

DOCKETED	
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Project Title:	2028 Energy Code Pre-Rulemaking.
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Document Title:	Presentations - June 24, 2026 (Day 2) - 2028 Energy Code Staff Pre-Rulemaking Workshop
Description:	Presentations from the June 24, 2026, 2028 Energy Code staff pre-rulemaking workshop.
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2028 Energy Code, Pre-Rulemaking

Presenter: Payam Bozorgchami P.E., Building Standards Branch

Date: June 24, 2026



Housekeeping Rules

Public Comments

Zoom App/Online

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- Press *6 to Mute/Unmute

When called upon

- CEC will open your line
- Unmute on your end
- Spell name and state affiliation, if any
- 2 minutes or less per speaker, 1 speaker per entity

Agenda for Today's Workshop



	Topics	Presenter
	Introduction & 2028 Overview	Payam Bozorgchami
	Data Center Improvements & HVAC – 300 Ton ACC Limit for Data Centers	Habtom Tewelde
	Covered Process Refrigeration	Haile Bucaneg
	HVAC Air Distribution – Modulating Dedicated Outdoor Air System (DOAS)	Anushka Raut, Habtom Tewelde
	HVAC Air Distribution – PVAV Turndown	Ronald Balneg
	HVAC Fault Detection and Diagnostics	Ronald Balneg

Agenda for Today's Workshop (Continue)



	Topics	Presenter
	Fenestration Improvements	Jose Perez
	Indoor Lighting Power Density	Sahar Daemi
	Indoor Lighting controls	Sahar Daemi
	Controlled Environment Horticulture	Thao Chau
	Solar Pool Heating for Existing Buildings	Danny Tam
--	Adjourn	----

California Energy Commission's Authority & Process



Public Resources Code (PRC 25402): Reduction of wasteful, uneconomic, inefficient, or unnecessary consumption of energy

- Warren Alquist Act Signed into law in 1974
- Mandates updates to Building Efficiency Standards and requires the building departments to enforce them through the permit process



CALIFORNIA
ENERGY COMMISSION



California Energy Commission
Warren-Alquist Act

State Energy Resources Conservation and Development Act

Public Resources Code
Section 25000 et seq.

Assembly Bill 130 (2025)



Limits updates to building standards affecting residential units before 2031 code cycle (effective date no sooner than Jan 1, 2032)

- All 2028 Energy Code updates will exclude buildings of Group R Occupancy including its common or public use areas
 - Residential Group R is defined Part 2 of Title 24
- Residential energy metrics will remain unchanged until 2031 Energy Code, including compliance metrics and weather files
- September 2025, CA Building Standards Commission Information Bulletin 25-03:
 - <https://www.dgs.ca.gov/BSC/News/Page-Content/Building-Standards-Commission-News-List-Folder/IB-25-03-AB-130>

Proposed Definition for Group R Occupancies

Will provide exceptions through the Energy Code



- **GROUP R OCCUPANCIES** residential Group R and common and public use areas as defined in Chapter 2 of the CBC, serving residential units, and structures accessory to residential units designated and constructed in accordance with the CRC, are also subject to Assembly Bill 130-2025.

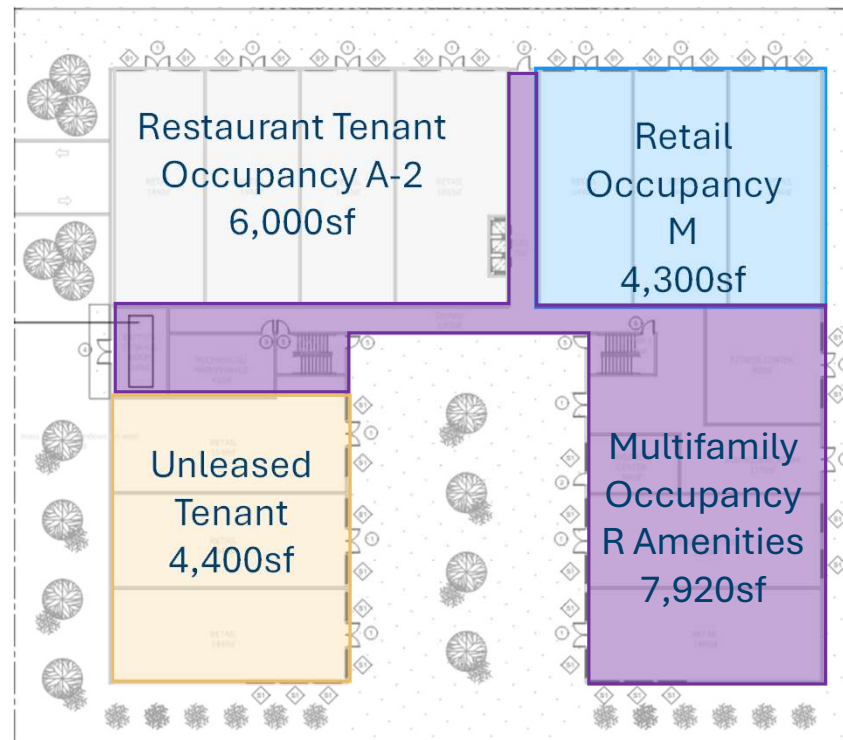
Proposed Definition for Group R Occupancies

Our understanding of Multifamily Occupancy in a Mixed Occupancy Building.



R-Occupancy (2025 Energy Code Stringency)

- 1st floor Amenities (A-2 lobby, R-2 corridors and stairs to multifamily occupancy, B leasing office). 2-5 floors supporting dwelling units and circulation to those dwelling units



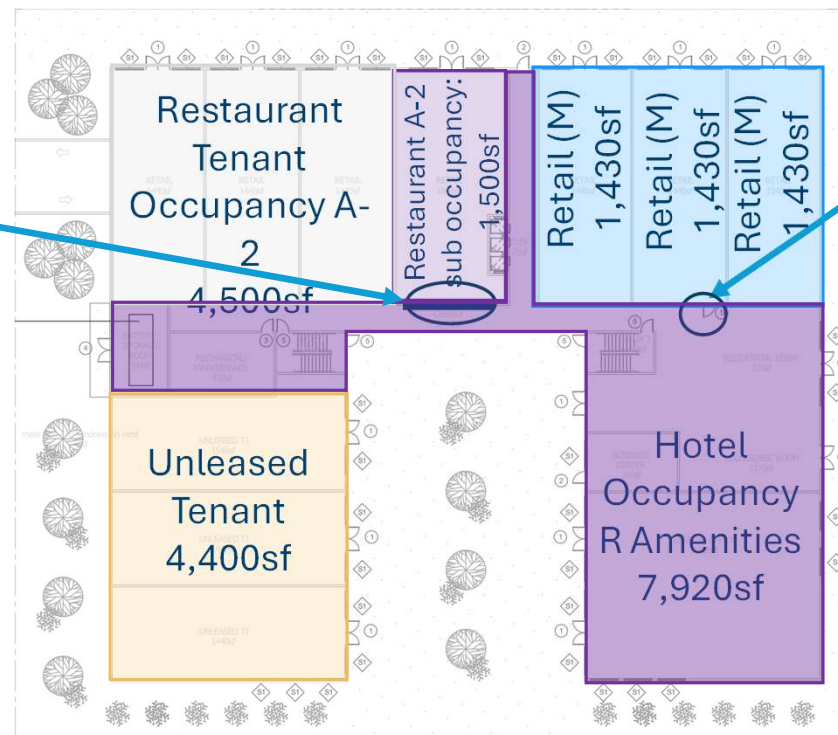
All of the non-R Occupancies that are not a sub occupancy nor share common areas with the R Occupancy and will be subject to 2028 stringency.

Proposed Definition for Group R Occupancies

Our understanding of Hotel/Motel in a Mixed Occupancy Building.



There is access to the restaurant from the hotel as sub-occupancy



One of the non-R Occupancies that is not a sub occupancy to the R Occupancy has access to common area of the R occupancy via a fire rated door and will be subject to 2028 stringency.

