TITLE 24, PART 6 | 2028 CODE CYCLE

Controlled Environment Horticulture (CEH) Space Conditioning

Codes and Standards Enhancement (CASE) Proposal

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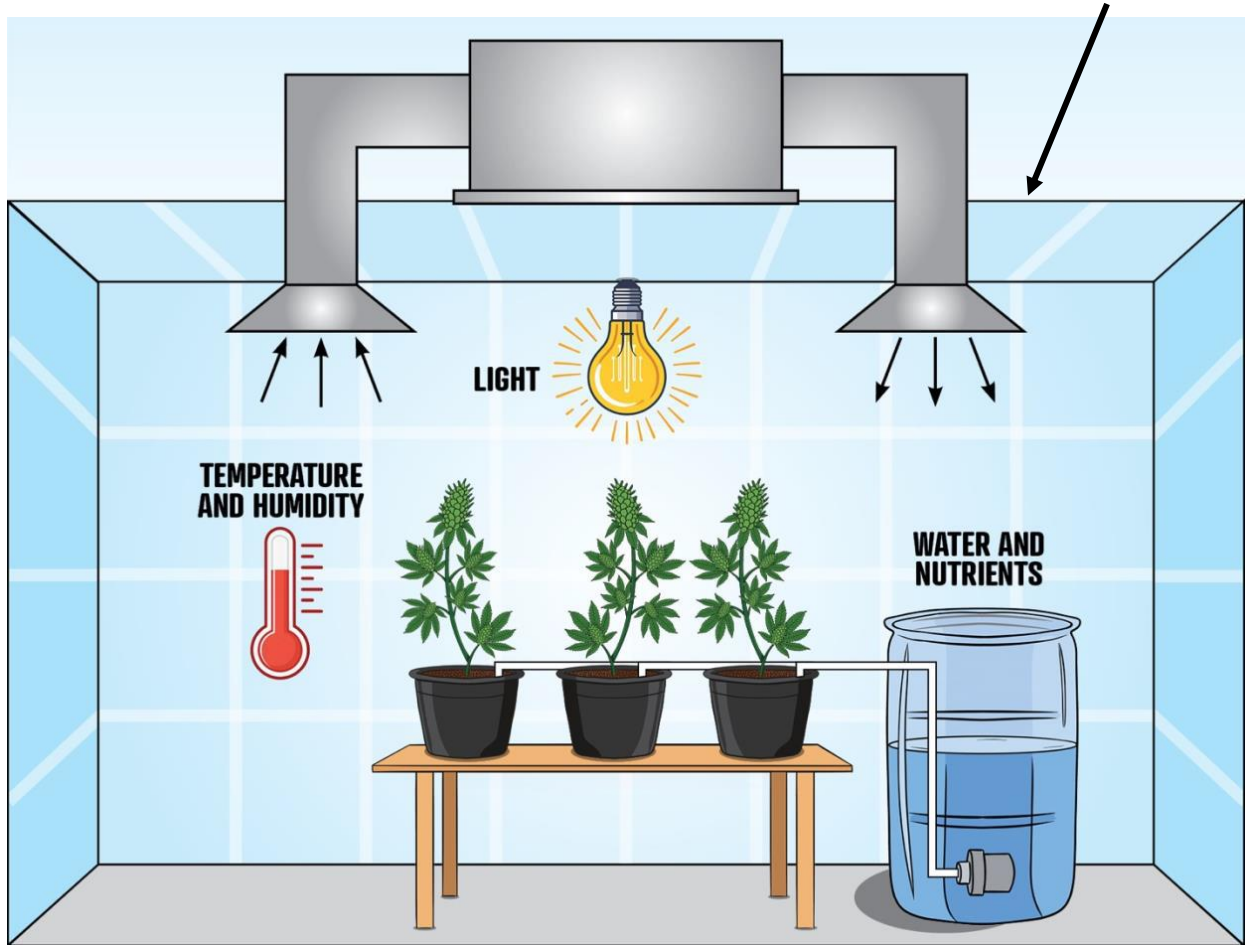
CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Proposal Description

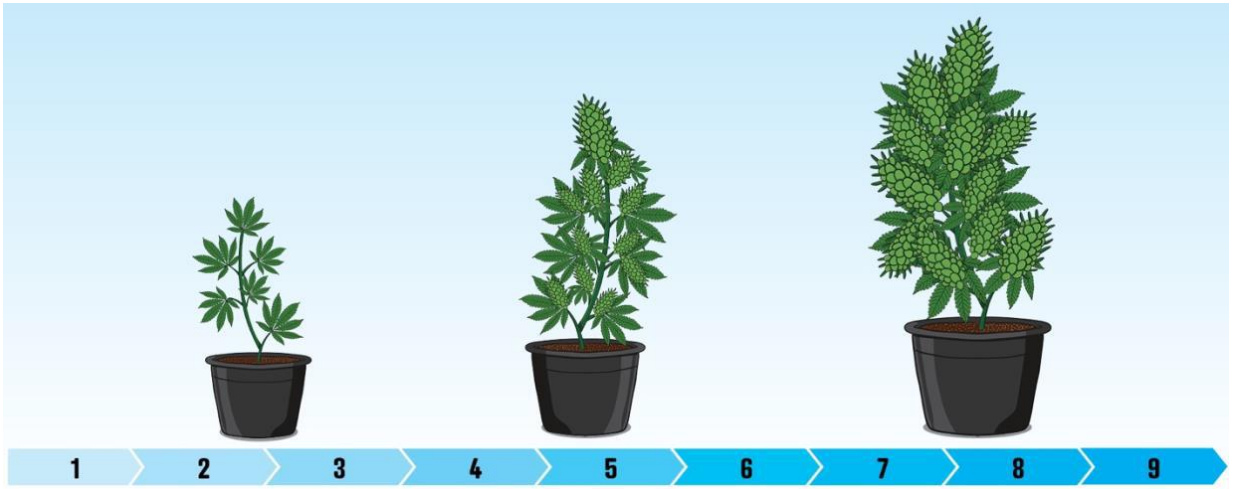
- Code Change Proposal
- Benefits
- Background Information

