Proposal Summary

Daylight Responsive Controls for Greenhouses

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Prepared by: Nicole Hathaway (2050 Partners)

Measure Description

Daylight Responsive Controls for Greenhouses

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

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

The proposed code change would apply to both new construction and alterations of greenhouse facilities. It is not climate-zone dependent, and no compliance software updates are anticipated. However, to ensure the proper functionality of the required controls, an acceptance test protocol for use by field technicians at the time of installation may be considered.

Language Clean Up

The proposed code change would also clarify requirements for indoor grow facility lighting controls. The current code requirements for control strategies can be interpreted to imply that a simple time switch is sufficient and that astronomical time switches are appropriate for indoor growing. This code language clean-up would specify that automatic scheduling devices capable of dimming the horticulture lighting and turning it on/off are required for indoor grow facilities.

In addition, the proposed code change would move the indoor grow facility electrical power distribution systems requirement – currently in the broader Controlled Environment Horticulture (CEH) section – into the CEH Lighting Controls section and explicitly include greenhouse lighting under the same 40 kW threshold.

Table 1 summarizes the scope of the proposed code change.

Table 1: Scope of Proposed Code Change

An "X" indicates the proposed code change is relevant.

Building Type(s)		single family	**Construction Type(s)**	X	new construction
		multifamily		X	additions
	X	nonresidential		X	alterations
Type of Change	X	mandatory	**Updates to Compliance Software**	X	no updates
		prescriptive			update existing feature
		performance			add new feature
Third Party Verification		no changes to third-party verification			
		update existing verification requirements			
	X	add new verification requirements			

Justification for Proposed Change

Daylight Responsive Controls for Greenhouses

CEH is one of the fastest-growing energy end-uses in California. Greenhouse facilities with supplemental lighting are expanding rapidly to support cannabis, leafy greens, and vine crops, and these systems are highly energy intensive. Without stronger controls, this sector risks locking in years of unnecessary energy use, higher operating costs for growers, and additional strain on California's electrical grid.

The proposed daylight responsive controls would deliver measurable and persistent energy savings ranging from an estimated 9%[1] to 26%[2] while improving crop consistency and grower control. By automatically adjusting lighting in response to

[1] Energy Solutions. CalNEXT Final Report: Greenhouse Lighting Controls. March 2023.

[2] NYSERDA. Adaptive Lighting Control Technology for Greenhouses. December 2020.

daylight availability, the measure ensures that plants receive the optimal amount of light each day, avoiding the waste and inefficiency of over-lighting. This reduces electricity use and lowers cooling loads, reducing grid demand during critical hours.

The proposal provides growers with flexibility and choice. They may select between a timeclock + PAR sensor pathway or a more advanced Daily Light Integral (DLI) pathway. Both reduce wasted energy, and the DLI option enables even greater savings and performance improvements. Importantly, the measure is designed to be practical: it does not impose additional software burdens, and compliance verification would remain straightforward, with possible enhancements through an acceptance test protocol.

From a policy perspective, this proposal builds directly upon the 2022 and 2025 Title 24 CEH measures, which first set minimum PPE requirements for horticultural lighting. By layering in controls, Title 24 can create a natural next step in California's multi-cycle strategy for CEH efficiency and decarbonization.

Language Clean Up

Under the current language, some stakeholders may interpret a simple time-switch—or even astronomical time-switch controls—as sufficient for indoor growing facilities. However, these approaches do not always adequately address the dimming requirements in the current code language, which ensures the controls can respond to the lighting needs of crops in indoor grow environments. The proposal would close an existing compliance gap by explicitly stating that automatic scheduling devices capable of dimming the horticulture lighting and turning it off are required, preventing misapplication of lower-performing strategies in energy-intensive facilities.

The language clean-up proposal would also simplify compliance verification for building officials by consolidating the electrical power distribution monitoring requirements into the CEH Lighting Controls section and extending them to greenhouse facilities under the same 40 kW threshold. This ensures consistent treatment of CEH lighting systems, reduces ambiguity for enforcement staff, and streamlines compliance forms for project teams. By clarifying compliance pathways, the proposal minimizes confusion in plan review and field inspection, addressing one of the most cited barriers to effectively enforcing CEH measures.

Data Needs / Information Requests

The Statewide CASE Team seeks the following information to inform the code change proposal. Data may be provided anonymously. To participate or provide information, please email Nicole Hathaway, nicolehathaway@2050partners.com directly and copy info@title24stakeholders.com.

Energy Savings

- Quantification of lighting energy savings for greenhouse crops (cannabis, leafy greens, vine crops) under DLI vs. Timeclock + PAR-based controls.
- Regional variability in solar availability and greenhouse light transmission factors by California climate zone.
- Current baseline control strategies and typical setpoints (PPFD thresholds, photoperiod hours) in greenhouses to support accurate savings modeling.
- Observed energy savings and crop performance data from greenhouse control installations (e.g., pilot projects, utility programs).