2028 Energy Code Drivers and Themes



State Goals

- Contribute to the state's GHG reduction goals
- Increase building energy efficiency cost-effectively

2028 Energy Code Areas of Interest – Nonresidential Buildings

- Continue to encourage efficient building decarbonization where possible
- Promote demand flexibility
- Covered process loads
- Existing buildings
- Compliance improvements



2025 Restructured Standards

To Be The New Structure for the 2028 Energy Code



Restructured 2025 Energy Code – California Code of Regulations – Title 24, Part 6 (For Information Only)

FIND IT: <https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency>

Organized by Building System



Chapter	Section	Subject.	Title
1	100.0-100.2	(a)(b)(c) 1.2.3. A.B.C. i.ii.iii a.b.c.	General Provisions All building types
2	110.0-110.12		Mandatory All building types
3	120.0-120.10		Mandatory Nonresidential, Covered Process
4	130.0-130.5		Mandatory Lighting & Electrical Nonresidential, Covered Process
5	140.0-140.10		Prescriptive and Performance Nonresidential, Covered Process
6	141.0-141.1		Additions, Alterations and Repairs Nonresidential, Covered Process
7	150.0		Mandatory Single-family
8	150.1		Prescriptive and Performance Single-family
9	150.2		Additions, Alterations and Repairs Single-family
10	160.0-160.9		Mandatory Multifamily
11	170.0-170.2		Prescriptive and Performance Multifamily
12	180.0-180.4		Additions, Alterations and Repairs Multifamily

CURRENT 2025 STRUCTURE

Chapter	Section	Subject.	Title
1	100-102	1.2.3... 1.2.3... 1.2.3... 1.2.3... 1.2.3...	General Provisions All building types
2	200		Definitions All building types
3	300-303		Envelope All building types, Nonresidential, Single-family, Multifamily
4	400-403		HVAC and Ventilation All building types, Nonresidential, Single-family, Multifamily
5	500-503		Plumbing All building types, Nonresidential, Single-family, Multifamily
6	600-603		Electrical and Lighting All building types, Nonresidential, Single-family, Multifamily
7	700-703		Renewables and Storage All building types, Nonresidential, Single-family, Multifamily
8	800-803		Pool and Spa All building types, Nonresidential, Single-family, Multifamily
9	900-911		Process Systems and Equipment Covered Process
10	1000-10001		Design Review and Commissioning Nonresidential

NEW 2028 STRUCTURE



Restructured Energy Code

- In response to industry feedback, we published the 2025 Restructured Code
 - Better aligns the Energy Code with other Parts of Title 24
 - Improves usability and navigation
 - Will be used as the basis for the 2028 Energy Code

Current Code Format

(a) **Roof deck, ceiling and rafter roof insulation.** The opaque portions of roof decks separating attic spaces from ambient air, and ceilings or rafter roofs separating conditioned spaces from unconditioned spaces or ambient air, shall meet the requirements of Items 1 through 4 below:

1. In Climate Zones 4 and 8 through 16, roof decks in newly constructed attics that are above conditioned space shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.184.

Exception 1 to Section 150.0(a)1:

- i. The space-conditioning system air handler and ducts are located entirely in conditioned space below the ceiling separating the occupiable space from the attic; or
- ii. The space-conditioning system air handler is located in unconditioned space and has 12 linear feet or less of supply duct, including the length of the air handler and the plenum, located in unconditioned space, with all other portions of the supply ducts located in conditioned space below the ceiling separating the occupiable space from the attic; or
- iii. The space-conditioning system is a ductless system.

Exception 2 to Section 150.0(a)1: Space-conditioning duct systems buried within insulation in an attic that complies using Section 150.1(b) and is verified according to RA 3.1.4.1.



Restructured Code Format

302.2 [Section 150.0] Mandatory requirements (Newly Constructed, Additions, Alterations).

302.2.1 [Section 150.0(a)] Roof deck, ceiling and rafter roof insulation.

The opaque portions of roof decks separating attic spaces from ambient air, and ceilings or rafter roofs separating conditioned spaces from unconditioned spaces or ambient air, shall meet the requirements below:

302.2.1.1 [Section 150.0(a)1] Attics above conditioned space.

In Climate Zones 4 and 8 through 16, roof decks in newly constructed attics that are above conditioned space shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.184.

Exception 1 to Section 302.2.1.1: The space-conditioning system air handler and ducts are located entirely in conditioned space below the ceiling separating the occupiable space from the attic; or

The space-conditioning system air handler is located in unconditioned space and has 12 linear feet or less of supply duct, including the length of the air handler and the plenum, located in unconditioned space, with all other portions of the supply ducts located in conditioned space below the ceiling separating the occupiable space from the attic; or

The space-conditioning system is a ductless system.

Exception 2 to Section 302.2.1.1: Space-conditioning duct systems buried within insulation in an attic that complies using [Sections 102.5.2](#) and [102.5.5 \[Section 150.1\(b\)\]](#) and is verified according to RA 3.1.4.1.

IOU CASE team and Consultants

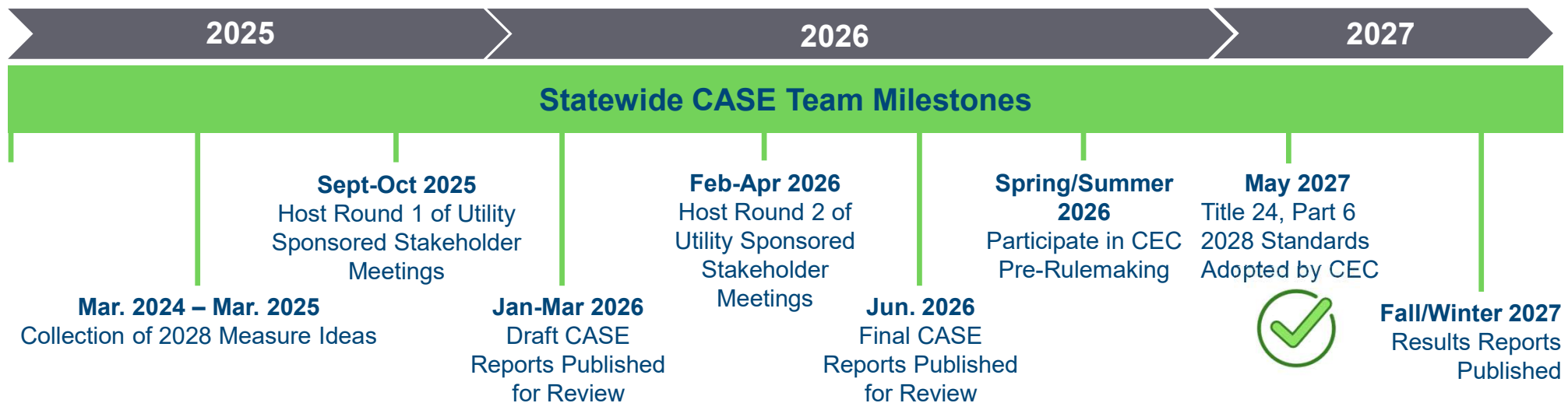
Thank You!!



Overview Schedule for the 2028 California Energy Code



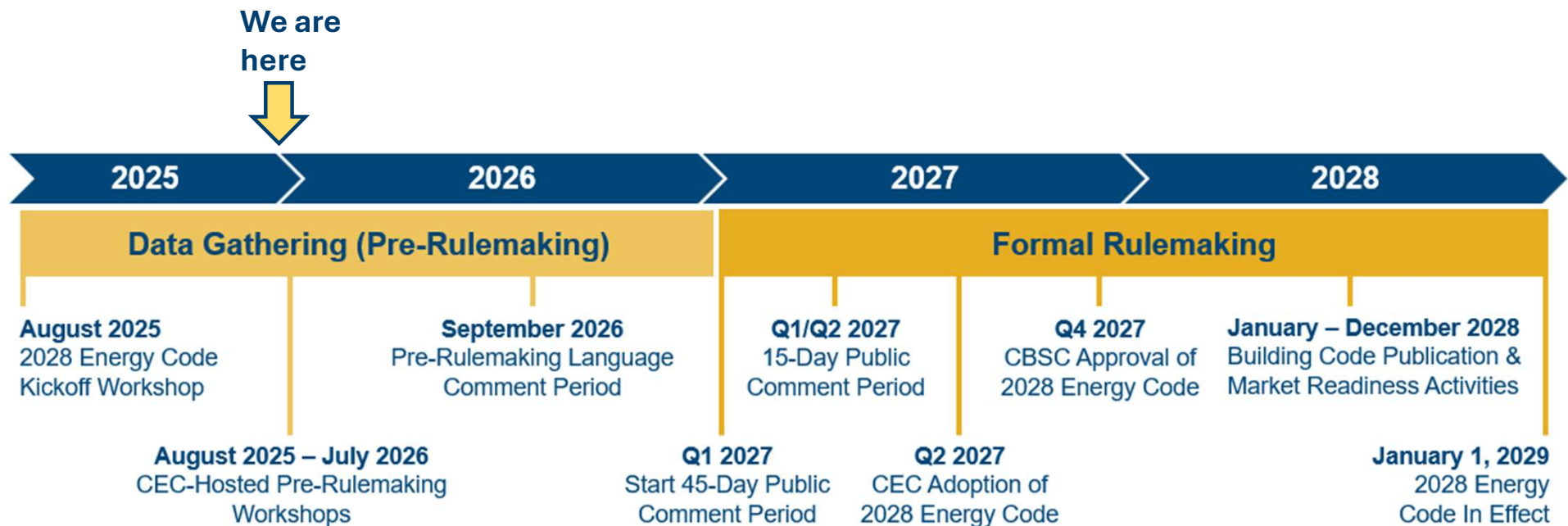
IOU CASE Team Schedule



Overview Schedule for the 2028 California Energy Code



2028 Energy Code



Comments for Today's workshop

Due Date: July 17, 2026, by 5:00 PM



Comments to be submitted to:

**[https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?
docketnumber=25-BSTD-03](https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03)**

Thank you for participating!