Fundamentals of Loads in an Indoor Growing Facility

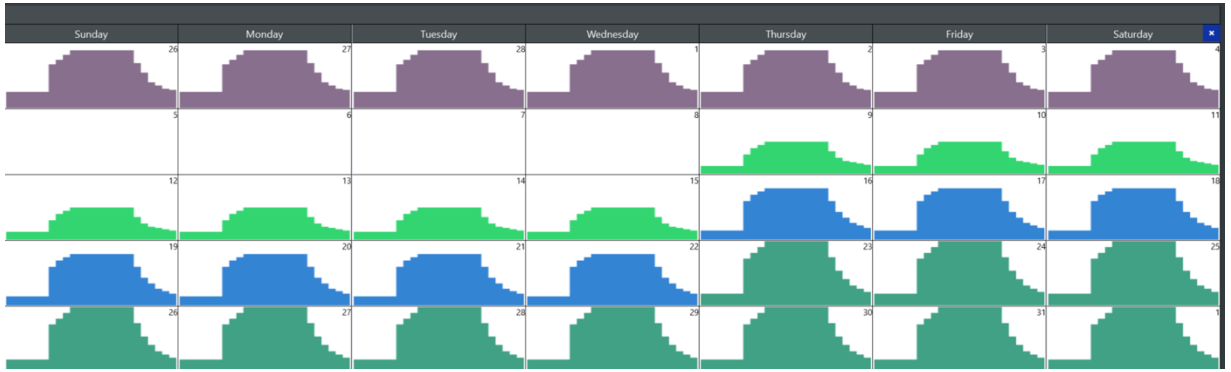
Envelope typically insulated and sealed with no glazing—almost all loads are internal



Typical nine week grow cycle



Five-week latent load example from TraneTrace energy model



https://www.etcc-ca.com/reports/controlled-environment-horticulture-energy-consumption-and-environmental-control-field

Rapid Load Growth in Existing Buildings: High Energy Intensity of Indoor Farms

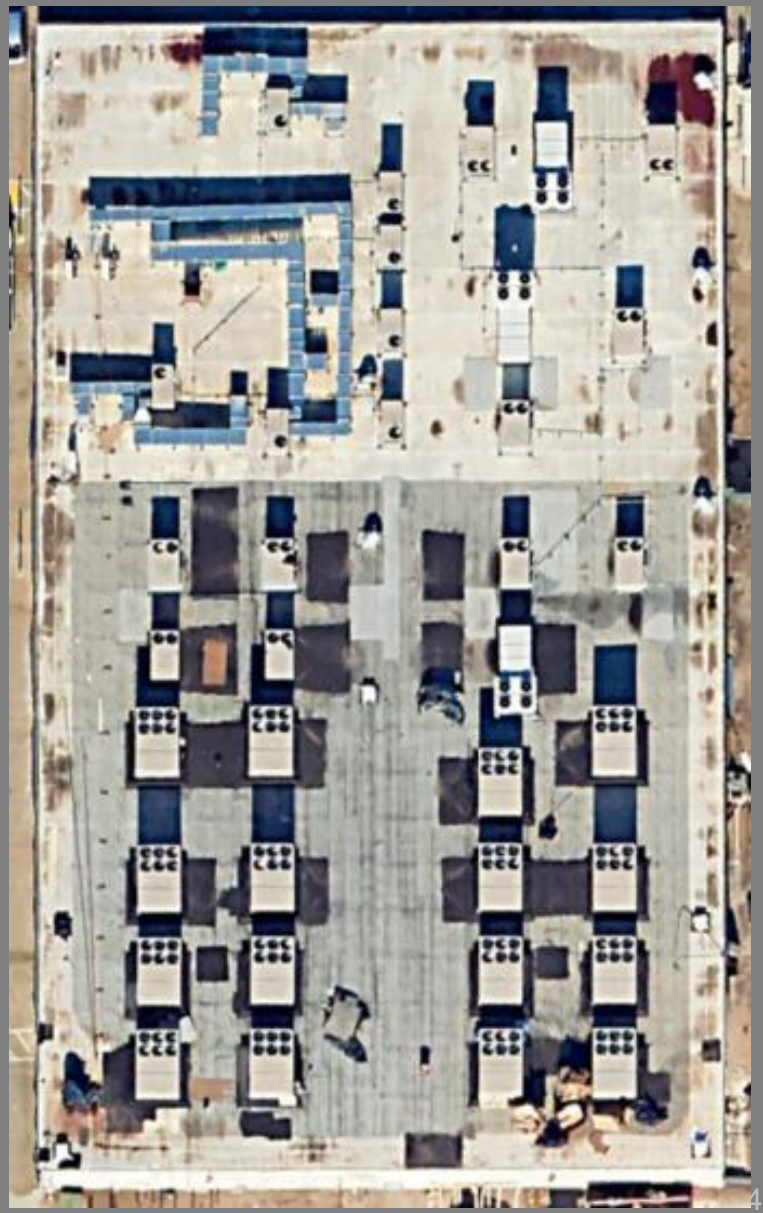
May 2021

~5 tons cooling capacity

Feb 2022

~200 tons cooling capacity

Nov 2023



~1000 tons cooling capacity

Mandatory Measures and Prescriptive and Performance Paths

Mandatory Measures

Must always be met, **may** be exceeded

Option #1

Prescriptive Approach

- **Simple but inflexible** – all or nothing approach to compliance.
- List of prescriptive requirements can apply to the whole building or system by system.
- New prescriptive requirements for CEH would likely be limited to mechanical system.

or

Option #2

Performance Approach

- **Allows flexibility** and building customization.
- Modeling software verifies whether the "Proposed Design" is as good as, or better than, the "Standard Design" (the baseline for performance).
- Tradeoffs would likely be limited to the mechanical system and related equipment and building systems.

Modeled after Energy Code Ace Fact Sheet

Current Code Requirements and Interpretation for indoor CEH

Code that applies to building types (such as conditioned warehouse) that are used as CEH facilities	Code that applies only to indoor CEH facilities:

• Mandatory Envelope
• Prescriptive Envelope
• Mandatory and Prescriptive HVAC Equipment and Controls
• Mandatory Outdoor Air Ventilation
	• Mandatory Grow Lighting
	• Mandatory Dehumidification options:
	  • Standalone dehumidifier meeting federal minimums
	  • Integrated HVAC/D capable of meeting 75% of annual reheat load with recovered energy
	  • Chilled water with 75% annual heat recovery
	  • Desiccant dehumidifier for low dewpoint applications

- As written, the “Conditioned Space” definition can be interpreted to apply to CEH facilities.
- Compliance professionals can already model and trade-off prescriptive features to demonstrate compliance.
  - However, models don’t account for the grow lighting and dehumidification load, and
  - HVAC equipment ratings do not reflect high-latent environment.
- Current performance-based compliance models do not reflect energy consumption.
- Mandatory dehumidification and prescriptive HVAC requirements do not recognize the overlap between these systems.

Proposed Code Change: Code Clarifications

Who it applies to: All CEH facilities. New construction, additions, and major alterations.

Creates/Clarifies Code Language and Definitions

- Exclude Indoor Controlled Environment Horticulture Space from Conditioned Space definition to recognize that the primary purpose of space is for an agricultural process (plant growth—not human occupancy).
- Creates new definition for "CEH Space Conditioning System".
- Introduces "Plant Canopy Area" as trigger.

Review/revise requirements for envelope, ventilation, etc.

- Reevaluate mandatory and prescriptive envelope requirements and other code requirements developed for human occupancy.
- Review/revise code requirements to align with industry practices related to plant growth (e.g. ventilation).

