appendix H.

The maintenance cost decrease for greenhouse lighting is due to a decrease in price for a double-ended HPS lamp compared to a combination of ceramic metal halide and double-ended HPS lamps. The blended baseline cost is estimated to be $67, and a double-ended lamp is estimated to cost $50. The greenhouse CEH lighting proposal would save $82 in maintenance cost over 30 years; the $82 savings translates to a reduction in maintenance cost of $4.12 per canopy square foot using the assumption of 20 square feet per luminaire for indoor grows. There was no assumed change in labor for either indoor or greenhouse lighting. The incremental maintenance cost values are included in Table 23

The baseline and proposed levels for greenhouse facilities assumed a lamp replacement every year and a luminaire replacement every 10 years.

### 2.4.5 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 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 3.6-4.9, making them highly cost-effective measures.

Table 25 and **Error! Reference source not found.** provide the cost effectiveness values for the proposed horticultural lighting efficacy measure.

### Table 25: 30-Year Cost-Effectiveness Summary Per Square Foot – Indoor CEH Lighting New Construction/Additions and Alterations

| Climate Zone | Benefits LSC Savings + Other PV Savings [a] (2026 PV$) | Costs Total Incremental PV Costs [b] (2026 PV$) | Benefit-to-Cost Ratio |
|---|---|---|---|
| All | $292.25 | $7.56 | 3.63 |

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). 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 CASE analysis period.

b. **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 B/C ratio is infinite.

### Table 26: 30-Year Cost-Effectiveness Summary Per Square Foot – Greenhouse CEH Lighting New Construction/Additions and Alterations

| Climate Zone | Benefits LSC Savings + Other PV Savings[a] (2026 PV$) | Costs Total Incremental PV Costs[b] (2026 PV$) | Benefit-to-Cost Ratio |
|---|---|---|---|
| All | $40.46 | $4.95 | 4.88 |

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). 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.

b. **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.

## 2.5 First-Year Statewide Impacts

### 2.5.1 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 2.3.2, 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).

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. Table 27 shows estimated crop breakdown for both indoor and greenhouse facility stock:

**Table 27: Facility Stock Crop Type Breakdown**

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

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 29 and Table 29 present first-year statewide savings from new construction, additions, and alterations.

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.

While a statewide analysis is crucial to understanding broader effects of code change proposals, there is potential to disproportionately impact DIPs that needs to be considered. Refer to Section 2.6 for more details addressing energy equity and environmental justice.

**Table 28: Statewide Energy and Energy Cost Impacts Indoor – New Construction, Additions, and Alterations Indoor Lighting**

| 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) |
|---|---|---|---|---|---|
| **New Construction & Additions** | 27.1 | 0.02 | N/A | 34.2 | 140.4 |
| **Alterations** | 62.1 | 0.06 | N/A | 78.5 | 321.9 |
| **Total** | **89.2** | **0.08** | N/A | **112.7** | **462.3** |

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

**Table 29: Statewide Energy and Energy Cost Impacts Indoor – New Construction, Additions, and Alterations Greenhouse**

| 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) |
|---|---|---|---|---|---|
| **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** |

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

### 2.5.2 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).[21] The Cost-Effectiveness Analysis presented in Section 2.4 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 30 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.

**Table 30: First-Year Statewide GHG Emissions Impacts**

| 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** | 89.2 | 5,963 | N/A | N/A | 5,963 | 734,401 |
| **Greenhouse** | 22.0 | 2,410 | N/A | N/A | 2,410 | 296,846 |
| **TOTAL** | **111.2** | **8,374** | **N/A** | **N/A** | **8,374** | **1,031,247** |

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

b. GHG emissions factors are included in the LSC hourly factors published by CEC here

## 2.5.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

## 2.5.4 Statewide Material Impacts

For this section's purposes, the material impacts of a PPE level of 2.3 micromoles per Joule for indoor CEH facilities and 1.9 micromoles per Joule for greenhouses were analyzed. The material impacts from the indoor CEH lighting proposal would come from the transition of HID lights to LEDs. There would be no significant material impacts from the greenhouse CEH lighting proposal, as the baseline and proposed efficacies both use high intensity discharge lighting.