QUESTIONS?



Data Center Efficiency Improvements, Definitions & Air Cooled Chiller Capacity Limits

Habtom Tewelde, P.E.



Terms & Abbreviations

Abbr.	Term
ACC	Air Cooled Chiller
AHU	Air Handling Unit
AWHP	Air-to-Water Heat Pump
Btu/hr	British Thermal Unit per Hour
CHW	Chilled Water
CRAH	Computer Room Air Handler
CW	Condenser Water
CDU	Coolant Distribution Unit
CT	Cooling Tower
DB	Dry Bulb Temperature
DFDD	Dual Fan Dual Duct
EER	Energy Efficiency Ratio
FW	Facility Water
FWS	Facility Water Supply

Abbr.	Term
FSD	Fire Smoke Damper
HX	Heat Exchanger
HW	Hot Water
LC	Liquid-Cooled
IT	Information Technology
IPLV	Integrated Part-Load Value
LWT	Leaving Water Temperature
LCCA	Lifecycle Cost Analysis
ITE	Information Technology Equipment
NPV	Net Present Value
OADB	Outdoor Air Dry Bulb
OAWB	Outdoor Air Wet Bulb
PUE	Power Usage Effectiveness
PV	Present Value



Terms & Abbreviations

Continued

Abbr.	Term
RDHX	Rear Door Heat Exchanger
SWH	Service Water Heating
SAT	Supply Air Temperature
TCS	Technology Cooling System
ΔT	Temperature Difference
WSE	Water-Side Economizer
WB	Wet Bulb Temperature



Summary of Proposed Code Changes for Computer Rooms

1. **Mandatory Requirements: Revised Threshold for Variable-Speed Fan Control 910.1 [120.6(j)3]**
2. **Prescriptive Requirements: Economizer Requirement Updates 201 [100.1(b)], 910.2 [140.9(a)], 910.4 [141.1(b)]**
 - 2.1 New Computer Room Integrated Economizer
 - 2.2 Revised Dry-bulb / Wet-bulb Economizer Thresholds
 - 2.3 New Liquid-Cooled Information Technology Equipment (ITE) Economizer Threshold
 - 2.4 New Differential Temperature and Variable Flow Requirements
 - 2.5 New Economizer Exception for Heat Recovery
 - 2.6 Revised Additions/Alterations Economizers
3. **New Mandatory Computer Room Heat Recovery Measure**
4. **Proposed Data Center Definitions**
5. **Air Cooled Chiller (ACC) 300 Ton Limit 401.3.12 [140.4(j)]**



1. Revised Computer Room Fan Control Measure Summary

- Existing Code Language
 - **910.1.3 [120.6(j)3]:** Unitary air conditioners exceeding 60,000 Btu/hr mechanical cooling capacity shall vary airflow as a function of load
- Proposed Code Language
 - **910.1.3 [120.6(j)3]:** Direct Expansion air conditioners exceeding 30,000 Btu/hr mechanical cooling capacity shall vary airflow as a function of load
- First Costs and Replacement Costs
 - \$1.63/ft² weighted average first cost
 - 10-yr estimated useful life (EUL) - two replacements over 30 years
- Maintenance Costs
 - Incremental maintenance costs: \$0
- Benefit-to-Cost Ratio
 - Ranges from 9.2 to 9.4 for all 16 climate zones

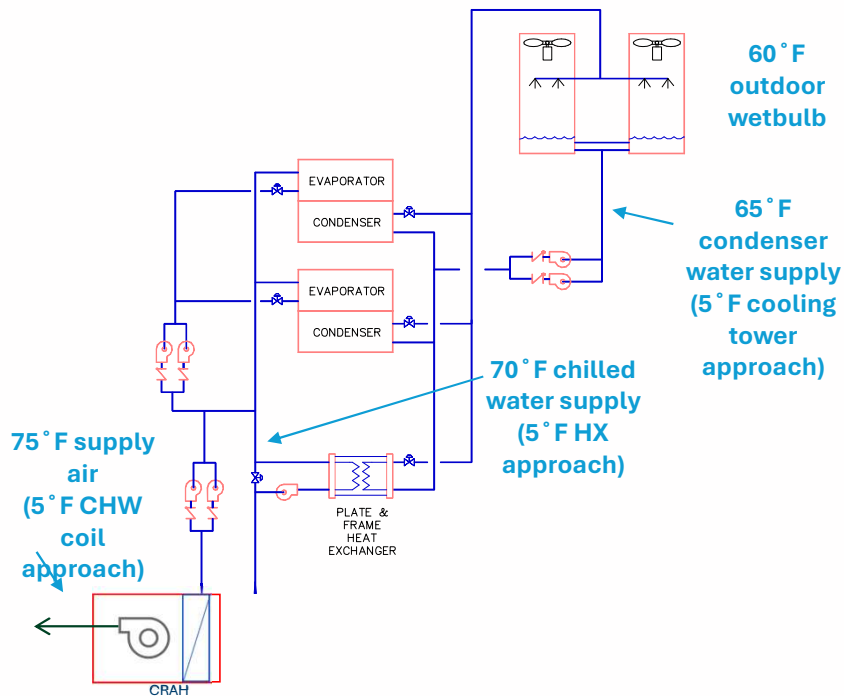
Question: Does lowering the computer room DX fan control threshold from 60,000 Btu/hr to 30,000 Btu/hr make sense? Are units in this size range typically available with variable speed fan control or could this affect cost, availability or lead times?



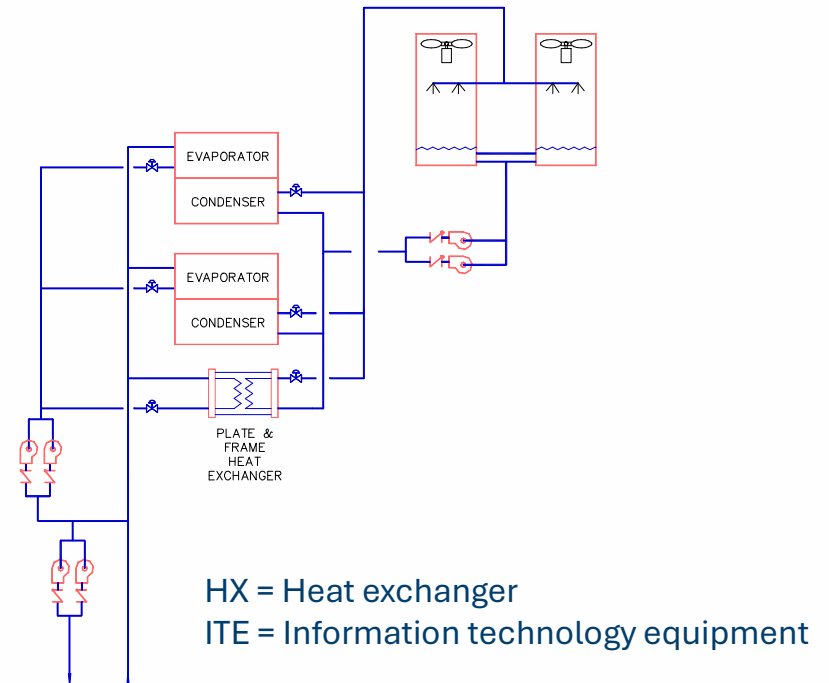
2.1 Integrated Economizer: Waterside Economizer Examples for Air-Cooled ITE

Purpose: Maximize economizer use and reduce chiller compressor load

Compliant configuration (Waterside economizer HX piped in series with evaporator); meets proposed 60°F outdoor wet-bulb threshold for full economizing



Non-compliant configuration (Waterside economizer HX piped in parallel with evaporator)



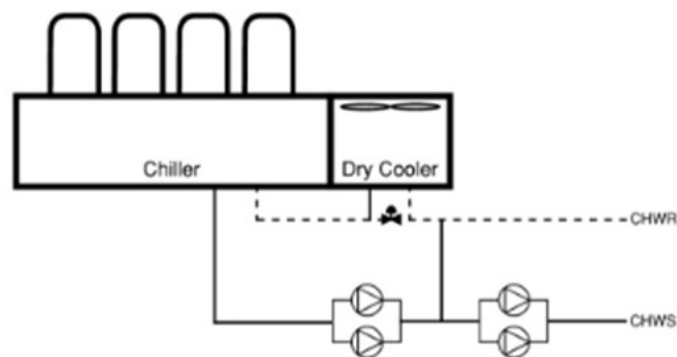
HX = Heat exchanger
ITE = Information technology equipment