Update compliance software with indoor CEH facility prototype

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

Plant Canopy Area, Facility Size, and Total Capacity

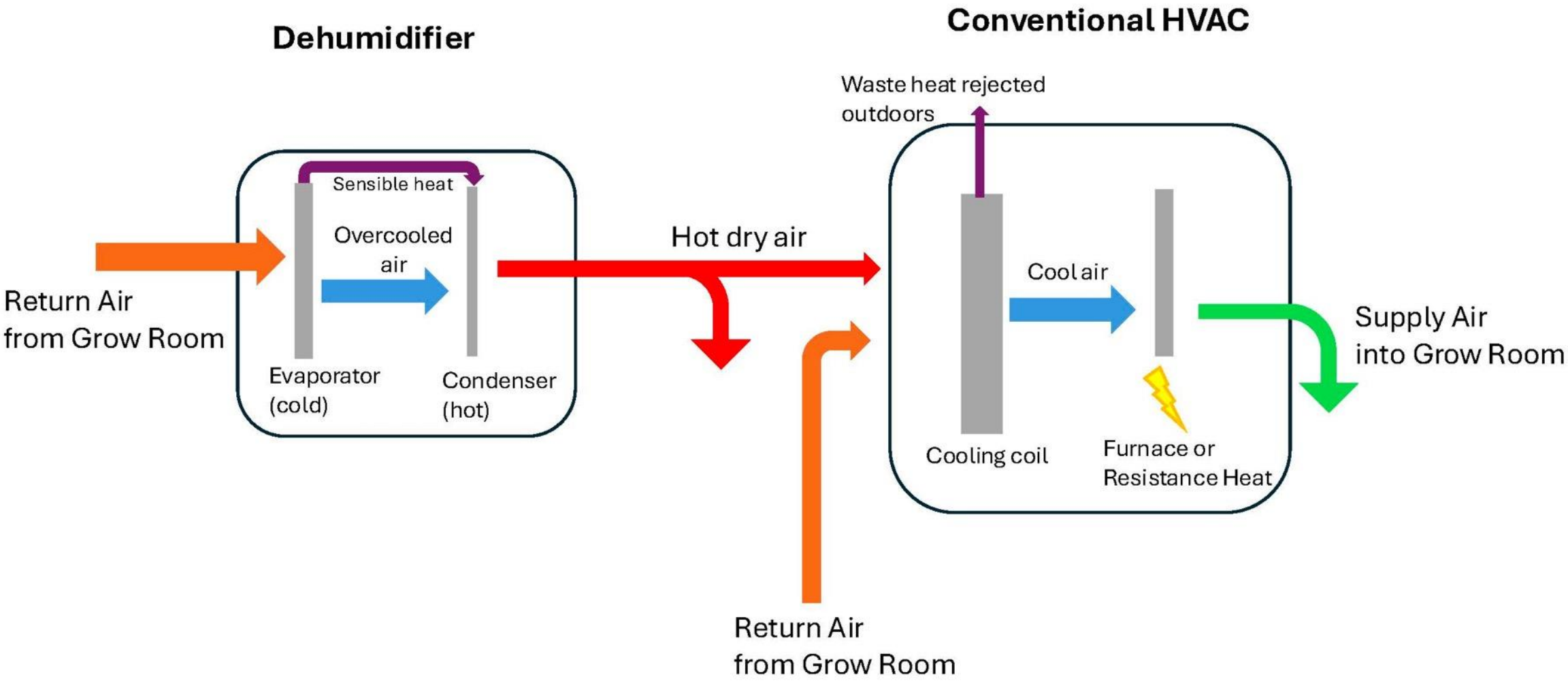
For determining canopy or cultivation area at indoor cannabis cultivation sites there are three main factors to consider*.

1. The room or rooms where plants will be grown
2. The trays and/or tables upon which the plants will be grown
3. An identifiable boundary in the form of trellising, trays, shelves, etc. that will serve to demarcate the canopy of the cultivation area

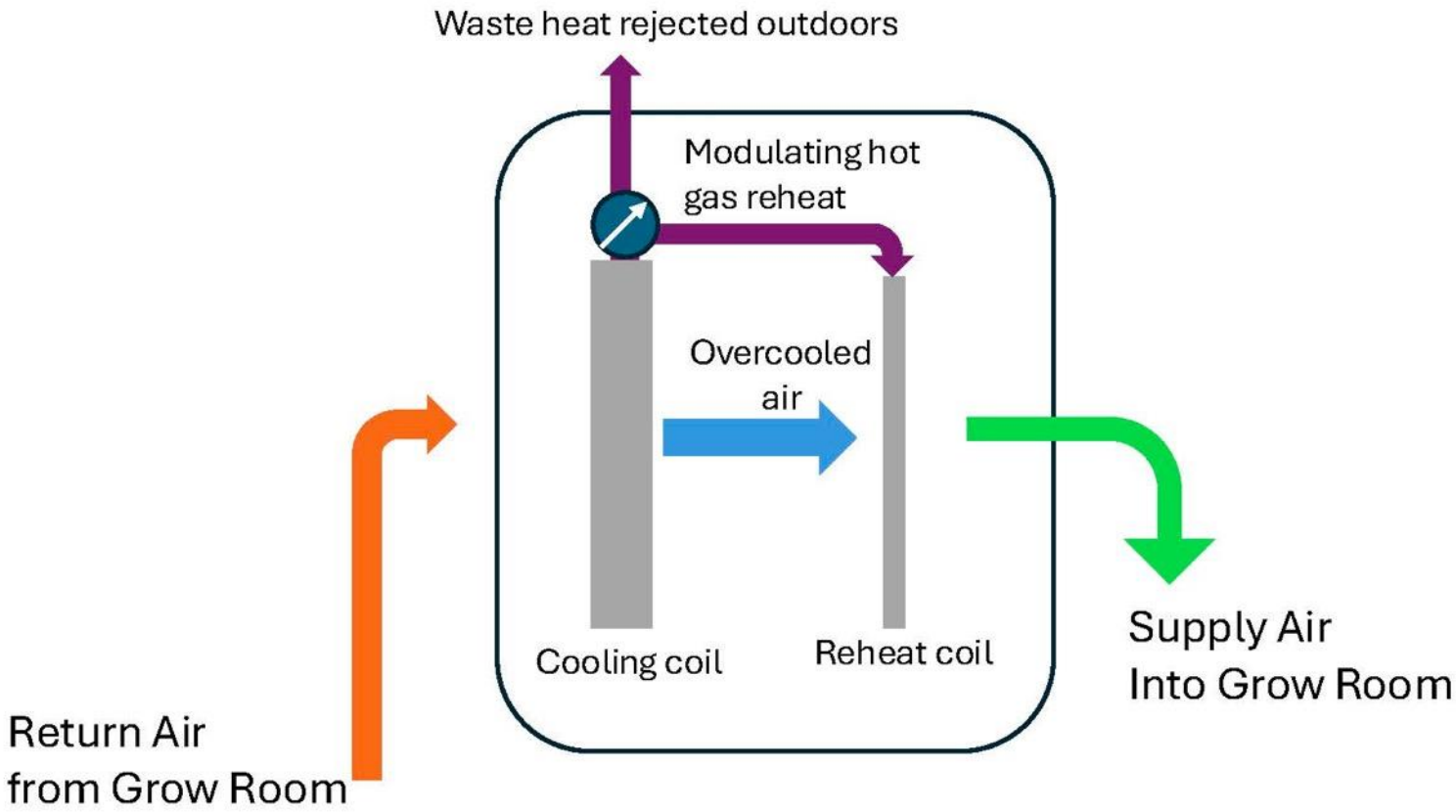
Example of Facilities with Single-Level Flower Rooms with Decoupled HVAC and Dehumidification			
Flower Room Canopy Area (sq. ft.)	≈ Approximate Flower Room Area (sq. ft.)	≈ Approximate Total Facility Footprint (sq. ft.)	≈ Approximate Total Cooling & Dehumidification Capacity for Flower Rooms (Tons)
5,000	6,700	15,000	200
22,000	29,000	66,000	870

