Proposal Summary

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Controlled Environment Horticulture Prescriptive Requirements for Space Conditioning Systems

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Measure Description

This proposed measure would establish mandatory sizing requirements and controls requirements for space conditioning systems providing heating, cooling, and dehumidification to support plant growth in Controlled Environment Horticulture (CEH) spaces and would prescriptively require these systems meet key functional and performance metrics.

These requirements would only apply to space conditioning systems serving CEH spaces with lighting power density (LPD) greater than 30 watts (W) per canopy square foot in indoor (skylight ratio below 50%) CEH facilities with at least of 5000 ft^2 of plant canopy. Facilities subject to these proposed prescriptive requirements would also have the option to comply via the performance pathway via a new indoor CEH prototype and modeling capabilities being introduced to the California Building Energy Code Compliance (CBECC) software.

These proposed requirements recognize that functions of cooling and dehumidification equipment are highly interactive and must be considered together, as a part of a space conditioning system that manages both temperature and humidity in CEH spaces. The proposed code changes would require the applicant to define a primary space conditioning system providing cooling, dehumidification, and reheat. The prescriptive requirements would require the primary system to have a variable sensible heat ratio (SHR), to be capable of modulating the amount of dehumidification process heat recovered between ten percent and 90 percent, and to be sized to meet at least [TBD 70 percent] of the peak combined sensible and latent load. The primary system could be an integrated direct expansion (DX) system, a desiccant-based system, or a heat recovery chiller system.

This prescriptive requirement would be used to set an energy budget for compliance via the performance pathway, where applicants could comply by modeling an alternative system.

The mandatory sizing requirement would require the submission of calculated sensible and latent loads and sizing calculations for space conditioning systems serving spaces with LPD above 30 W per canopy square foot.

In addition to the primary space conditioning system, the proposed requirements would allow the use of supplemental equipment to meet sensible or latent loads exceeding the primary system's capacity.

Mandatory requirements would require the installation of a central control system for the primary space conditioning system, with additional controls integrating any supplemental equipment with the primary system.

Mandatory requirements for the primary system would require that it be controlled to do the following:

- Modulate sensible heat ratio (SHR) in response to room conditions and temperature and humidity setpoints;
- Modulate reheat to reject or recover dehumidification process heat, as needed to meet supply air setpoints; and
- Limit the use of primary heating (i.e. resistance, furnace, or boiler) heat to periods when the use of recovered process heat cannot meet supply air setpoints.

Controls for supplemental unitary dehumidification equipment without variable SHR or heat rejection capability would be required to do the following:

- Integrate and stage supplemental equipment with primary system to meet temperature and humidity setpoints;
- Stage unitary dehumidifiers in response to humidity sensors (including those that measure relative humidity, dewpoint, or wet bulb);
- Only activate dehumidification equipment when either all waste heat can be used in the space or the primary system cannot satisfy 100 percent of cooling, heating, and dehumidification loads.

The requirements would be the same for all 16 California Climate Zones. The proposed requirements would apply to new construction, additions, and major alterations. Replacing a single piece of equipment in a larger system would not trigger the requirements (minimum threshold to be defined prior to publication of the Final CASE Report).

This code change proposal would also review and reconsider requirements from the general non-residential space conditioning code, such as outdoor air ventilation requirements, that may negatively impact plant growth or efficiency.

Title 24, Part 6 does not currently include prescriptive measures for CEH spaces, and CBECC does not currently include an indoor CEH prototype. To provide facility designers with flexibility in equipment selection, CBECC would need to be updated for use in demonstrating compliance using the performance approach.

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**		no updates
	X	prescriptive			update existing feature
	X	performance		X	add new feature
Third Party Verification	X	no changes to third party verification			
		update existing verification requirements			
		add new verification requirements			

Justification for Proposed Change

CEH facilities, particularly indoor facilities with high lighting power density, are among the most energy-intensive buildings in California. In these facilities, the horticultural lighting and space conditioning systems make up about 80 percent of energy consumption, split roughly evenly between them. Each of these two end-uses provides significant opportunities for savings. Until this code cycle, CEH lighting has been the primary focus of Title 24, Part 6, leaving significant opportunity for code to regulate CEH space conditioning systems and achieve deep statewide savings. For indoor cannabis facilities, flower rooms contribute roughly 86 percent of facility energy use. A field study of flower rooms in two California CEH facility found an average EUI of 760kBtu/sf/year. [1]

[1] Controlled Environment Horticulture: Energy Consumption and Environmental Control Field Study https://www.etcc-ca.com/reports/controlled-environment-horticulture-energy-consumption-and-environmental-control-field

Since large-scale indoor farming is relatively new (driven primarily by legalization of cannabis in California), CEH facility designers initially had little choice but to repurpose conventional HVAC equipment and dehumidifiers to manage sensible and latent loads in indoor farms. However, space conditioning systems designed to support plant growth need to adapt to highly variable latent and sensible loads, which lead to highly variable room sensible heat ratio (SHR). Sizing methods, design approaches, and equipment requirements are vastly different from those for spaces designed primarily for human occupancy—and equipment designed to maintain human comfort is poorly suited to the unique conditions found in CEH process spaces.