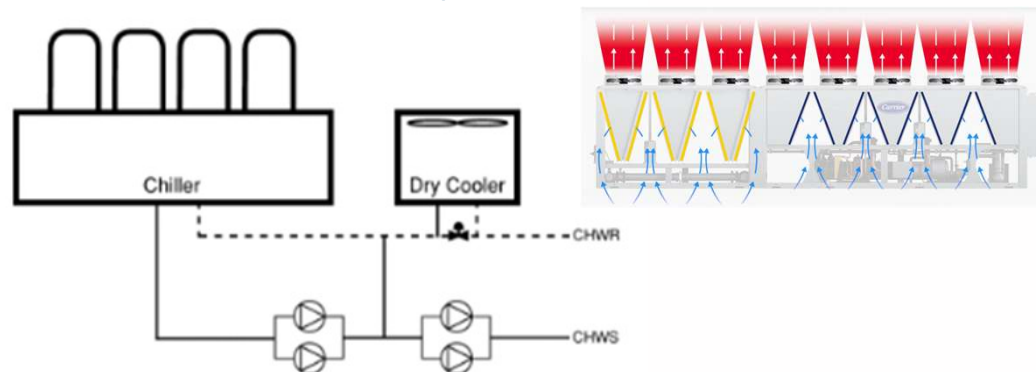
2.1 Integrated Economizer: Air-Cooled Chillers

Purpose: Ensure air-cooled chiller economizers provide real partial cooling savings without limiting chiller operation

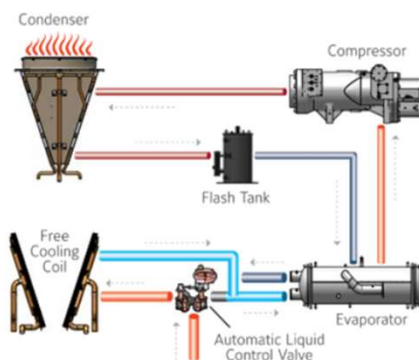
Non-compliant (air-cooled chiller with dry cooler piped into primary circuit)



Potentially **compliant** (air-cooled chiller with dry cooler piped into secondary circuit)



Likely **non-compliant** air-cooled chillers with integrated economizer coils that are served by the same condenser fans that serve refrigerant condenser coils





2.2 Revised Economizer Thresholds

➤ Current T24-2025 Provisions:

- Air economizer capable of 100% cooling at 65°F DB / 50°F WB (at SAT 65°F - 80.6°F), or
- Water economizer capable of 100% cooling at 50°F DB / 45°F WB (at SAT 65°F - 80.6°F)

➤ Proposed T24-2028 Provisions:

- Computer room economizer capable of 100% cooling at following outdoor conditions (at SAT of 75°F)

Type of ITE	Outdoor Dry-Bulb	Outdoor Wet-bulb
Air-Cooled ITE in a computer room with: • Average air-cooled ITE design load > 25 kW/rack, and • Served by a cooling system that does not evaporate water at these outdoor conditions	≤ 55°F	≤ 55°F
All liquid-cooled ITE in buildings with a design liquid-cooled ITE load greater than 2 MW	≤ 75°F	≤ 75°F
All other ITE	≤ 65°F	≤ 60°F

Question: Any concerns with the proposed economizer thresholds, particularly the 75°F DB/WB threshold for liquid-cooled ITE? If so, are there design conditions or manufacturer requirements that may need clarification?



2.2 Lifecycle Cost Analysis (LCA) for Revised Wet-bulb Economizer Threshold

- Modeled computer room with CHW CRAHs with waterside economizer (WSE)
- Approach from OAWB to SAT = CT approach + HX approach + CRAH coil approach
- Base Case approach = 30°F (45°F OAWB to 75°F SAT)
- Proposed approach = 15°F (60°F OAWB to 75°F SAT)
- Worked with equipment suppliers and contractors to determine total incremental cost



2.2 Lifecycle Cost Analysis (LCA) for Revised Wet-bulb Economizer Threshold

Description	CRAH Coil	WSE HX	Cooling Tower	Total	CRAH Total Static
Base Case Design Approach (°F)	8	11	11	30	2.25
Proposed Design Approach (°F)	5	5	5	15	2.45
Incremental Cost / kW of capacity	\$35.68	\$6.98	\$42.40	\$85.06	-
Installation multiplier	1	2	2		-
Total incremental cost / kW of capacity	\$35.68	\$13.96	\$84.80	\$134.44	-

Percentage of Time in 100% Economizer Mode

Climate Zone (Location)	Basecase	Proposed
4 (San Jose)	23%	81%
7 (San Diego)	10%	59%
9 (Los Angeles)	11%	65%
12 (Sacramento)	25%	75%

Question: Are these assumptions representative?



2.2 Lifecycle Cost Analysis (LCA) for Revised Wet-bulb Economizer Threshold (Summary Per kW of ITE)

- Proposed 15°F approach reduces cooling energy cost across all modeled climate zones
- Lifecycle energy cost savings range from about \$684 to \$1,045 per kW of ITE
- Without Chiller Downsizing
 - Benefit-to-cost ratios remain cost-effective: 3.3 to 5.0.
- With chiller downsizing credit
 - Benefit-to-cost ratios improve to 4.4 to 6.6
- Chiller downsizing can reduce first cost, with the largest benefit shown in San Jose

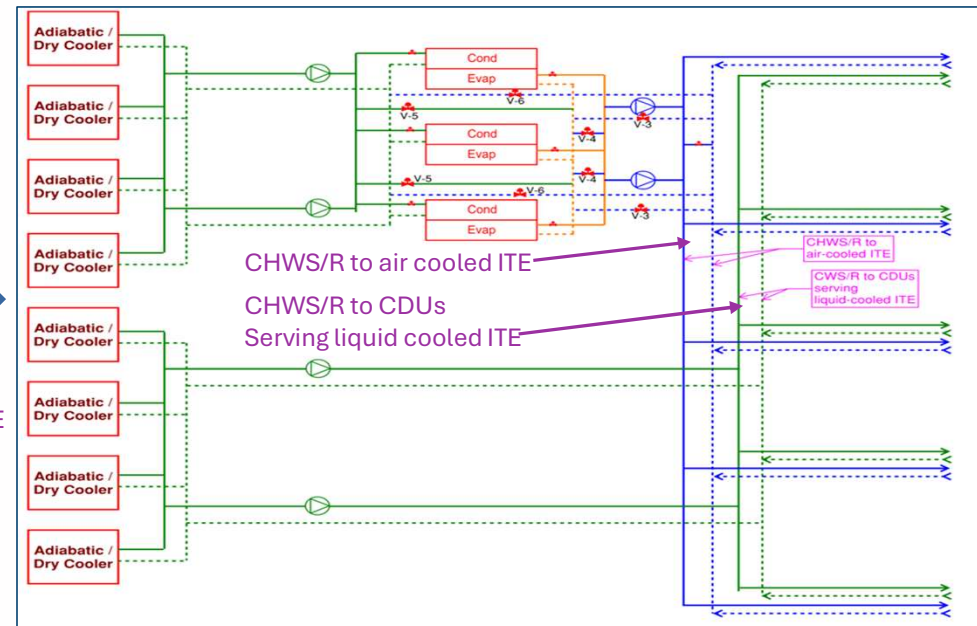
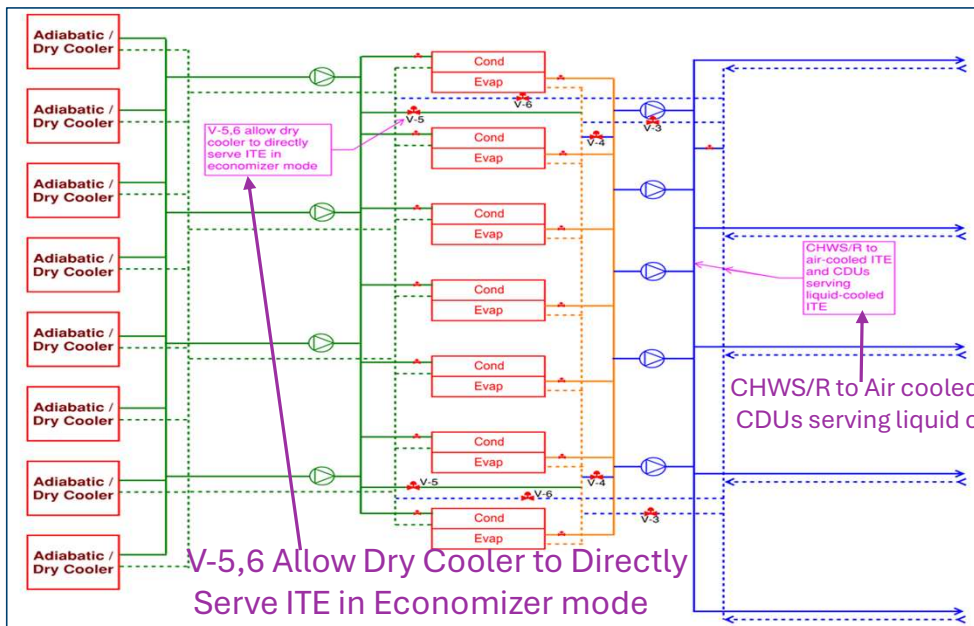


2.3 New Liquid-Cooled (LC) ITE Economizer Threshold

Purpose: Applies to >2 MW liquid-cooled ITE, Requires 100% economizing at 75°F DB/WB & Reduces chiller use and avoids overcooling

Non-compliant: Single plant sending 70°F FWS to CRAHs and Coolant Distribution Unit (CDUs)

Compliant: Separate LC plant with 75°F OADB → 90°F FWS to CDU → 95°F TCS to LC ITE



Question: For projects with both air-cooled and liquid-cooled ITE, have you encountered design challenges with using separate cooling plants or higher-temperature facility-water loops? If so, what alternative design approach could provide similar economizer performance?