*https://sonomacountylawlibrary.org/Main%20County%20Site/Administrative%20Support%20%26%20Fiscal%20Services/CAO/Documents/Projects/Cannabis/Determining%20Canopy%20Comprehensive.pdf

Background Information: Decoupled System



Background Information:
Integrated Dehumidification, Cooling, and Reheat



Background Information: Wraparound System

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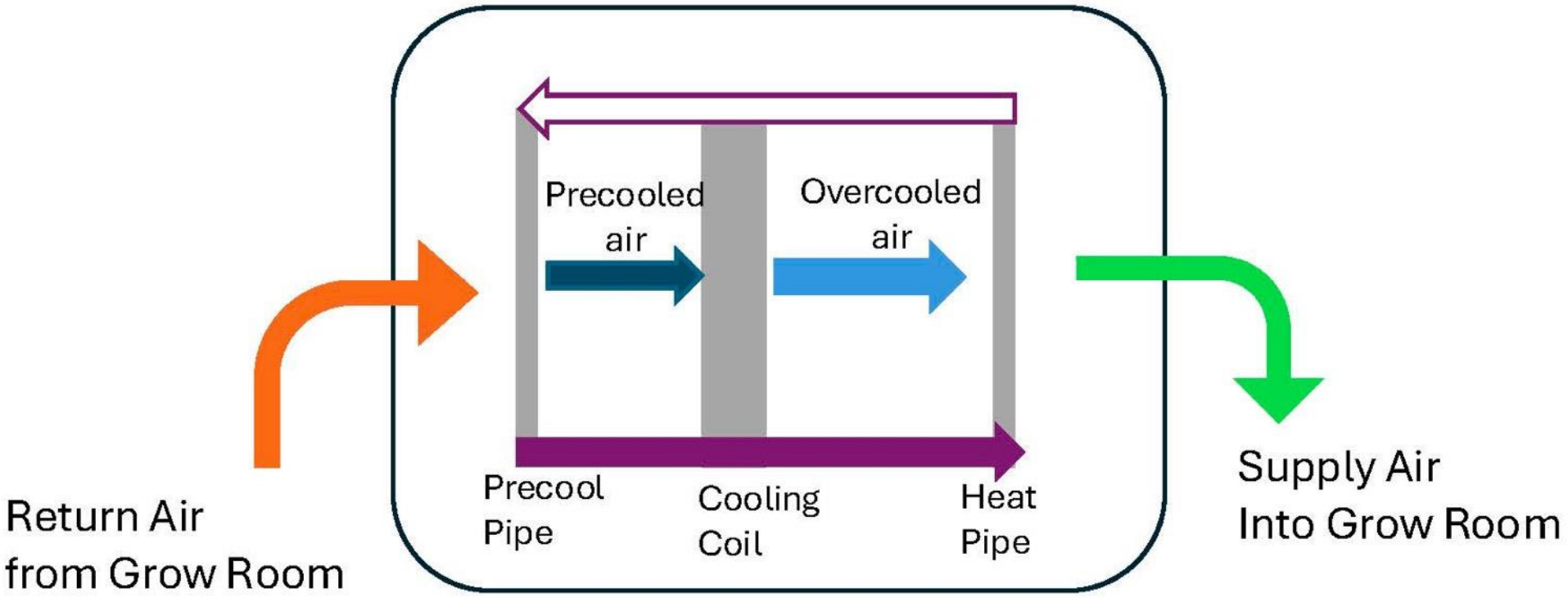

Background Information: How Energy is Saved

Waste heat recovery when needed, rejection when not needed

- Supplemental dehumidification processes add all waste heat (latent and compressor heat exhausted at ~100F) into the grow room, regardless of whether it is needed.
- An integrated system reheats the air to the desired temperature and rejects extra heat to the outdoors, eliminating the need for the cooling system to remove the dehumidifier's waste heat.

Synchronized and precise control

- A single control system manages cooling and dehumidification functions in tandem, varying the sensible and latent load removal to match the needs of the grow room.
- Variable speed compressors and fans can modulate their output to meet the load rather than short cycling at full power.

Optimal sizing for the unique demands of cultivation

- Decoupled systems are often oversized to meet the latent loads of a grow room and the sensible loads generated by the dehumidifiers.

Less equipment running

- Separate cooling and dehumidification equipment must operate simultaneously.

Proposed Code Change: CEH-Specific Mandatory Sizing

Who it applies to: Indoor growing facilities above 5,000 square feet of plant canopy area with a high lighting power density (tentatively above 30W/canopy square foot). New construction, additions, and major alterations.

Proposed Mandatory Sizing Requirements:

- Must provide design conditions throughout each grow cycle, including:
  - Lighting intensity and schedule
  - Canopy area
  - Irrigation rate and/or evapotranspiration rate
  - Indoor temperature and humidity setpoints and tolerances
- Equipment sized to meet design heating, cooling, and dehumidification at peak sensible and latent loads.
- Load calculation and sizing method in reference appendix and/or ASHRAE Sizing Guidelines (pending).

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

Proposed Code Change: Prescriptive Requirements

Who it applies to: Indoor growing facilities above 5,000 square feet of plant canopy area with a high lighting power density (tentatively above 30W/canopy square foot). New construction, additions, and major alterations.