First Costs

- Incremental equipment and installation costs for greenhouse timeclock + PAR-based controls and DLI-based systems (sensors, software, commissioning).
- Typical labor and installation costs in greenhouse facilities.
- Variability in first cost by canopy size, greenhouse configuration, and crop type.

Technical Feasibility

- Availability and reliability of timeclock + PAR-based controls and DLI-capable control systems for greenhouse applications.
- Adoption rates of DLI controls compared to PAR on/off and dimming controls in greenhouses.
- Greenhouse glazing transmissivity factors (type, age, and material).
- Industry acceptance of timeclock + PAR-based controls and DLI as a standard practice for greenhouse crops.

Market Readiness

- Prevalence of supplemental lighting in greenhouses by crop type.
- Market penetration of weather-based predictive DLI software and hardware in greenhouse operations.
- Stakeholder input on crop-specific DLI targets and operational setpoints in greenhouses.
- Number of greenhouse control systems currently available that can meet DLI-based requirements.
- Reasons a grower may object to installing and using DLI controls.

Non-Energy Benefits

- Crop quality and consistency improvements in greenhouses from maintaining optimal DLI.
- Potential reduction in greenhouse gas emissions from reduced lighting and cooling loads.
- Reduced operator intervention and improved automation for greenhouse growers.
- Possible water-use and plant health benefits from better transpiration management.

Expected Useful Life and Maintenance Costs

- Longevity of sensors, software, and control systems in greenhouse settings.
- Maintenance schedules and costs for greenhouse lighting control equipment.
- Expected accuracy and recalibration intervals for greenhouse sensors.
- Availability of serviceable/replaceable components in greenhouse control systems.

Economic Impacts

- Effects of incremental timeclock + PAR-based controls and DLI control requirements on small vs. large greenhouse growers.
- Potential cost barriers for low-margin greenhouse crops (e.g., leafy greens, tomatoes).
- Job creation opportunities in greenhouse lighting control installation and commissioning.
- Equity impacts—ensuring smaller greenhouse operations can feasibly adopt advanced controls.

Draft Code Language

1.1 Guide to Marked Up Language

The proposed changes to the Standards and Reference Appendices are provided below. Changes to the 2025 documents are marked with blue underlining (new language) and ~~strikethroughs~~ (deletions).

1.2 Title 24, Part 1

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

1.3 Title 24, Part 6

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

DAILY LIGHT INTEGRAL (DLI): Photosynthetic photon flux density (PPFD) integrated over 24 hours in units of mol/m2/day.

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

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

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

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

PHOTOSYNTHETIC PHOTON FLUX DENSITY (PPFD): Photosynthetic Photon Flux per unit of surface area, expressed in micromoles per square meter per second (µmol/m²/s), as defined by ANSI/ASABE S640.

PAR SENSOR. A device that measures photosynthetic photon flux density (PPFD) in the photosynthetically active radiation (PAR) range of 400 to 700 nanometers, typically expressed in micromoles per square meter per second (µmol/m²/s) and used to monitor light levels for the purpose of managing and controlling CEH lighting systems.

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

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

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

3. Conditioned greenhouses, building envelope….

4. Conditioned greenhouses, space-conditioning systems…

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

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

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

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

A. Luminaire PPE. Horticultural lighting shall have a luminaire photosynthetic photon efficacy (PPE) of at least 2.5 µmol/J.

B. Lighting Power Monitoring Capable. Electrical power distribution systems serving CEH indoor grow spaces and greenhouses shall be designed so that a measurement device is capable of monitoring the electrical energy usage of the aggregate horticultural lighting load.

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

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

C. Indoor Growing Space Lighting Control. Horticultural lighting systems serving indoor growing spaces shall be controlled by an automatic scheduling device that complies with all of the following:

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

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

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

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

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

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

a) A scheduling device that can automatically turn lights on and off at least 4 times per day per control zone must be installed.
b) Each scheduling device shall control no more than 40 kW of connected lighting per control zone.
c) The device must include program backup capabilities that:
    1. Retain the lighting schedule for at least 7 days during power loss.
    2. Preserve the date and time settings for at least 72 hours during a power interruption.

ii. Daylight responsive control. The daylight responsive control shall:

a) Control up to 40 kW of connected lighting per control zone.
b) Be capable of dimming lighting continuously from 100% to 10% of full power based on available PPFD.
c) Turn off the supplemental lighting when daylight PPFD exceeds the crop's target PPFD.
d) A single sensor may serve multiple control zones if each zone has separately configured calibration settings.

iii. Daily Light Integral (DLI) Control for Greenhouses. Control shall:

a) Be capable of dimming lighting between 100% and 10% of full power and turning lighting off.
b) Automatically dim supplemental electric lighting based on cumulative DLI from both daylight and electric light.
c) Be capable of maintaining—but not exceeding—a user-defined daily DLI target.
d) Each control zone may include up to 40 kW of connected lighting load.
e) A single sensor may serve multiple control zones, as long as:
    1. Each zone has independent calibration settings, and
    2. DLI is calculated separately for each zone.

1.4 Reference Appendices

There are no proposed changes to the reference appendices.