2.3 LCA for New Liquid-Cooled ITE Economizer Threshold - Cost

- Started with actual 8.5 MW data center in Bay Area with two plants:
 - Cooling towers → Bag Filters → CW → CDUs (6.5 MW)
 - Cooling towers → Chillers / HXs → CHW → CRAHs (2.0 MW)
- Redesigned the data center for single plant (baseline):
 - Cooling towers → Chillers / HXs → CHW → CDUs + CRAHs
- Mechanical and electrical contractors priced the redesign.
- Baseline (single plant) higher costs for:
 - Chillers, CTs, HX, basket strainers, bag filters
 - Generators
- Proposed (separate plants) higher costs for:
 - CW and CHW distribution piping
- Net incremental cost is negative (separate plants costs less)

Proposed Case vs. Baseline Case Incremental Cost Savings: Cooling Tower Scenario

Proposed Case	Electrical	Mechanical	Total
Total Incremental first cost	\$ 1,950,000	\$ 1,926,586	\$ 3,876,586
Incremental first cost per kW of Liquid-Cooled ITE	\$ 300	\$ 296	\$ 596



2.3 LCA for New Liquid-Cooled ITE Economizer Threshold - Energy

➤ Analysis Assumptions:

- Standalone data center with 80% liquid-cooled and 20% air-cooled ITE
- Title 24 load profile (equal time at 25%, 50%, 75%, 100% load)
- 16 climate zones
- Dry cooler ΔT : 15°F
- Technology Cooling System pump energy is the same for base and proposed cases, so not modeled
- CRAH fan energy same for base case and proposed, so not modeled

Question: Do the assumed design conditions, such as 95°F TCS supply, 90°F facility-water supply, and 15°F dry cooler ΔT , generally reflect typical liquid-cooled ITE design practice? If not, what values should be considered?



2.3 Continued

Partial Power Usage Effectiveness (PUE) of Cooling Tower Scenario (San Jose)

Simulation #	Description	Partial PUE (Chiller, Cooling Tower, Pump)
1A – Base Case	Combined Plant with low LWT for all	1.031
1B – Base Case	Combined Plant with high LWT, then Chillers cool to low LWT for RDHXs	1.043
2 – Proposed	Separate 1B (tower-only) Plant for CDUs; Separate 1A Plant for RDHX	1.023

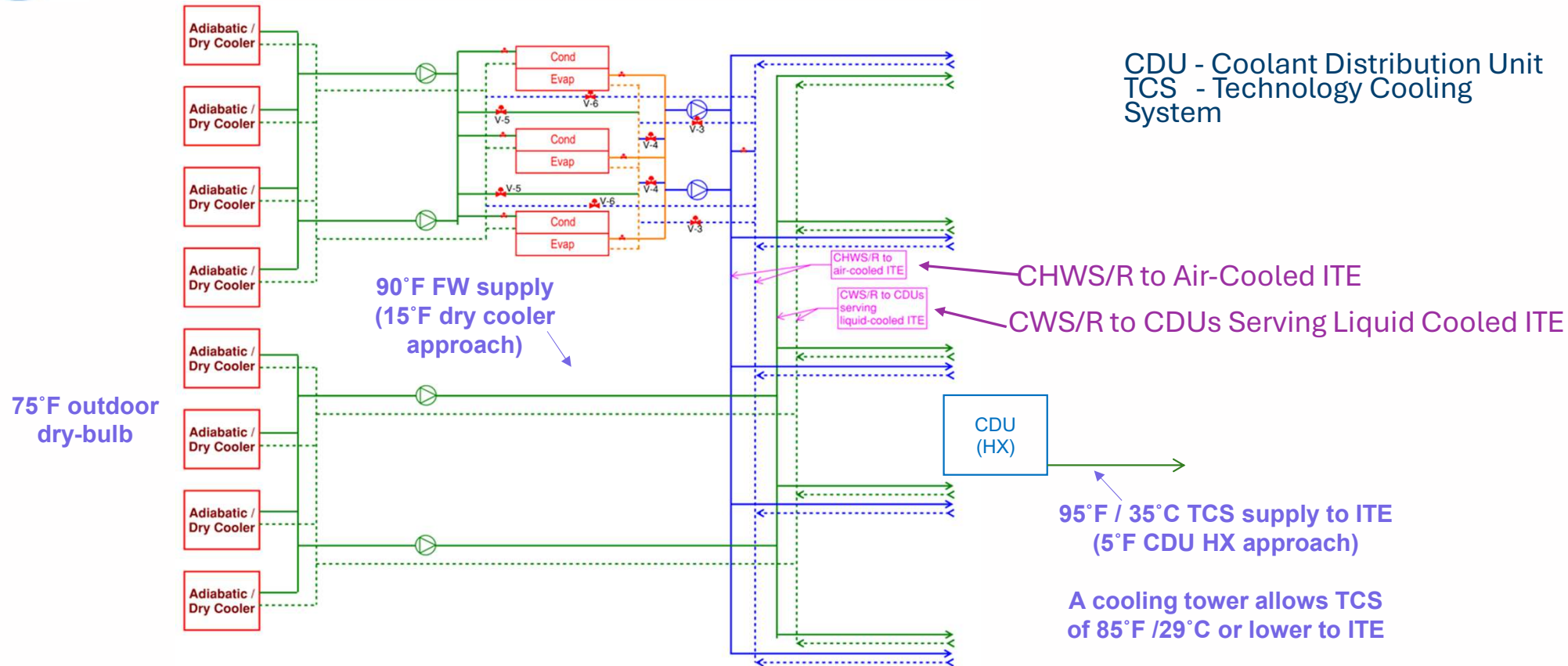
Partial PUE of Dry Cooler Scenario (San Jose)

Simulation #	Description	Partial PUE (Chiller, Tower, Dry Cooler, Pump)
1A – Base Case	Combined Plant with low LWT for all	1.071
1B – Base Case	Combined Plant with high LWT, then Chillers cool to low LWT for RDHXs(Rear Door Heat Exchanger	1.045
2 – Proposed	Separate 1B (dry cooler only) Plant for CDUs; Separate 1A Plant for RDHX	1.031



2.3 Liquid-Cooled ITE Economizer Example

Proposed for buildings with >2 MW of liquid-cooled ITE



Question: Any concerns with delivering 90°F facility water to the CDU and maintaining 95°F TCS supply to the ITE during full economizer operation?



2.4 New Differential Temperature (ΔT) and Variable Flow Requirement

- Air handling systems > 30,000 Btu/hr
 - Return to supply air ΔT of at least 20°F
 - Vary airflow as a function of ITE load
 - Minimum airflow $\leq 25\%$ of design airflow
 - Constant ΔT at ITE loads from 25% to 100%
- Chilled water and facility water systems
 - Return to supply fluid ΔT of at least 15°F
 - Vary fluid flow as a function of ITE load
 - Constant ΔT at ITE loads from 25% to 100%

Question: Do stakeholders see any design or controls challenges with maintaining the proposed 20°F air ΔT and 15°F water ΔT as ITE load varies from 25% to 100%?