Proposed Prescriptive Requirements

1. Plant canopy area **between 5,000 and 22,000 square feet:**
    - Primary mechanical system with variable sensible heat ratio (SHR) [range TBD], modulating heat recovery/rejection, variable capacity compressor(s), and variable fan speed
    - Primary system sized to meet at least [TBD%] of peak latent and sensible load
    - Controls integrating primary mechanical system with supplemental equipment (cooling, dehumidification, and reheat)
2. Plant canopy area **greater than 22,000 square feet:**
    - Mechanical system with four-pipe heat recovery chilled water system and
        - Wraparound heat recovery, OR
        - Chiller sized to serve no more than [TBD%] of total peak latent and sensible load (assumes alternating 12-hour lighting schedule)
    - Chillers with at least [TBD] efficiency rating
    - Heat recovery designed to meet [TBD%] of the peak heating load

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

Applicants can comply via the performance path by modeling systems to meet an equivalent energy budget.

Benefits of the Proposed Change

Energy Savings

- Reduces space conditioning energy consumption by approximately 25 to 40%[1,2] against current code baseline.

Minimal Incremental Cost

- Systems with modulating heat recovery/rejection need less total system capacity than systems without.
- The lower tonnage “cancels out” the higher cost/per ton of these systems.

Potential Yield Improvements

- Plant growth improves when systems adapt to variable latent & sensible loads and maintain tighter tolerances.

Avoid Need for Inefficient Modifications

- Right-sized, variable-capacity space conditioning equipment with heat recovery reduces the need to add inefficient "fixes" after installation (e.g. resistance reheat).

Design and Compliance Improvements

- Performance path offers design flexibility.
- New CEH Space Conditioning definition simplifies code and addresses inconsistencies (e.g. ventilation).

[1] CASE Team developed calibrated energy models based on field monitoring data.
[2] Field studies: https://www.energy350.com/wp-content/uploads/2019/08/3-0313_0466_000034-Smith-Non-Lighting-EE-in-Indoor-Cannabis.pdf

Background Information: High Energy Intensity of I

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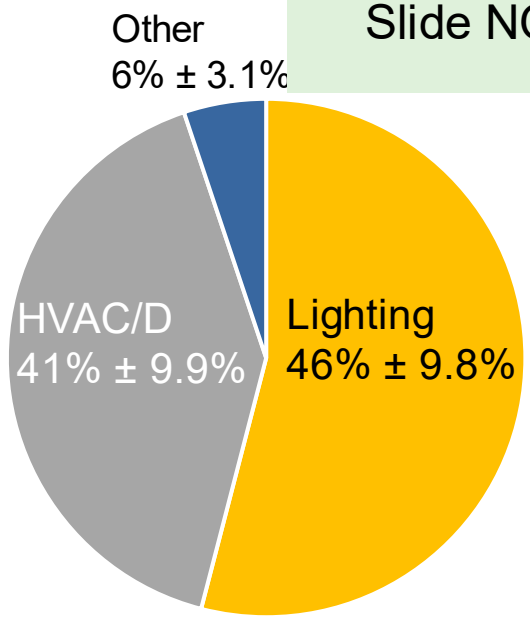
- CEH facilities have among the highest energy use intensity of California buildings.
- Historically ~40% of total energy use in CEH facilities for space conditioning (about the same as lighting) and likely to increase as a percentage of energy consumption for facilities with LED.
- Most indoor facilities do not allow air exchange with outdoors, limiting opportunities for efficiency (e.g. air side economizing).
- Extremely high internal loads must be managed with mechanical systems.
- Highly variable loads and tight tolerances for temperature and humidity control can increase energy use if not managed correctly.



Electricity end use in indoor cannabis cultivation facilities using predominately HPS lighting[1,2,3,4]

[1] https://www.sciencedirect.com/science/article/abs/pii/S0301421512002285?via%3Dihub
[2] https://etcc-ca.com/reports/controlled-environment-horticulture-energy-consumption-and-environmental-control-field
[3] https://assets.bouldercounty.gov/wp-content/uploads/2020/05/EIOF-BC-Cultivation-Assessment-Summary-Report_Final-5_4_20.pdf
[4] https://www.nwcouncil.org/sites/default/files/cannabisReport.pdf

Background Information: Regulatory Landscape

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Complex Regulatory Framework

- Currently very few CEH Space Conditioning requirements in Title 24 Part 6.
- Federal regulations apply to standalone dehumidifiers, potentially preempting more stringent regulations.
- Test procedures for standalone dehumidifiers do not represent indoor agriculture conditions.
- No federal test procedure or rating system for integrated dehumidification/cooling equipment.

2025 CASE Proposal

1. Require modulating capacity dehumidification equipment and controls
2. Require HVAC and dehumidification system commissioning
3. Require HVAC and dehumidification load sizing calculations

"All three 2025 HVAC/D measures dropped due to lack of time to work through feedback from industry"

Background Information: Current Code Requirements

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Current (2025) requirements: Title 24 Part 6 HVAC + Dehumidification Requirements

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

1. Indoor growing, dehumidification. Dehumidification equipment 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.

All T24 nonresidential envelope and HVAC requirements apply (aside from a few exemptions)

*Title 24 does not allow the use of renewable power to comply with this requirement
*CEH processes currently exempt from ASHRAE HVAC or dehumidification requirements

Background Information: Market Status and Opportunities

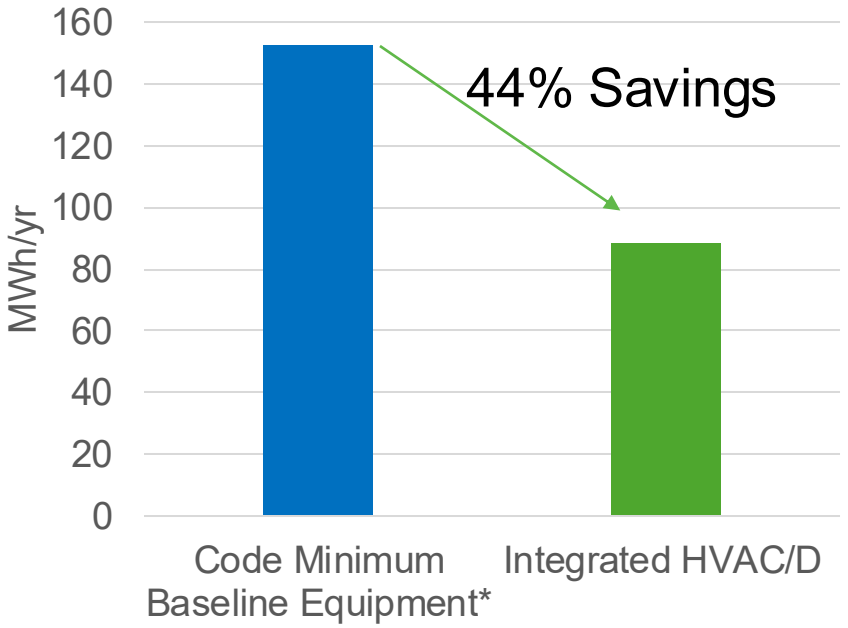
Market Slow to Adopt New and Efficient Technologies

- California is an early-adopter state for indoor ag (cannabis).
- Growers initially used equipment designed for other applications (office/residential systems).
- First-generation integrated systems (pool dehumidifiers, etc.) underperformed, creating negative perceptions.
- Continued reliance on inefficient equipment designed for other applications.