To assess this proposal's material impact, the Statewide CASE Team analyzed online reports documenting material contents of LED, CFL and incandescent lamps and conducted general research for their contents. The reports on LEDs, CFLs, and

[21] 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.

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 LED grow lights, it was determined that this was the best available information.

The Statewide CASE Team expects to see a decrease in mercury since HIDs contain mercury while LEDs do not. One 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 (Lim, et al. 2013). 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 (Lim, et al. 2013). Similarly, in this study, LED lamps contain levels of copper in between that of CFLs and incandescent lamps, 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 incandescent lamps and CFLs (Lim, et al. 2013). HPS lamps do not typically contain detectable levels of these elements, so increases in these metals are expected.

For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see Appendix D: .

**Table 31: First-Year Statewide Impacts on Material Use**

| Material | Impact | Per-Unit Impacts (Pounds per Square Foot) | First-Year [a] Statewide Impacts (Pounds) | Embodied GHG emissions saved (Metric Tons CO2e) |
|---|---|---|---|---|
| **Mercury** | Decrease | 0.00017 | 247.53 | 1.36 |
| **Lead** | No Change | N/A | N/A | N/A |
| **Copper** | No Change | N/A | N/A | N/A |
| **Steel** | No Change | N/A | N/A | N/A |
| **Plastic** | No Change | N/A | N/A | N/A |
| **Arsenic** | No Change | N/A | N/A | N/A |

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

### 2.5.5 Other Non-Energy Impacts

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

## 2.6 Addressing Energy Equity and Environmental Justice

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. 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. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[22] 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).

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 serve as critical steps to achieving energy equity. To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences of proposals on DIPs.

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 Final CASE 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 CEH facilities including members of DIPs. The California Department of Industrial Relations Division of Occupational Health and Safety (Cal/OSHA) maintains regulations to protect

[22] 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 and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

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 effect 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. HVAC/D Equipment and Controls Integration

## 3.1 Measure Description

### 3.1.1 Justification and Background Information

#### *3.1.1.1 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 ran into several 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:

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.

#### *3.1.1.2 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.

## 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 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, Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential 2022) and February 9, 2023 (CASE, Nonresidential Commercial Kitchens and Controlled Environment Horticulture Utility-Sponsored Stakeholder Meeting 2023). The Statewide CASE Team also presented on November 2, 2022, at the Resilient Harvests industry conference in Long Beach, CA.

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.

### 3.2.2 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 CA 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 CA 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 CA.” 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.

# 4. Proposed Revisions to Code Language

## 4.1 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 <u>underlining</u> (new language) and ~~strikethroughs~~ (deletions).

## 4.2 Standards

<u>(h) **Mandatory Requirements for Controlled Environment Horticulture (CEH) Spaces**</u>

(…)

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 <u>2.3</u> ~~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 ~~1.7~~ 1.9 micromoles per joule; or

ii. Luminaires with removable or serviceable lamps shall have lamps with a rated PPE of at least ~~1.7~~ 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).

## 4.3 Reference Appendices

There are no proposed changes to the Reference Appendices.

## 4.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

## 4.5 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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# 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 32 and nonresidential existing statewide building stock is presented in Table 33. The projected nonresidential new construction that will be impacted by the proposed code change in 2026 is presented in Table 32. 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 33. 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 32.

The Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 36 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 32 presents the percentage of floorspace assumed to be impacted by the proposed change by climate zone.

Table 32: 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 33: 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 34: 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Large Office | 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 |
| Medium Office | 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 |
| Small Office | 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 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 |
| Medium 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 |
| Strip Mall | 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 |
| 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 | 0.00 | 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 |
| Small School | 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 |
| Non-refrigerated Warehouse | 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 |
| Hotel | 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 |
| Assembly | 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 |
| Hospital | 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 |
| Laboratory | 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 |
| Restaurant | 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 |
| Enclosed Parking Garage | 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 |
| Open Parking Garage | 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 |
| Grocery | 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 |
| Refrigerated Warehouse | 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 |
| Controlled-environment Horticulture | 0.06 | 0.05 | 0.22 | 0.03 | 0.14 | 0.18 | 0.00 | 0.02 | 0.02 | 0.19 | 0.21 | 0.21 | 0.06 | 0.01 | 0.03 | 0.00 | 1.46 |
| Vehicle Service | 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 |
| Manufacturing | 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 |
| Unassigned | 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 |
| TOTAL | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 1.5 |