2.5 New Economizer Exception for Heat Recovery

- **EXCEPTION 1:** Computer rooms under 5 tons (18 kW) in buildings without economizers
- **EXCEPTION 2:** Computer rooms under 20 tons (70 kW) may use a second fan system without an economizer if another economizer fan system also serves the room, if all of the following are met:
 - Economizer must meet the computer room cooling load when other spaces are at 50% load, at 65°F dry-bulb or below, or 50°F / 60°F wet-bulb or below; and
 - An economizer system that can stop service to other spaces in the building when those spaces are unoccupied and serve only the computer rooms.
- **EXCEPTION 3:** Computer rooms that reject heat to a heat recovery system that is sized to accept at least 50% of the design computer room heat and that serves either:
 - Space heating systems and/or service water heating systems with design loads greater than 5 times the computer room design cooling load, or
 - Processes determined by the Executive Director to require more than 50% of the design computer room heat for more than 3,000 hours/year



2.6 Revised Additions/Alterations Economizers

➤ **Propose deletion of the following language in T24-2025:**

- ~~Air econ capable of 100% cooling at 55°F DB / 50°F WB, or~~
- ~~Water econ capable of 100% cooling at 40°F DB / 35°F WB~~

➤ **Propose incorporation of the following *computer room economizer* requirement in T24-2028:**

- Exception 1 to Section 910.2.2: Individual computer rooms with an ITE design load under 5 tons (18 kW) ,current code.
- Exception 1 to section 910.4.2 Individual computer rooms with ITE load under 10 tons (35 kW)
- ~~Exception 2: New systems serving existing *computer room* ≤ 50 tons (176 kW)~~
- ~~Exception 3: New systems serving new *computer room* in existing building ≤ 20 tons (70 kW)~~
- Exception 2: New systems serving existing *computer room* where:
 - Total capacity of the new cooling system is less than 500 tons and less than 50% of the total *computer room* cooling system capacity, and
 - New cooling system includes economizer capable of 100% cooling at the following:

Original Permit Date of Existing Computer Room	Dry-bulb	Wet-bulb
Before 1/1/2014	No economizer requirement	
1/1/2014 – 12/31/2022	<u>55°F</u>	<u>35°F</u>
1/1/2023 – 12/31/2028	<u>65°F</u>	<u>45°F</u>

Question: For existing computer room alterations, have you seen design constraints such as limited space or controls integration that could make the proposed economizer requirements difficult to apply?



3. New Mandatory Computer Room Heat Recovery Measure

- Heat recovery mandatory for new buildings with:
 - Total computer room ITE load > 100 kW; and
 - Non-computer room floor area > 35,000 ft²
- Heat recovery capacity must be at least:
 - 0.5 x peak heat rejection of computer room cooling system, or
 - 0.2 x (space heating system capacity + service water heating (SWH) system capacity)
- Justification
 - Computer rooms can provide consistent sources of efficient, low carbon heating for building heating loads
 - There are many system options to comply including:
 - Heat recovery water-to-water chillers
 - 4-pipe (heat recovery) air-source heat pumps
 - Dual-Fan-Dual-Duct air transfer to hot deck
 - Water-source heat pumps



3. Energy and Cost Analysis - Computer Room Heat Recovery

Analysis Assumptions

- **Climate Zones:** All
- **Building Type:** Medium Office and Large Office with a 100-kW computer room
- **Base Case:**
 - Dual Fan Dual Duct (DFDD) system
 - Hot water (HW) coil in hot deck served by either of the following:
 - Air-to-water heat pump (AWHP)
 - Natural gas boiler
- **Proposed Case:**
 - DFDD system
 - AWHP or natural gas boiler serves as backup heating source to HW coil in hot deck (sized for full capacity)
 - Computer room return air ducted to hot deck AHU mixing section to supply heat to office as primary heating source



3. Computer Room Heat Recovery

Incremental Costs

- Local mechanical contractor provided a quote to install heat recovery per the scope described in the heat recovery analysis (previous slide).
- AHU vendors provided hot deck mixing section cost

Heat Recovery Incremental First Costs

Design Component	Proposed Costs (2029 PV\$)
Fire Smoke Damper (FSD)	\$10,000
Duct from FSD to AHU Transfer Air opening	\$7,000
Additional Controls	\$20,000
Economizer mixing section to hot deck AHU	\$7,250
Total First Cost	\$44,250
Total First Cost (\$/ft2)	\$1.26



4. Proposed Data Center Definitions

- **Computer Room:** is a room within a building whose primary function is to house electronic equipment and that has a design information technology equipment (ITE) equipment power density ≤ 10 kW or ≤ 20 Watts/ft² (215 Watts/m²) of conditioned floor area
- **Data Center:** is any space whose primary function is to house electronic equipment and that has a design information technology equipment (ITE) power density exceeding 10 kW and 20 W/ft²
 - Small Data Center
 - Space with ITE load > 10 kW & $\leq 2,000$ kW.
 - Large Data Center
 - Space with ITE load $> 2,000$ kW & $\leq 25,000$ kW.
 - Hyperscale Data Center
 - Space ITE equipment power density $> 25,000$ kW.
- **Server Aisle:** is an aisle of racks of Information Technology (IT) server equipment in any Computer Room or in a Small, Large, or Hyperscale Data Center. While networking equipment may also be housed on these racks, it is largely a group of one or more racks to manage server or networking equipment.



5. Current Limit and Exceptions

- Current Requirement: Section 401.3.12 [140.4(j)] limits chilled water plants to no more than 300 tons of cooling capacity per building from air cooled chillers (ACCs)
- Current Exceptions
 - Where water quality at building site fails to meet manufacturer specifications for the use of water-cooled chillers
 - Chillers used to charge a thermal energy storage system with a design temperature of less than 40°F
 - Systems serving healthcare facilities
- Additional Exceptions included in 2025 CASE Draft Proposal:
 - Air-to-water heat pumps that provide space or hydronic heating only
 - High-efficiency air-cooled chillers with Path B efficiencies of at least 10.72 EER and 20.10 IPLV
 - Air-cooled chillers with heat recovery where the cooling capacity minus the recovered heating capacity is no more than 300 tons per chilled water plant
- Reconsidering the limit because of data center projects in water-stressed regions of the state and for alterations to existing facilities
- CASE Team summarizes prior 2025 analysis and the implications for the current 300 ton ACC limit



5. Analysis Results and Policy Question

➤ Water Impact:

- Water Impact: Water savings were significant, ranging from 0.27 to 9.85 gallons/ft²-yr depending on climate zone

➤ Cost Effectiveness :

- The memo shows the measure is cost effective in active climate zones when water cost savings are included, with benefit-to-cost ratios from 1.35 to 3.41

➤ Policy Questions:

- Have you encountered challenges with the 300 ton limit as written? If so, please describe the scenarios
- Is there were a narrow pathway for high efficiency ACCs in water stressed areas, what would that pathway look like?

Slide 42

GA1 I reworded these questions a bit
Achong, Gypsy@Energy, 2026-06-16T15:23:27.872

TH1 0 you made it better.
Tewelde, Hab@Energy, 2026-06-16T16:30:20.467



Questions or Comments

Comments can be submitted to the CEC's Pre-rulemaking docket:
[California Energy Commission : e-comment : Submit Comment](#)

Comments on today's workshop are due **July 17, 2026, by 5 pm**

Contact information: Hab.Tewelde@energy.ca.gov

Thank you !



Covered Process Refrigeration

Haile Bucaneg, Senior Mechanical Engineer, Building Standards Branch
June 24, 2026

Refrigeration Overview



Overview

- Existing code requirements
- What is being proposed
- Justification
- Energy impact results
- Incremental costs

Existing 2025 Code Requirements



Requirements being reviewed

1. **Table 901.1 (2) [Table 120.6-A-2]** – Mandatory specific efficiency test requirements
2. **Section 901.1.7.4 [Section 120.6(a)5D]** – Mandatory screw compressor requirements for compressors greater than 150 HP to automatically vary compressor volume ratio
3. **Sections 901.1.8.1 and 902.1.5.1 [Section 120.6(a)8 and 120.6(b)5]** – Transcritical CO₂ refrigeration system gas cooler system mandatory requirements prohibiting air-cooled gas coolers in specific climate zones
4. **NA 7.10** – Acceptance testing requirements for refrigeration equipment



2028 Proposed Code Requirements

Specific Efficiency Testing Procedures

- **Table 901.1 (2) [120.6-A-2]** – Minimum specific efficiency for fan-powered evaporators
 - Based on Air-Conditioning, Heating, and Refrigeration Institute (AHRI) test procedures AHRI 420 and AHRI 1250
 - Proposed revisions:
 - Incorporate appropriate definitions and language from AHRI 420
 - Additional specifics for calculating evaporator specific efficiency
 - Additional specifics for rating conditions
 - Options for calculating/simulating specific efficiency

2028 Proposed Code Requirements



Specific Efficiency

- **Justification**

- Identify rating conditions
- Procedures to confirm equipment specific efficiency

- **Energy Savings**

- No change in equipment energy usage

- **Incremental Cost**

- Reduce testing cost



2028 Proposed Code Requirements

Variable Compressor Volume Ratio Trigger

- **Section 901.1.7.4 [Section 120.6(a)5D] – Variable compressor volume ratio**
 - Add exception for transcritical CO₂ screw compressors

Existing Requirement Trigger	Proposed Requirement Trigger
Compressor electric motor power greater than 150 HP	Compressor displacement 450 CFM or greater



2028 Proposed Code Requirements

Variable Compressor Volume Ratio Trigger Savings and Costs

- **Justification**

- Transcritical CO₂ screw compressors operate at a higher pressure where variable volume ratio is not feasible
- Compressor volume is a better indication for compressor size
- Stakeholder input from equipment manufacturers