Current Opportunities

- Variety of reliable, variable-capacity products now available (e.g. reconfigured DOAS, purpose-built CEH equipment).
- Offer better performance and energy savings at similar cost (if properly sized).

Independent Case Study: Energy Savings from Switching to Integrated HVAC/D Equipment from Code Minimum Baseline[1]



*Decoupled RTUs and low-cost standalone dehumidifiers

[1] https://www.energy350.com/wp-content/uploads/2019/08/3-0313_0466_000034-Smith-Non-Lighting-EE-in-Indoor-Cannabis.pdf

Marked-up Code Language

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See Title24stakeholders.com for marked-up code language

The following sections would be modified

Title 24, Part 1	Title 24, Part 6	Reference Appendices
▪ No changes	▪ Section 100.1(b) ▪ Section 120.6(h) ▪ Section 140.9(d) **(new)** ▪ Section 141.1(c)	▪ Appendix NA7.X ▪ Appendix NA 9 **(new)**

Poll

What types of dehumidifiers do you commonly see used in high LPD indoor farms? Are there less common products and emerging technologies that you would want to be able to model?

Please consider refrigerant (compressor) dehumidifiers, solid desiccant wheel dehumidifiers, liquid desiccant dehumidifiers, heat exchanger-based dehumidifiers, integrated HVAC/D systems, modified DOAS, indoor pool dehumidifiers, and any others.

Open ended response

Market and Technical Considerations

- Current Conditions and Trends
- Potential Barriers and Solutions
- Technical feasibility

Current Market Conditions

- **Estimates for Small and Medium Facilities (5,000 – 22,000 canopy square feet)**
  - Most (~75%) facilities use fixed capacity and/or high-SHR cooling equipment (e.g. VRF) with (electric resistance or natural gas heat) to control sensible loads and standalone dehumidifiers to control latent loads. [1]
    - Most of these facilities use conventional thermostats and humidistats with little to no staging or integration between dehumidifiers and cooling equipment.
  - Some (~25%) facilities use variable capacity with heat recovery as primary means of controlling both temperature and humidity.
- **Estimates for Large Facilities (>22,000 canopy square feet)**
  - Approx 25% use four-pipe chilled water space conditioning systems that are compliant with the proposed measure.
- **2025 Case Report Assumptions [2]**
  - 5% of facilities use variable capacity space conditioning systems.
  - 95% use decoupled systems.

[1] Based on California compliance data from 2023-2024.
[2] https://title24stakeholders.com/measures/cycle-2025/controlled-environment-horticulture/

Current Market Share: Small/Medium Facilities

Market share: percentage of buildings that already use the proposed technology or design practice (at or above the proposed stringency level)

Current Market Share

Estimates based on analysis of California compliance data from 2023-2024.

Poll

What is the current market share for <u>new construction (including additions)</u>? That is, what percentage of new construction indoor farms in California currently rely primarily on **modulating integrated HVAC/D**? (5,000—22,000 sq. ft. canopy)

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
g. 61% - 70%
h. 71% - 80%
i. 81% - 90%
j. 91% - 100%

Poll

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What is the current market share for <u>alterations</u>? That is, what percentage of annual retrofits of indoor farms in California currently rely primarily on **modulating integrated HVAC/D**? (5,000—22,000 sq. ft. canopy)

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
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Current Market Share: Large Facilities

Market share: percentage of buildings that already use the proposed technology or design practice (at or above the proposed stringency level)

Current Market Share

Estimates based on analysis of California compliance data from 2023-2024.

Poll

What is the current market share for <u>new construction (including additions)</u>? That is, what percentage of new construction indoor farms in California currently rely primarily on a **four-pipe heat recovery chilled water system**? (>22,000 sq. ft. canopy)

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
g. 61% - 70%
h. 71% - 80%
i. 81% - 90%
j. 91% - 100%

Poll

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What is the current market share for <u>alterations</u>? That is, what percentage of annual indoor farm retrofits in California currently rely primarily on a **four-pipe heat recovery chilled water system with series heat recovery**? (>22,000 sq. ft. canopy)

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
g. 61% - 70%
h. 71% - 80%
i. 81% - 90%
j. 91% - 100%

Technical Considerations

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CEH System Design and Sizing

- Equipment that modulates within a wide SHR range and can modulate heat rejection/recovery can better meet varying latent and sensible loads.
- Cannabis grows require very tight environmental tolerances; setpoints and loads vary throughout the grow cycle.
- Indoor CEH facilities have almost all internal loads, very little air exchange or thermal gains through envelope.

Controls Integration

- Off-the-shelf horticulture controls support efficient use of supplementary equipment.
- Custom solutions are available for specific needs.

Variety of Efficient Solutions

- Efficient integrated DX and chilled water systems are widely available; some are designed specifically for cannabis indoor farms.
- Designers may assemble custom solutions, but several off-the-shelf products meet code requirements for small/medium facilities. Hydronic systems are typically built-up from a kit of parts (as for commercial applications).
- Decoupled systems with integrated controls and cooling/dehumidification equipment exceeding federal minimum efficiency can be as efficient as baseline integrated systems.

Per Unit Energy and Cost Impacts

Methodology and Assumptions

- Energy and Energy Cost Savings
- Incremental Costs

Energy and Energy Cost Savings Methodology

- Using CEC's methodology and metrics

Facility Type: high lighting intensity indoor CEH facility

Small and Medium Facilities (5,000-22,000 canopy square feet)

- Baseline: Humidistat-controlled standalone dehumidifiers and thermostat-controlled, single-stage HVAC with electric resistance and/or natural gas reheat.
- Proposed: Variable capacity system with modulating hot gas reheat (HGRH), and variable sensible heat ratio.