**Table 35: 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Large Office | 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 |
| Medium Office | 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 |
| Small Office | 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 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 |
| Medium 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 |
| Strip Mall | 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 |
| 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 | 0.00 | 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 |
| Small School | 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 |
| Non-refrigerated Warehouse | 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 |
| Hotel | 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 |
| Assembly | 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 |
| Hospital | 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 |
| Laboratory | 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 |
| Restaurant | 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 |
| Enclosed Parking Garage | 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 |
| Open Parking Garage | 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 |
| Grocery | 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 |
| Refrigerated Warehouse | 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 |
| Controlled-environment Horticulture | 0.06 | 0.04 | 0.22 | 0.09 | 0.53 | 0.69 | 0.09 | 0.06 | 0.13 | 0.30 | 0.21 | 0.38 | 0.44 | 0.04 | 0.05 | 0.02 | 3.34 |
| Vehicle Service | 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 |
| Manufacturing | 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 |
| Unassigned | 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 |
| TOTAL | 0.1 | 0.0 | 0.2 | 0.1 | 0.5 | 0.7 | 0.1 | 0.1 | 0.1 | 0.3 | 0.2 | 0.4 | 0.4 | 0.0 | 0.1 | 0.0 | 3.3 |

Table 36: 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) |
|---|---|---|
| Large Office | 0.0 % | 0.0 % |
| Medium Office | 0.0 % | 0.0 % |
| Small Office | 0.0 % | 0.0 % |
| Large Retail | 0.0 % | 0.0 % |
| Medium Retail | 0.0 % | 0.0 % |
| Strip Mall | 0.0 % | 0.0 % |
| Mixed-use Retail | 0.0 % | 0.0 % |
| Large School | 0.0 % | 0.0 % |
| Small School | 0.0 % | 0.0 % |
| Non-refrigerated Warehouse | 0.0 % | 0.0 % |
| Hotel | 0.0 % | 0.0 % |
| Assembly | 0.0 % | 0.0 % |
| Hospital | 0.0 % | 0.0 % |
| Laboratory | 0.0 % | 0.0 % |
| Restaurant | 0.0 % | 0.0 % |
| Enclosed Parking Garage | 0.0 % | 0.0 % |
| Open Parking Garage | 0.0 % | 0.0 % |
| Grocery | 0.0 % | 0.0 % |
| Refrigerated Warehouse | 0.0 % | 0.0 % |
| Controlled-environment Horticulture | 70.0 % | 8.0 % |
| Vehicle Service | 0.0 % | 0.0 % |
| Manufacturing | 0.0 % | 0.0 % |
| Unassigned | 0.0 % | 0.0 % |

Table 37: 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% |

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# 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 were calculated making use of the average emissions factors specified in the United States Environmental Protection Agency’s U.S. EPA Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion (United States Environmental Protection Agency 2018). This ensures consistency between state and federal estimations of potential environmental impacts. The electricity emissions factor calculated from the eGRID data is 240.4 metric tonsCO2e per GWh. The Summary Table from eGrid 2016 reports an average emission rate of 529.9 pounds CO2e/MWh for the WECC CAMX subregion. This value was converted to metric tons CO2e/GWh.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in Chapter 1.4 of the U.S. EPA’s Compilation of Air Pollutant Emissions Factors (AP-42) (United States Environmental Protection Agency 1995). The U.S. EPA’s estimates of GHG pollutants that are emitted during combustion of one million standard cubic feet of natural gas are: 120,000 pounds of CO2 (carbon dioxide), 0.64 pounds of N2O (nitrous oxide) and 2.3 pounds of CH4 (methane). The emission value for N2O assumes that low NOx (nitrogen oxide) burners are used in accordance with California air pollution control requirements. The carbon equivalent values of N2O and CH4 were calculated by multiplying by the global warming potentials (GWP) that the California Air Resources Board used for the 2000-2016 GHG emission inventory, which are consistent with the 100-year GWPs that the Intergovernmental Panel on Climate Change used in the fourth assessment report (AR4). The GWP for N2O and CH4 are 298 and 25, respectively. Using a nominal value of 1,000 Btu per standard cubic foot of natural gas, the carbon equivalent emission factor for natural gas consumption is 5,454.4 metric tons CO2e per therms.