Over the past decade there have been significant advances in the development of variable capacity, fully integrated space conditioning systems suitable for high latent loads, and capable of quickly adjusting to highly variable loads, offering better environmental control and far more efficient operation than fixed-capacity, "decoupled" systems. Unfortunately, many designers continue to use inefficient fully decoupled equipment in the design of new facilities, even though much more efficient, better performing, integrated equipment is now available from multiple manufacturers and has been recommended for energy efficiency and more precise environmental control in industry best-practices guides for several years.

The market's failure to broadly adopt this more efficient space conditioning equipment presents an excellent opportunity for the energy code to develop new efficiency requirements for CEH facilities.

The opportunity for energy savings is very high because energy intensity of indoor farms is very high, market adoption of efficient space conditioning systems is relatively low, and the current energy code language does not address CEH HVAC systems or the interaction between HVAC and dehumidification systems. Statewide CASE Team energy modeling of HVAC and dehumidification systems indicate that energy used by more efficient integrated HVAC/dehumidification (HVAC/D) systems is approximately 40 percent less than energy use by a decoupled, code-minimum HVAC and dehumidification system, consistent with measured and modeled data.

Furthermore, the more precise temperature and humidity control provided by variable-capacity integrated systems can increase crop yields, reduce mold risk, and help avoid crop loss. As demonstrated in a recent comparative study[2], facilities using these systems can produce more grams of dried product per square foot and per kWh, improving both space and energy resource efficiency.

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[2] R. Pusapati, CEA Integrated HVAC+D, https://drive.google.com/file/d/1ynf0Jg7nIo1EmWs3rsjwkzdDJkWGJ6RL/view

Data Needs / Information Requests

The Statewide CASE Team is seeking the following information to inform the code change proposal. Data may be provided anonymously. To participate or provide information, please email Amy Droitcour amydroitcour@2050partners.com directly and copy info@title24stakeholders.com.

- Market practice for indoor farm envelope design
- Performance and quality specification for integrated and decoupled systems
- Key attributes and differences between different integrated DX systems
- Cost considerations and economies of scale for chilled water systems
- Typical threshold (canopy square footage) for direct expansion (DX) vs chilled water
- Typical lifespan and maintenance intervals for equipment
    - Standalone dehumidifiers
    - Conventional cooling equipment
    - Integrated DX
    - Chillers
    - Fan coils
- Differences in replacement process (compressor vs. whole unit) for different equipment types
- Price per ton for different equipment types
- Other equipment costs / savings for different system types
- Documented impact on yield / quality from improved control, integrated vs. decoupled systems, other system attributes
    - Rates of new construction of CEH facilities, awareness of cannabis facility construction in jurisdiction
- Attributes, advantages, and modeling approaches for new/emerging dehumidification technologies
- Reasons facility operators object to integrated space conditioning equipment
- Percent of indoor farms installing integrated space conditioning systems without standalone dehumidifiers or with only a small number of standalone dehumidifiers.
- Percent of indoor farms installing hydronic space conditioning systems.

- Percent of indoor farms with hydronic space conditioning systems that include 4-pipe heat recovery chillers with wraparound heat pipes.

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

CONDITIONED SPACE, DIRECTLY is an enclosed space that is provided with wood heating, mechanical heating that has a capacity exceeding 10 Btu/hr-ft², or mechanical cooling that has a capacity exceeding 5 Btu/hr-ft². Directly conditioned space does not include process space or CEH space. **(**See "process space" and "Controlled Environment Horticulture (CEH) Space")

CONTROLLED ENVIRONMENT HORTICULTURE (CEH) SPACE is a building space dedicated to growing plants ~~production~~ by manipulating indoor environmental conditions, such as through electric lighting, irrigation, mechanical heating, mechanical cooling, or dehumidification. CEH space does not include building space where plants are grown solely to decorate that same space.

PLANT CANOPY AREA is the area, in square feet, where mature, or flowering, plants are grown. Each part of the total canopy area is defined by clearly identifiable physical boundaries around all areas that will contain mature plants. Physical boundaries include, but are not limited to, interior walls, shelves, greenhouse walls, hoop house walls, garden benches, hedgerows, fencing, garden beds, garden plots, or stakes delineating the perimeter. If plants will be grown in multiple tiers, the area of each tier shall be summed to determine the plant canopy area. Plant canopy area includes all actively used growing surfaces, but excludes aisles, non-plant production zones, and equipment-only areas.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

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

1. **Indoor growing, dehumidification.** Dehumidification equipment in Controlled Environment Horticulture (CEH) spaces with less than or equal to

5000 sq. ft. of plant canopy area or with lighting power density less than or equal to 30 Watts per canopy square foot shall be one of the following:

A. Dehumidifiers subject to regulation under federal appliance standards tested in accordance with 10 CFR 430.23(z) and Appendix X or X1 to Subpart B of 10 CFR Part 430 as applicable, and complying with 10 CFR 430.32(v)2;

B. Integrated HVAC system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat;

C. Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or

D. Solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50°F or less.

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6. **Indoor growing, space conditioning systems.** In facilities with greater than 5,000 feet total canopy area, space conditioning systems serving indoor CEH spaces with lighting power density greater than 30 Watts per canopy square foot shall comply with the following:

A. **Sizing, space conditioning system.** Space conditioning system(s) shall be sized to meet the design heating and cooling loads calculated according to [TBD NA.9].