Large Facilities (>22,000 canopy square feet)

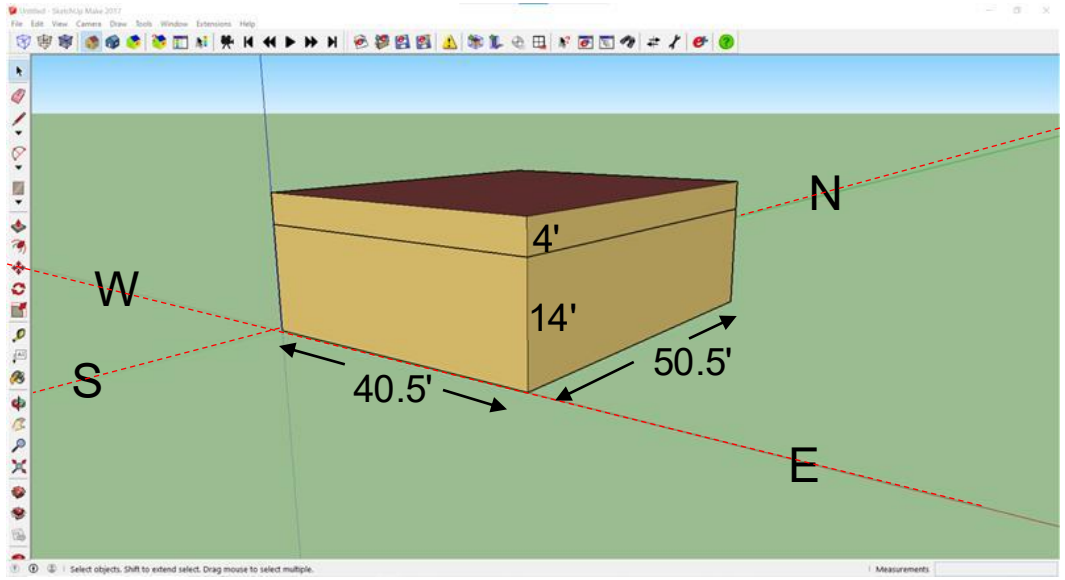
- Baseline: 4-pipe hydronic and heating system with water-cooled heat recovery providing 75% of annual reheat energy and a natural gas boiler providing the other 25% of annual reheat energy.
- Proposed: water cooled chiller using waste heat recovery for approximately 95% of reheat, high efficiency chiller, and series heat recovery.

Energy Savings Modeling Assumptions

- **Facility size**
  - Small/Medium: 8,400 square foot canopy (flowering)
  - Large: 42,000 square foot canopy (flowering)
- **Metal building insulation:** R-26 (roof), R-19 (walls)
  - 1 exterior wall (N) without windows and 3 adiabatic interior walls
  - Plenum above ceiling
- **Grow Rooms**
  - **Canopy area:** 70% of room area, single-level
  - **Max Lighting intensity:** 48.5 Watt/sq. ft. canopy
  - **Photosynthetic photon efficacy (PPE):** 2.3 µMol/J
  - **Photosynthetic photon flux density (PPFD):** 1200 µMol/m2/s with dimming
  - **Max evapotranspiration latent cooling load:** 80 Btuh/square foot

Space Conditioning Setpoints:

	Early (weeks 1-2)	Mid (weeks 3-7)	Late (weeks 8-9)
Lights on	82°F/67%RH	79°F/57%RH	73°F/48%RH
Lights off	79°F/65%RH	75°F/54%RH	70°F/46%RH



Energy Modeling Assumptions

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- Simulating energy savings in EnergyPlus with CBECC rulesets
- Simulating using the following prototypical buildings and climate zones

Prototypical Buildings

- Indoor grow facilities
- Cannabis flower
- Model exterior wall in all cardinal directions

Climate Zones

- Climate zones 3, 10, 12, 16

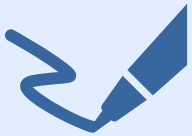
Key Modeling Assumptions

Slide NOT shown

Prototype: Small/Medium Indoor CEH Facility

Standard Design

1. Thermostat-controlled, single-stage packaged DX cooling sized to sensible load (11.9 EER, 31.5 tons/room).
2. Humidistat-controlled standalone DX dehumidifiers meeting federal minimum (0.64gal/kWh) sized to meet remaining latent load.
3. No hot gas reheat (electric resistance reheat).
4. Constant volume fans.



Proposed Design

1. Packaged variable capacity DX system sized to both sensible and latent loads (12.23 EER, 39.2 tons/room).
2. Modulating hot gas reheat capable of recovering/rejecting up to 90% of waste heat for reheat, no electric reheat.
3. Variable air volume fans.

Key Modeling Assumptions

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Prototype: Large Indoor CEH Facility

Standard Design

1. Four pipe fan coil system
2. 0.61kW/ton chiller efficiency
3. Heat recovery chiller meeting 75% of annual reheat load and natural gas boiler to meet remaining heating load
4. No series heat recovery

Proposed Design

1. Four pipe fan coil system sized to cooling, dehu, and reheat load.
2. 0.57 kW/ton chiller efficiency
3. Heat recovery chiller meeting 95% of annual reheat load, natural gas boiler to meet remaining heating load
4. Series heat recovery with effectiveness of 90%

Incremental Cost Framework

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Prototype(s): Small/Medium Indoor CEH Facility (5,000-22,000 canopy square feet)

Baseline

First Cost

1. Design
2. Equipment
   - Fixed capacity
   - Standalone DX dehumidifiers
3. Installation
4. Commissioning

30-Year Maintenance Costs

1. Equipment repair/replacement
2. Regular Maintenance

Proposed

First Cost

1. Design (Includes Sizing)
2. Equipment
   - Variable capacity
3. Installation
4. Commissioning

30-Year Maintenance Costs

1. Equipment repair/replacement
2. Regular Maintenance

Incremental Cost Framework

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Prototype(s): Large Indoor CEH Facility (>22,000 canopy square feet)

Baseline

First Cost

1. Design
2. Equipment
   - 4-pipe hydronic cooling/dehu and heating system
   - Water cooled 75% heat recovery chiller (annual heating load)
3. Installation
4. Commissioning

30-Year Maintenance Costs

1. Equipment repair/replacement
2. Regular Maintenance

Proposed

First Cost

1. Design (Includes Sizing)
2. Equipment
   - 4-pipe hydronic cooling/dehu and heating system
   - Water cooled 95% heat recovery chiller (annual heating load)
   - Series heat recovery
3. Installation
4. Commissioning

30-Year Maintenance Costs

1. Equipment repair/replacement
2. Regular Maintenance

Approach for Gathering Costs

Direct Outreach to Stakeholders

- Collect design, installation, and equipment costs from design engineers and mechanical contractors who specialize in CEH space conditioning from past projects.
- Conduct interviews with manufacturers, distributors, and facility designers.
- Interview HVAC service companies to develop maintenance, repair, and replacement costs and time intervals for each system type.

System sizing and design cost calculations

- Develop correctly sized baseline and proposed designs and solicit bids from installing contractors.

Data requested (for standalone dehumidifiers, conventional cooling, integrated DX, chillers, and fan coils):

- Design, installation, and equipment costs or bids from previous projects, with sizing details
- Maintenance, repair, and replacement costs from service companies
- Input about experience with different CEH space conditioning systems

Compliance Verification

- Key Aspects of Compliance Verification
- Barriers and Solutions
- Revisions to Compliance Software

Key Aspects of Compliance Verification

- **Field Verification**
  - Evaluating requirements for verification of controls settings by field technician.
- **Updates to Compliance Software**
- **Updates to NRCI-PRC-E**
  - Document key installed equipment specifications.
- **Updates to NRCC-PRC-E: Load Calculations and Sizing Guide**
  - Document assumptions for each high intensity lighting grow room.
  - Document HVAC/D equipment capacity.
  - Calculate room loads and sensible heat ratio and compare to documented equipment capacity and sensible heat ratio.