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 LED grow lights, 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 (Lim, et al. 2013). 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 (Lim, et al. 2013). 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 (Lim, et al. 2013). 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 2.5.4. See 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).[23, 24] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[25] 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 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). The total emissions reductions from this measure are the total GHG emissions reductions from Section a combined with emissions reductions (or additional emissions) from embodied carbon in Section 2.5.4.

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[23] 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.

[24] 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% 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.

[25] 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.

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

This appendix discusses how the recommended compliance process, which is described in sections 2.1.5, could impact various market actors. Table 38 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 38 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[26] training.

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

Table 38 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 38: 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<br>• 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)<br>• Update the certificate of acceptance document | • The Statewide CASE Team recommends including the following data fields in the certificate of compliance document:<br>• Canopy size.<br>• PPE ratings of lighting luminaires in micromoles per joule.<br>• Type of dehumidification system and its moisture removal efficiency in pounds of moisture per kilowatt-hour.<br>• Type of HVAC system<br>• Yes/no on the use of carbon dioxide. |
| **Indoor Horticulture Facility Designer** | • Design facility to the needs and plans of the facility owner.<br>• Comply with relevant non-energy efficiency related building codes. | • Design a facility that meets applicable Title 24, Part 6 requirements and other building standards.<br>• Complete or assist in completing a certificate of compliance document for permit application.<br>• Ensure building plans are consistent with the information in the certificate of compliance.<br>• 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:<br>• Examples showing facilities that are compliant with Title 24, Part 6.<br>• 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.<br>• Comply with non-energy standards in Title 24, Part 6. | Would have to design HVAC and dehumidification 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: |

| 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 |
|---|---|---|---|---|
| | • If a conditioned greenhouse, comply with required nonresidential envelope requirements. | Would have to design lighting systems that meet the proposed requirements | | • Examples showing facilities that are compliant with Title 24, Part 6.<br>• Examples showing facilities that are not compliant with Title 24, Part 6 with explanations as to why. |
| **Lighting Designer** | • Identify lighting luminaires and lighting controls that suit the needs of the facility.<br>• Coordinate design with HVAC designers to account for interaction between lighting and HVAC/dehumidification systems.<br>• Serve as an expert in lighting technology. | • Would have to design lighting systems that meet the proposed requirements.<br>• May need to document compliance with the proposed requirements.<br>• Identify lighting luminaires and lighting controls that meet the proposed standards.<br>• 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.<br>• 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** | No relevant tasks under current code. | • Would need to verify horticultural lighting load calculations and equipment specifications are compliant with the proposed requirements. | Compliance process would not change for the proposed measure | • Develop training for building department officials to handle new code requirements.<br>• 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 |
|---|---|---|---|---|
| | | • Become aware of relevant code requirements and updated compliance documents.<br>• Review submitted building plans and compliance documents to verify compliance. | | |
| **General Contractor** | Build the horticulture facility in accordance with the building plans. | • Would have to build a horticulture facility that meets the proposed requirements.<br>• When field changes result in noncompliance, obtain an approval from the enforcement agency of the revised certificate of compliance document.<br>• 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.<br>• 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. |

# Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that 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 Draft 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 39. 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 39: 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, Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential 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, Nonresidential Commercial Kitchens and Controlled Environment Horticulture Utility-Sponsored Stakeholder Meeting 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.

