Proposal Summary

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Controlled Environment Horticulture: Daylight Responsive Controls for Greenhouses

Last updated: February 8, 2026

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Measure Description

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

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

The proposed code change would apply to both new construction and alterations of greenhouse facilities. The requirement would not be climate-zone dependent, and no compliance software updates would be anticipated. However, an acceptance test protocol for use by field technicians at the time of installation is proposed to ensure the proper functionality of the required controls. For this proposal, field technicians are generally the controls installer or an equivalent role and are not required to be certified acceptance technicians.

The proposed code change would also clarify requirements for indoor grow facility lighting controls. Because of a lack of clarity, stakeholders may erroneously interpret the current code requirements for control strategies to imply that a simple time switch is sufficient and that astronomical time switches are appropriate for indoor growing. The code language clean-up proposed in this report would explicitly specify that automatic scheduling devices capable of dimming the horticulture lighting and turning it on and off are required for indoor grow facilities.

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

Table 1 summarizes the scope of the proposed code change. Note that this proposal has acceptance testing performed by a field technician. Because the field technician is typically a member if the installation team, this acceptance testing is not considered "third party verification."

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

CEH is one of California's fastest-growing and most energy-intensive energy end-uses, driven by the rapid expansion of greenhouses that use supplemental light for crops like cannabis, leafy greens, and vine vegetables. Without stronger controls, this sector risks locking in years of unnecessary energy use and higher operating costs for growers.

Based on published field studies, the proposed daylight responsive controls requirement would deliver measurable and persistent energy savings ranging from an estimated 9

percent[1] to 26 percent[2] while improving crop consistency and grower control. Additionally, a recent model-based study shows that some specific pairings of greenhouse locations and crops in California can save up to 81 percent of lighting energy use by deploying DLI controls as compared to basic scheduling or photoperiod timers where the lights turn on at full power for 12 hours[3]. By automatically adjusting lighting in response to daylight availability, the measure ensures that plants receive the optimal amount of light each day to grow effectively while avoiding the waste of over-lighting. This practice reduces electricity use and lowers cooling loads. This reduction is particularly impactful during the grid's critical peak hours—typically mid-to-late afternoons—when widespread energy use, primarily from air conditioning, puts the entire electrical grid under its greatest stress.

The proposal provides growers with flexibility and choice. They may select between a timeclock + PAR sensor pathway or a more advanced DLI pathway. Both options reduce wasted energy, though the DLI option enables even greater savings and performance improvements. Importantly, the measure is designed to be practical by not imposing additional software burdens and ensuring 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, Part 6 CEH measures, which first set minimum PPE requirements for horticultural lighting along with time-clock controls and dimming requirements. By layering in daylight responsive controls, Title 24 can take the next step in California's multi-cycle strategy for CEH efficiency and decarbonization.

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

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

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

[3] ERI, CalNEXT Final Report: Smart Controls for Data-Driven Indoor Agriculture Field Evaluation. September, 2025.

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.
- Feedback on the practicality of allowing a single sensor to serve multiple control zones (≤40 kW each), given zone-specific differences (e.g., shading, thermal curtains, blackout curtains).
- Stakeholder recommendations on an appropriate minimum time delay in code language to ensure persistent energy savings and prevent nuisance fluctuations.
- Information on standard dimming practices for horticultural LED lighting, including the most common low-end dimming range in use.

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.
- Input on whether a field verification protocol could be based on existing manufacturer or installer commissioning practices.

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) of daylight and electric light integrated over 24 hours in units of mol/m2/day.

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

LUMINAIRE PHOTOSYNTHETIC PHOTON EFFICACY (PPE) is photosynthetic photon flux emitted by a luminaire between 400 and 700 nm divided by input electric power in

units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.-

PHOTOSYNTHETIC PHOTON FLUX (PPF) is the rate of flow of photons between 400 ~~to~~ and 700 nanometers in wavelength from a radiation source, expressed in units of 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 and Dimmability. Horticultural lighting shall have a luminaire photosynthetic photon efficacy (PPE) of at least 2.5 µmol/J when tested at the manufacturer-designed state with the highest power consumption. Horticultural

lighting shall be capable of continuous dimming between 100% and 10% of full power in response to a line voltage, low voltage, or wireless signal.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix A: Control up to 40 kW of connected lighting per control zone,
Appendix B: Be capable of automatically dimming lighting continuously from 100% to 10% of full power based on available PPFD,
Appendix C: Turn off the electric lighting when daylight PPFD exceeds the crop's target user-defined PPFD, and
Appendix D: A single sensor may serve multiple control zones if each zone has separately configured calibration settings.

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

a. Be capable of dimming electric lighting between 100% and 10% of full power and turning lighting off.
b. Automatically dim the electric lighting based on user-defined DLI from both daylight and electric light.
c. Each control zone may include up to 40 kW of connected lighting load.
d. 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

Appendix NA7.X Controlled Environment Horticulture Acceptance Tests

NA7.x.1 Horticulture Lighting Controls Acceptance Tests

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

Prior to Functional testing, verify and document the following:

(a) Lighting control zones are shown on plan documents.
(b) Electric lighting power for each control zone is shown on plan documents, and maximum lighting power for all zones does not exceed 20 kW per zone.
(c) The automatic time schedule controls showing at least four different schedule periods per day and lighting dimming setpoints for each period are shown on plan documents.
(d) Automatic time schedule control is installed and programmed to match the schedule and lighting dimming setpoints on the plan documents.

(e) The correct time and date are properly set in the lighting scheduling controller.

(f) The battery back-up is installed and energized.

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

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

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

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

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

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

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

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

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

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

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

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

NA7.x.1.3 Greenhouse Lighting Control Construction Inspection

Prior to Functional testing, verify and document the following:

(a) Lighting control zones are shown on plan documents.

(b) Electric lighting power for each control zone is shown on plan documents, and maximum lighting power for all zones does not exceed 40 kW per zone.

(c) Electric lighting control method is shown on plans:

1. Automatic Scheduling with Daylight Responsive control, or
2. Daily Light Integral (DLI) control

(d) PAR sensor locations and associated lighting control zone(s) are shown on plan documents.

(e) If Automatic Scheduling with Daylight Responsive control is used, verify the following information:

1. The automatic time schedule controls showing at least four different schedule periods per day and lighting dimming setpoints for each period are shown on plan documents.
2. Automatic time schedule control is installed and programmed to match the schedule and lighting dimming setpoints on the plan documents.
3. The correct time and date are properly set in the lighting scheduling controller.
4. The battery back-up is installed and energized.

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

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

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

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

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

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

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

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

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

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

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

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

NA7.x.1.5 Greenhouse Daylight Responsive Control Functional Testing

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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