B. **Heat recovery.** Dehumidification equipment shall be capable of recovering at least 90% of dehumidification process heat.

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

i. Equipment shall be sized to meet heating loads that cannot be met using waste heat from the dehumidification process according to [TBD NA.9].

ii. Equipment shall be controlled to only operate when heating load exceeds 100% of the available dehumidification process heat.

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

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

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

E. **Dehumidification equipment without modulating heat recovery/rejection.** If used, dehumidification equipment without modulating heat recovery/rejection shall:

i. Be controlled from a central controller that sequences unitary dehumidifiers automatically based on dehumidification load.

ii. Only be activated during periods when all waste heat can be used in the space or when other space conditioning equipment cannot satisfy 100% of cooling, heating, and dehumidification loads.

F. **Field verification.** Field verification of specified equipment and functional performance tests shall demonstrate the correct installation and operation of components, systems and system-to-system interfaces in accordance with the test requirements in [TBD NA7.X].

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

(d) Prescriptive Requirements for Indoor Controlled Environment Horticulture Spaces.

1. Indoor growing, space conditioning systems. In facilities with over 5,000 feet total canopy area, space conditioning systems serving indoor CEH Spaces with lighting power density greater than 30 Watts per canopy square foot shall comply with the following:

A. Construction documents shall identify a primary space conditioning system capable of providing cooling, dehumidification, and reheat using heat recovered from the dehumidification process. The primary space conditioning system shall be an integrated DX system, a four-pipe chilled water system, or a desiccant dehumidification system.

B. The primary system must be sized to meet at least (TBD%) of peak latent and sensible load.

C. The primary system shall have the following capabilities:

i. Variable sensible heat ratio (SHR) ranging from 0.45 (or lower) to 0.75 (or higher) and;

ii. Modulating heat recovery/rejection capable of both:

a. Recovering at least 90% [TBD] of total dehumidification process heat, and

b. Rejecting at least 90% [TBD] of dehumidification and cooling process heat.

D. The primary CEH Space Conditioning System shall be controlled by a system that is configured to:

i. Modulate sensible heat ratio in response to measured room conditions and temperature and humidity setpoints;

ii. Modulate reheat to reject or recover dehumidification process heat, as needed to meet supply air setpoints; and

iii. Modulate supply fan speed in response to measured room conditions and temperature and humidity setpoints.

SECTION 141.1 – REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONS, ALTERATIONS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS

(c) Controlled Environment Horticulture Spaces.

1. Indoor Growing, Space-Conditioning Systems and Dehumidification. For all additions of greater than 5,000 canopy square feet and all alterations that add greater than 5,000 canopy square feet, and all alterations that replace greater than [TBD] percent of the total capacity of newly installed heating, ventilation, air conditioning, cooling, and dehumidification systems is altered in buildings with indoor growing shall meet the applicable requirements of Sections 120.6(h)1, 120.6(h)2, 120.6(h)6, and 140.9(d).

Reference Appendices

Appendix NA7.X Controlled Environment Horticulture Acceptance Tests

[TBD]

The Statewide CASE Team will update this section to include detailed functional testing steps prior to publication of the Draft CASE Report.

Appendix NA9 Controlled Environment Horticulture Space Conditioning System Sizing

NA 9.1 Purpose and Scope

The purpose of this load calculation and sizing guide is to provide instructions for calculating loads and sizing space conditioning equipment in Controlled Environment Horticulture spaces.

1. This load calculation and sizing procedure is applicable to CEH spaces with lighting power density greater than 30 Watts per canopy square foot in CEH facilities with canopy area of 5,000 square feet or larger.

NA9.2 Canopy Square Footage

[TBD instructions on calculating canopy square footage of a CEH space]

NA9.3 Load Calculations

1. In calculating design loads, the following inputs values shall be specified:
    i. Lighting intensity and schedule
    ii. Canopy area
    iii. Irrigation rate and/or evapotranspiration rate
    iv. Temperature and humidity setpoints and tolerances
2. Latent and Sensible Load Calculations.

[TBD; calculations would account for evapotranspiration loads (latent cooling loads and evaporative sensible heating loads), environmental setpoints, and lighting loads. Calculations would account for variations in setpoints, internal loads, and outdoor climate factors (ambient temperature, solar radiation) throughout each grow cycle and TMY weather year.]

The Statewide CASE Team will update this section to include sizing instructions prior to the publication of the draft CASE Report.

NA9.4 Sizing of Space Conditioning System

[TBD; will describe sizing calculations to meet proposed requirements in 120.6(h)6 and 140.9(d).]

NA9.4 Sizing of Supplemental Heating

[TBD; will describe sizing calculations to meet proposed requirements in 120.6(h)6C.]