## 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 40.

**Table 40: Engaged Stakeholders**

| Contact | Organization | Date of Outreach | Method of Outreach |
|---|---|---|---|
| **Andrew Gustafson** | TRC | 6/17/2022 | Meeting |
| **Andrew Horowitz** | Kubo Greenhouses | 10/28/2022 | Meeting |
| **Andrew Horowitz** | Kubo Greenhouses | 10/31/2022 | Meeting |
| **Dan Dettmers** | Quest Climate | 11/2/2022 | Meeting |
| **Keith Coursin** | Desert Aire | 11/2/2022 | Meeting |
| **Brian Kammers** | Desert Aire | 11/2/2022 | Meeting |
| **Adrian Giovenco** | Inspire Transpiration Solutions | 11/2/2022 | Meeting |
| **Rupal Choksi** | Madison Indoor Air Quality | 11/2/2022 | Meeting |
| **Nicole Hathaway** | CLTC (California Lighting Technology Center) | 11/15/2022 | Meeting |
| **Dick Kramp** | AB Energy | 11/15/2022 | Meeting |
| **Kurt Parbst** | Borlaug | 11/15/2022 | Meeting |
| **Garth Torvestad** | 2050 Partners | 11/16/2022 | Meeting |
| **Aaron Hodgson** | Glass House | 11/21/2022 | Meeting |
| **Jeremy Yon** | Current lighting | 12/2/2022 | Meeting |
| **Nicole Hathaway** | CLTC | 12/13/2022 | Meeting |
| **Corinne Wilder** | Fluence | 12/13/2022 | Email |
| **Ihor Lys** | Agnetix | 12/13/2022 | Email |
| **Andrew Horowitz** | Kubo Greenhouses | 12/13/2022 | Meeting |
| **Joji Singh** | Inspire Transpiration Solutions | 12/14/2022 | Email |
| **Robert Hanifin** | Svensson | 12/19/2022 | Meeting |
| **Tony Vilgiate** | CABA Tech | 12/20/2022 | Meeting |
| **Ryan Doyle** | Agxano | 12/20/2022 | Meeting |
| **Tom Roth** | Hawthorne Gardening Company | 12/20/2022 | Meeting |
| **Bob Gunn** | Seinergy | 12/20/2022 | Meeting |
| **HVAC Working Group** | Quest Climate, Desert Aire, Inspire, TRC, McHugh Energy, Franklin Energy | 1/4/2023 | Meeting |
| **HVAC Working Group** | Quest Climate, Desert Aire, Inspire, TRC, McHugh Energy, Franklin Energy | 1/24/2023 | Meeting |
| **Ted Tiffany** | Guttmann Blaevoet | 1/13/2023 | Meeting |
| **Tony Vilgiate** | CABA Tech | 1/12/2023 | Meeting |
| **Ryan Doyle** | Agxano | 1/12/2023 | Meeting |

# 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 2.4 of this report. This appendix presents energy cost savings in nominal dollars.

**Table 41: 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 42: 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 43 and Table 43 provide details of the luminaires and lighting costs utilized in the CEH lighting cost analysis for both greenhouse and indoor CEH facilities.

**Table 43: 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 44: 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 Grow Light, 240/277 Volt / SKU: HT101206 | $467 | 2100 | 1000 |
| DE HPS | DimLux | DimLux Expert Series 1000 Watt Double Ended HPS/MH Grow Light 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 Grow Light / SKU #: GC-1000WMPDEFSHP | $349 | 2100 | 1000 |
| DE HPS | Iluminar | Iluminar 1000 Watt Double Ended Grow Light with HPS Bulb, 120-240 Volt / SKU #: ILUM-DE-N1K | $265 | 2100 | 1000 |
| DE HPS | Iluminar | Iluminar 600/750 Watt Double Ended Grow Light with HPS Bulb, 120-240 volt / SKU #: ILUM-DE-N756-24 | $259 | 1407 | 750 |
| DE HPS | NanoLux | Nanolux Summit Series Modular Grow Light System/SKU #: NL-SUMMIT-SERIES | $441 | 1027.8 | 600 |
| DE HPS | NanoLux | Nanolux Summit Series Modular Grow Light 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 Grow Light, 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 Grow Light 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 Grow Light | $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 LED grow lights | $1,700 | 1602 | 1050 |
| LED | HLG | Horticulture Lighting Group HLG Scorpion Diablo 650 Watt LED Grow Light SKU 22968 | $1,399 | 1900 | 650 |
| LED | HLG | Horticulture Lighting Group HLG 350R LED Grow Light 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 |