- **Energy Savings**

- No change in equipment energy usage claimed

- **Incremental Cost**

- No additional costs
- Variable volume ratio is standard option for most equipment

2028 Proposed Code Requirements



Transcritical CO₂ Refrigeration System Gas Coolers

- Section 901.1.8 [120.6(a)8] and 902.1.5 [120.6(b)5] – Prohibit air-cooled gas coolers in specific climate zones (CZ) for transcritical CO₂ refrigeration systems

Impacted Facilities	Proposed Exception
Refrigerated Warehouse (CZ 9 – 15)	Freezers: 20 tons or smaller Coolers: 40 tons or smaller
Commercial Refrigeration (CZ 10 – 15)	Freezers: 20 tons or smaller Coolers: 40 tons or smaller

2028 Proposed Code Requirements



Transcritical CO₂ Gas Coolers Savings and Costs

- **Justification**

- Analysis for original measure focused on larger systems only
- Additional public input regarding thresholds for exception

- **Incremental Cost**

- Lower installation costs for air-cooled gas coolers
- Lower maintenance costs
- Lower water usage

2028 Proposed Code Requirements



Acceptance Testing

- **Reference Appendices NA7.10** – Refrigerated warehouse acceptance testing
 - Construction inspection requires sensor calibration using a National Institute of Standards and Technology (NIST) traceable instrument
 - Functional testing dependent on load and ambient conditions

Acceptance Testing	Proposal
Construction Inspection	Allow factory and field calibration
Functional Testing	Allow simulated conditions by manipulating controller inputs

2028 Proposed Code Requirements



Acceptance Testing Savings and Costs

- **Justification**

- Identifying installation errors over calibration errors
- Relying on load and ambient conditions may be unreliable

- **Energy Savings**

- No change in equipment energy usage

- **Incremental Cost**

- Reduce testing costs by reducing repeat visits and adding flexibility

Comments for Today's Workshop



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[https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?
docketnumber=25-BSTD-03](https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03)

Thank you for participating!

Questions?



2028 Pre-Rulemaking Workshop

HVAC Air Distribution – Modulating Dedicated Outdoor Air System (DOAS)

Anushka Raut, Air Pollution Specialist, Standards Development Unit

June 24, 2026



Acknowledgements

CA Codes and Standards Enhancement (CASE) Team

Bryan Boyce, and Shaojie Wang, Energy Solutions

Jeff Stein, Taylor Engineers

John Bade, West Monroe



2028 Proposed Requirements Overview

Nonresidential Buildings

- Two Mandatory requirements (newly constructed buildings)
 - **Submeasure a:** Modulating air valves
 - **Submeasure b:** Occupied standby spaces

- Three Prescriptive requirements (newly constructed and existing nonresidential buildings)
 - **Submeasure c:** Supply air delivery option
 - **Submeasure d:** Supply air temperature
 - **Submeasure e:** Design minimum outdoor air

Mandatory Requirements – Newly Constructed Only





2028 Proposed Requirements: Submeasure a

New Mandatory Requirements: Modulating Air Valves

- Modifies subsection 401.2.1.2 [Section 120.1(d)], and 401.3.5.2 [Section 140.4(c)2] and clarifies subsection 401.2.2 [Section 120.2].
- Applies to:
 - DOAS $\geq$ 3,000 CFM
 - Zones with demand-controlled ventilation (DCV) or occupied standby systems
- Proposed Requirement:
 - Allow zone-level airflow modulation
 - Maintain ventilation to occupied zones
 - Modulate DOAS supply fan speed



2028 Submeasure a: Cost-effectiveness

Energy Savings Analysis Approach

Hybrid Energy Plus and spreadsheet analysis demonstrated Benefit-Cost Ratio (BCR) > 1.0

Parameter	Assumption/Scope
Baseline building prototypes	• Large, medium, and small offices • Large and small schools
Operating assumptions	• HVAC schedule ~90 hrs./week • Sensitivity analysis 53 hrs./week
What was evaluated?	• Occupied Standby • DCV • Fan Energy Savings • Heating and cooling impacts
System types	• Standard DOAS • DOAS with energy recovery
Key findings	• BCR > 1.0 (Range: 2.04–9.17) • Cost-effective across evaluated scenarios



2028 Submeasure a: Cost-effectiveness (Cont.d)

Occupancy and Ventilation Analysis

Space type	Savings Evaluated
Open office (Low density)	Occupied standby savings
Conference rooms/classrooms (High density)	Occupied standby + DCV savings

- Savings calculated on square-foot basis
- Survey-based space distributions
- Study-based occupancy assumptions
- Reduced HVAC operation sensitivity analysis



2028 Proposed Requirements: Sub measure b

Added a new Table 401.2.1-A - Required Occupied Standby Spaces

➤ Educational Facilities

- Lecture/post secondary classrooms
- Lecture halls (fixed seats)
- Multiuse assembly (<1,000 ft²)

➤ General Spaces

- Breakrooms
- Conference/meeting rooms
- Corridors

➤ Office Buildings

- Main entry lobbies
- Office spaces

➤ Miscellaneous/Public Assembly Spaces

- Bank vaults/safe deposits
- Banks or bank lobbies
- Information technology equipment facilities
- Transportation waiting
- Lobbies



2028 Proposed Requirements: Table 401.2.1-A

New Mandatory Requirements: Occupied Standby Spaces

New Table 401.2.1-A (Submeasure b) rationale:

➤ Aligns:

- HVAC (Section 401.2.1.2.5 [Section 120.1(d)5] & Table 401.2-A [Table 120.1-A]), and
- Lighting occupied standby spaces (Section 601.2.2.3.5 [Section 130.1(c)5] & Section 601.2.2.3.6 [Section 130.1(c)6])

➤ Applies to:

- DOAS and mixed-air systems
- Spaces designated with Footnote “F” in Table 401.2-A [Table 120.1-A] only
- Additional spaces included in the lighting controls measure proposal

Prescriptive Requirements – All Nonresidential Buildings





2028 Proposed Requirements: Submeasure c

Prescriptive Requirement: Supply Air Delivery Option

- Modifies Section 401.3.17.2 [Section 140.4(p)2]
- Applies to:
 - All DOAS systems
 - Newly constructed buildings, additions and alterations
- Proposed Requirement
 - Adds option 3 to Section 401.3.17.2 [Section 140.4(p)2]
 - Delivers DOAS outdoor air at the inlet to zonal terminal coils
 - Fan shut down or reduced fan speed when zones do not require heating or cooling



2028 Proposed Requirements: Submeasure d

Prescriptive Requirement: Supply Air Temperature

- Revise Section 401.3.17.4 [Subsection 140.4(p)]
- Applies to:
 - DOAS with mechanical heating and cooling
 - Newly constructed buildings, additions and alterations
- Proposed Requirement
 - Revises DOAS supply air temperature from 60°F to 55°F in heating mode
 - Limits supply air temperature to no less than 75°F in cooling mode
 - Rationale: Reduces unnecessary reheating and re-cooling to improve DOAS system efficiency.



2028 Proposed Requirements: Submeasure e

Prescriptive Requirement: Design minimum outdoor air

- Added new Subsection 401.3.21
- Applies to:
 - DOAS and mixed air systems
 - Newly constructed buildings, additions and alterations
- Proposed Requirement
 - Based on ASHRAE 90.1-2022 addendum p and 62.1-2025
 - Adds prescriptive limits on design minimum outdoor air
 - Limits outdoor airflow to ventilation, exhaust makeup, and pressurization needs
 - Allows up to 10% above required ventilation rates



Feedback Request from the Public

- Modulating DOAS – Current Code Interpretation
 - How are DCV and occupied standby requirements currently being interpreted in design, plan review, and acceptance testing of DOAS systems?
 - Please share any project examples where DOAS systems were treated differently than mixed-air systems?
- Modulating DOAS – Clarification vs. New Requirement
 - Please suggest edits to clarify that DCV and occupied standby requirements apply to DOAS systems
- Modulating DOAS – Per-Zone Airflow Modulation
 - What considerations do you foresee in trying to modulate outside air at each zone for DOAS systems serving multiple space-conditioning zones?
- Modulating DOAS – Alternative Design Pathways
 - Are there alternative design approaches that could provide similar ventilation reduction during low-occupancy periods?
 - If so, what code language would make those approaches clear?



Feedback Request from the Public (Continued)

➤ Modulating DOAS – Controls and BAS/DDC Assumptions

- For new buildings with BAS/DDC controls, what level of additional programming, coordination, and commissioning is typically needed to support DOAS modulation, DCV, and occupied standby?
- Are there scenarios where the controls effort may be higher or lower?

➤ Occupied Standby Cleanup

- Please suggest edits to clarify intent of the occupied standby cleanup language
- Are there space types, size thresholds, or lighting-control interactions situations where examples would help avoid confusion?