Proposed Load Calculation Inputs: Lighting In

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Lighting Input Table			
Room Condition	Condition 1 (Peak Latent)	Condition 2 (Pre-Harvest/Finishing)	Condition 3 (Dark Period
Photoperiod (hours)			
Canopy Area (sq. ft.)			
Fixture Type			
Fixture Quantity			
Watts/Fixture			
Total Power (kW)			
EUI (W/sf canopy)			

[1]Condition 1 (Peak Latent) occurs when Et is the greatest.
[2] In rooms where the target conditions change over time, Condition 2 (Finishing) occurs when the target relative humidity is the lowest, often right before plants are harvested.
[3]Condition 3 (Dark Period) occurs when lights are off during the highest plant Et that occurs during the dark period.

Proposed Load Calculation Inputs: Irrigation Ir

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Irrigation Input Table			
Room Condition	Condition 1 (Peak Latent)	Condition 2 (Pre-Harvest/Finishing)	Condition 3 (Dark Period
Canopy Area (sq. ft.)			
Plant Quantity			
Irrigation Rate (gal/plant/day)			
% Drainage[1]	20%	20%	20%
Dark Period Et % of Light Period Et[2]	30%	30%	30%
Latent Load (gal / sq.ft. canopy / day)			
Latent Load (GPH)			

Select Evapotranspiration Rate (Et) calculation method:

- Irrigation (fill out irrigation table)
- Model (certification required

[1]20% default value, can be overwritten (user-defined)

[2]30% default value, can be overwritten (user-defined)

Poll

What aspects of code impacting CEH facilities require clarification or re-evaluation?

Open ended response

Compliance Software Updates: Current Capabi

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Current CBECC Capabilities

- CBECC does not currently have an indoor CEH prototype.
- Some of the cooling and heating equipment used in CEH facilities can be modeled in CBECC (e.g. RTUs).
- Assumptions and inputs about internal loads (lighting, humidity) vastly underestimate the loads in a typical CEH facility and cannot represent variations throughout grow cycles.
- Some controls sequences cannot be modeled in CBECC.

Current EnergyPlus Capabilities

- Lighting loads, latent loads, evaporative cooling, and most space conditioning equipment in CEH facilities can be modeled in Energy Plus.
- EnergyPlus can be used to model CEH facilities by modifying internal loads.
- Some of the default controls settings in EnergyPlus are limited, but the Energy Management System feature can be used to simulate equipment staging in response to latent loads.

Compliance Software Updates to Support Performance Approach

Planned CBECC Updates

- Indoor CEH Prototype, including default assumptions for variable latent and sensible loads (daily and throughout grow cycle) is under development.
- Create default functions that would recreate EMS customization and previous analysis.
- Develop a limited number of new inputs in CBECC (specific variables TBD).
- Define a high lighting intensity CEH space function and default settings.
- Add less common heat recovery/dehumidification technologies as needed (e.g. hot gas reheat, desiccant systems).

Planned EnergyPlus Updates

- Enable correct end use reporting for dehumidifiers by separating fan and coil energy use.
- Update source code to increase the hot gas reheat limit from 30% to at least 90%.
- Add less common heat recovery/dehumidification technologies as needed (e.g. heat exchanger-based dehumidifiers, Carolina heat pipe).

Data Needs

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Market Information

- Market practice for indoor farm envelope design
- Rates of new construction of CEH facilities, awareness of cannabis facility construction in jurisdiction
- Reasons facility operators object to integrated space conditioning equipment

Space Conditioning System Data

- Performance and quality specifications for integrated and decoupled HVAC/D systems
- Key attributes and differences between different integrated DX systems
- Cost considerations and economies of scale for chilled water systems
- Differences in replacement process (compressor vs. whole unit) for different equipment types
- Attributes, advantages, modeling approach for new/emerging dehumidification technologies

Facility Practices

- Typical threshold (canopy square footage) for direct expansion (DX) vs. chilled water
- Documented impact on yield / quality and energy savings from improved control, integrated vs. decoupled systems, other system attributes

Poll

What else should we know? Are there market or technical barriers or solutions we should consider?

Open ended response

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Market Barriers and Solutions

Market Barriers	Potential Solutions
1. There are few energy modeling tools that accurately reflect the conditions in indoor CEH facilities.	1. CASE team will make required updates to EnergyPlus and handoff to CBECC team.
2. Negative perceptions of integrated equipment from unreliable first-generation equipment.	2. Confirm the latest generation of equipment avoids noted performance issues and develop explain how issues with first-gen integrated equipment have been resolved.
3. Perception of higher incremental cost per ton and total system cost (if sized incorrectly).	3. Demonstrate the need for less total capacity from correctly-sized modulating integrated systems.
4. Lack of design professionals familiar with indoor ag environments and sizing.	4. Develop standard sizing methodology, guidelines, and training.
5. Limited access to conventional capital and tax benefits (depreciation) impacts investment decisions and may lead designers to prioritize expedited timelines.	5. Leasing strategies enable depreciation and conventional financing.

Technical Barriers and Solutions

Technical Barriers	Potential Solutions
1. No space conditioning equipment standards or test procedures specific to CEH applications.	1. Develop code requirement and system specifications that do not rely on test procedure or federal standards.
2. Complexity of controls, especially for integrated systems.	2. Conduct stakeholder outreach with manufacturers and vendors to identify solutions.
3. High load conditions and continuous operation can lead to equipment failure and maintenance needs.	3. Allowing additional capacity and multiple units to reduce the impact of equipment failure.

Compliance Barriers and Solutions

Compliance Verification Barriers	Potential Solutions
1. Difficult to commission CEH HVAC/D systems without plants in the space. 2. Newly required metrics (e.g. SHR) may not be listed on equipment . 3. Currently no federal standards, test procedures, or rating system for CEH-specific equipment. 4. Lack of industry standard guidelines for sizing space conditioning systems, making it difficult to verify correctly sized systems. 5. Increases or decreases in future canopy area may be difficult to regulate.	1. Do not require commissioning but provide compliance credit for sensors to support successful commissioning. 2. Work with OEMs selling into the indoor ag market to provide key metrics. 3. Develop requirements that do not rely on test procedures to ensure performance, work to develop test procedures for subsequent code cycles. 4. Support ASHRAE Indoor Ag MTG to develop guidelines and/or develop simple guidelines in T24 appendix. 5. Develop cost-effective code triggers for additions and alterations to space conditioning systems.

Cost Effectiveness Results

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Climate Zone	Benefits *30-year Energy Cost Savings + Other PV Savings* (2029 PV$)	Costs *Total Incremental PV Costs* (2029 PV$)	Benefit-to-Cost Ratio
1	$#,### – $#,###	$#,### – $#,###	#.# – #.#
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Results vary by prototypical building

134.79

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