| Fixture Type | Manufacturer | Model | Fixture Cost | PPF | Fixture Wattage |
|---|---|---|---|---|---|
| LED | ION | Ion 320w Veg LED Grow Light SKU 23635 | $599 | 800 | 320 |
| LED | Growers Choice | Grower's Choice ROI-E200 Horticulture LED Grow Light 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 LED Grow Light 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 Grow Light (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 LED Grow Light, 208/240 Volt / SKU #: CT1930E -240V | $1,517 | 1930 | 780 |
| LED | Gavita | Gavita Pro 900e 345 Watt LED Grow Light with LED Adapter/SKU #: GAVITA-900E | $879 | 900 | 345 |
| LED | Sun System | Sun System RS 1850 720 Watt LED Grow Light | $765 | 1850 | 720 |
| LED | Efinity | Efinity Ecogrow 630 Watt LED Grow Light / SKU #: EFINITY-ECOGROW | $675 | 1701 | 630 |
| LED | Covert | Covert PRO 630 Watt Full-Spectrum LED Grow Light /SKU #: CT-LED-PRO-630 | $850 | 1750 | 630 |
| LED | Covert | Covert LED-X 500 Watt Full-Spectrum LED Grow Light /SKU #: CT-LEDX-500 | $499 | 1050 | 500 |
| LED | ChilLED Tech | ChilLED Growcraft X6 Mini 330 Watt LED Grow Light /SKU #: GC-COM-330-X6M | $649 | N/A | 330 |
| LED | ChilLED Tech | ChilLED Growcraft X3 500 Watt LED Grow Light / SKU #: GC-COM-500-X3 | $769 | N/A | 500 |
| LED | ChilLED Tech | ChilLED Growcraft X6 600 Watt LED Grow Light / SKU #: GC-COM-600-X6 | $1,249 | N/A | 600 |
| LED | ChilLED Tech | ChilLED Growcraft X6 1000 Watt LED Grow Light / SKU #: GC-COM-1000-X6 | $1,549 | N/A | 1000 |
| LED | California LightWorks | California Lightworks SolarSystem SS275 200 Watt Full Spectrum LED Grow Light/SKU #: SS275 | $515 | 350 | 200 |
| LED | California LightWorks | California Lightworks SolarSystem SS550 400 Watt Full Spectrum LED Grow Light/SKU #: CLW-SS550 | $849 | 888 | 400 |
| LED | California LightWorks | California Lightworks SolarSystem 550 Watt LED Grow Light with Controller / SKU #: SS550-BUNDLE | $1,038 | 888 | 550 |
| LED | California LightWorks | California Lightworks Solar System SS1100 800 Watt Full Spectrum LED Grow Light/SKU #: CLW-SS1100 | $1,699 | 1730 | 800 |
| LED | Black Dog LED | Black Dog PhytoMAX-3 8SC 410 Watt LED Grow Light / SKU #: BD-PM3-8SC | $1,314 | N/A | 410 |
| LED | Black Dog LED | Black Dog PhytoMAX-3 12SC 615 Watt LED Grow Light / SKU #: BD-PM3-12SC | $1,714 | N/A | 615 |
| LED | Black Dog LED | Black Dog PhytoMAX-3 16SC 815 Watt LED Grow Light / SKU #: BD-PM3-16SC | $2,214 | N/A | 815 |
| LED | Black Dog LED | Black Dog PhytoMAX-3 20SC 1020 Watt LED Grow Light /SKU #: BD-PM3-20SC | $2,614 | N/A | 1020 |
| LED | Current Lighting | GE Current L1000 Greenhouse LED Grow Light 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 Grow Light with 3,100K Bulb, 277 Volt/SKU #: DL315FS277 | $433 | 706 | 315 |
| CMH | NanoLux | Nanolux Summit Series Modular Grow Light System/SKU #: NL-SUMMIT-SERIES | $441 | 1842.5 | 1063 |
| CMH | NanoLux | CMH 630 Watt DE Fixture with 3K lamp | $441 | 932.7 | 667.5 |