➤ FCU Return-Air-Inlet Delivery Option

- For designs that deliver DOAS air to the fan coil return-air inlet, what design details should be considered to ensure ventilation air reaches the occupied zone when the fan coil cycles off or operates at low airflow?
- Are there duct, plenum, return-path, or fan-minimum-flow conditions that should be clarified?



Feedback Request from the Public (Continued)

➤ DOAS Supply-Air Temperature Limits

- What input should be considered on the proposed DOAS supply-air temperature limits, including the 55°F mechanical heating cap and 75°F mechanical cooling floor?
- Are there California climate zones, heat recovery designs, neutral-air DOAS designs, or operating conditions where additional clarification would be helpful?



Questions or Comments

Comments can be submitted to the CEC's Pre-rulemaking docket:
[California Energy Commission : e-comment : Submit Comment](#)

Comments on today's workshop are due **July 17, 2026, by 5 pm**

Contact information: Anushka.Raut@energy.ca.gov

Thank you for participating!



Packaged Variable Air Volume Turndown

Ronald Balneg, Mechanical Engineer
June 24, 2026



2028 Proposed Requirements

Packaged Variable Air Volume Turndown – New Construction

New section in 401.3.14 [Section 140.4(m)]

- Add prescriptive requirements to Packaged Variable Air Volume (PVAV) turndown requirements
 - mechanical cooling equipment capable of airflow reduction down to the larger of 15% of design supply airflow or sum of outdoor airflow requirements in 120.1(c)3; or
 - Return of excess airflow greater than 120.1(c)3 through bypass
 - airflow returned through duct or plenum – not through conditioned space
 - capable of mechanical cooling not more than 200 CFM/ton
 - Exceptions:
 - Group R Occupancies
 - Climate Zone 1 primarily heated by gas systems
 - Systems without direct digital controls (DDC)



2028 Proposed Requirements

Packaged Variable Air Volume Turndown - Alterations

New Section 401.5.2.2.1.3

- Comply with 401.3.14 when any of the following are replaced:
 - Central air handler, or
 - Direct expansion air conditioner of a multiple zone system.
- Exceptions:
 - No return ceiling plenum, or the return ceiling plenum has been determined to be unsafe to use return ceiling plenum as bypass
 - When only terminal units being replaced
 - Replacement of an indoor packaged air conditioner or heat pump where insufficient space exists for a bypass



2028 Proposed Requirements

Packaged Variable Air Volume Turndown

Acceptance Testing

Modifications to Nonresidential Appendices 7.5.6

- Verify system can meet minimum zone airflow and enable cooling
- Use Building Management System (BMS) to close outside air and set all VAV boxes to minimum
- Performance path: total airflow set to minimum airflow for mechanical cooling + 5% of airflow
- Lower zone setpoints to confirm cooling starts
- Confirm fan maintains discharge static pressure +/- 10% of current operating setpoint
- Confirm fan controls stabilize within 5 minutes



Energy Savings Methodology

Packaged Variable Air Volume Turndown

- CBECC modeling
 - Medium office building
 - Schools (pending analysis)
- Reduced occupancy schedule to mimic current office use (based on North American office utilization)
- Baseline
 - New Construction and Additions – Air to Water Heat Pump with Electric Resistance Boiler
 - Alterations – Gas boiler
 - 30% of minimum airflow fraction
- Proposed Requirements
 - Turndown airflow to greater of 15% or sum of outdoor airflow requirements in 120.1(c)3
 - System types remain the same for new construction and additions; and alterations



Energy Impacts and Cost

Packaged Variable Air Volume Turndown

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	4.3	0.1	-	7.2	39
Alterations	8.2	-0.8	0.8	11.9	75
Total	12.5	-0.7	0.8	19.1	114



Energy Impacts and Cost

Packaged Variable Air Volume Turndown

- Incremental First Cost and Annual Maintenance Cost
 - **First cost:** \$30,000 – bypass (4x the cost assumption of ASHARE Addendum u to 90.1-2022)
 - **Maintenance:** \$9,000 – 3x actuators replaced at 15 years

- Benefit to Cost Ratio:
 - Greater than 1 across all climate zones – except climate zone 1 for alterations
 - Newly constructed buildings and additions: **2.99 – 11.2**
 - Alterations: **0.91 – 7.36**



Energy Impacts and Cost

Request for information

➤ **Bypass Constructability**

- For projects that have used the bypass path, what are some things we need to consider for construction capability and space constraints?
- Any common challenges with space, plenums, duct routing, or fire/smoke and return-air configurations?

➤ **Alterations & Existing Conditions**

- For alteration projects, where is clarification needed for systems with limited space, fully ducted returns, congested plenums, or indoor packaged units with no bypass space?



Energy Impacts and Cost

Request for information

➤ **200 cfm/ton Assumption**

- Based on field experience, is 200 CFM/ton generally achievable with current equipment?
- Are there equipment types or applications needing further clarification?

➤ **Existing Controls/BMS Capability**

- What controls or BMS/DDC limitations could affect turndown or bypass compliance?
- Are there sequence, sensor, or controller capability issues to consider in existing buildings?

Questions/Comments?





Comments and Contact Information

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Comments can be submitted to the pre-rulemaking docket 25-BSTD-03:
<https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03>

Contact information: Ronald.Balneg@energy.ca.gov



Nonresidential HVAC Fault Detection and Diagnostics

Ronald Balneg, Mechanical Engineer
June 24, 2026



2025 Existing Requirements

Nonresidential HVAC Fault Detection and Diagnostics

Section 401.2.2.9 [Section 120.2(i)]

- Current fault detection and diagnostics (FDD) requirements limited to economizers
 - In newly installed air handlers with > 33 kBtu/hr mechanical cooling;
 - Requirements for:
 - Temperature sensors;
 - Controller display;
 - Fault reporting;
 - Fault detection; and
 - Certification to California Energy Commission



2028 Proposed Requirements

New mandatory section 401.2.2.9 (120.2(i))

- Extend FDD beyond economizers to systems that meet all the following:
 - HVAC units >300 kBtu/hr;
 - Serving >3 zones; and
 - $\geq 100,000$ ft² in nonresidential projects.

- Applies to newly installed equipment in additions/alterations
 - Excludes minor improvements.

- Adds definitions for “Fault” and “FDD.”



2028 Proposed Requirements

New mandatory section 401.2.2.9 (120.2(i))

- FDD would be required to detect and diagnose:
 - HVAC running outside scheduled hours or beyond allowed user override;
 - AHU Heating or Cooling-coil valve leaking or not responding;
 - Inoperable terminal unit dampers;
 - Zone temperature sensor failure or fault; and
 - Building HVAC control fan motor command at 100% or placed in manual override.

- FDD would be required to:
 - Specify fault detected;
 - The affected equipment or system by name or identifier; and
 - Recommend corrective actions.



2028 Proposed Requirements

New mandatory section 401.2.2.9 (120.2(i))

➤ FDD Communication & Data Requirements

- Communicate faults and diagnoses through at least one of the following:
 - Reporting to an energy management control system monitored by facility staff; or
 - Reporting to a fault management application that automatically notifies a remote HVAC service provider
- Display the fault, diagnosis status, and values of all monitored sensors in either an energy management control system or a fault management application
- Trend system performance data at least every 15 minutes (or event-based) and store data for a minimum of six months

➤ Exceptions for Group R Occupancies



2028 Proposed Requirements

New Section 401.2.7.12 (120.5) for acceptance testing

Acceptance Testing

Reference Appendices NA7.5.12 will be modified and include new sections for FDD acceptance testing

- Construction Inspection
- Functional Testing:
 - Occupancy Schedule
 - Fan Override
 - Cooling / Heating Valves
 - Zone Temperature Sensor (5% of units to be tested)



Energy Savings Methodology

Nonresidential HVAC Fault Detection and Diagnostics

- EnergyPlus modeling
- Large Office and Large School building prototype used
- Each fault modeled individually and combined
 - Temperature sensor fault – 20% failure
 - Valve leakage – 40% leaking
 - HVAC scheduling – 23% prevalence rate
 - Fan failure – 20% failure

Standard Design

- 2-3 months fault resolution

Proposed Design

- 1 month fault resolution



Energy Impacts and Cost

Nonresidential HVAC Fault Detection and Diagnostics

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	1.02	0.51	0.03	268.71	183.95
Alterations	3.91	1.98	0.11	968.04	670.31
Total	4.93	2.48	0.14	1,236.75	854.25



Energy Impacts and Cost

Nonresidential HVAC Fault Detection and Diagnostics

- Long Term System Cost Savings – 30 years
 - Large Office: \$5.51–\$9.75 per ft²
 - Large School: \$6.79–\$14.01 per ft²
- Incremental First and Annual Maintenance Cost
 - \$0.09 per square foot incremental first cost
 - \$0.09 per square foot annual maintenance cost
- Benefit-to-Cost Ratio Greater than 1:
 - Across all climate zones
 - New construction and additions - 5.85 – 10.24
 - Alterations - 5.86 - 10.06



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Thank you for participating!

Questions?

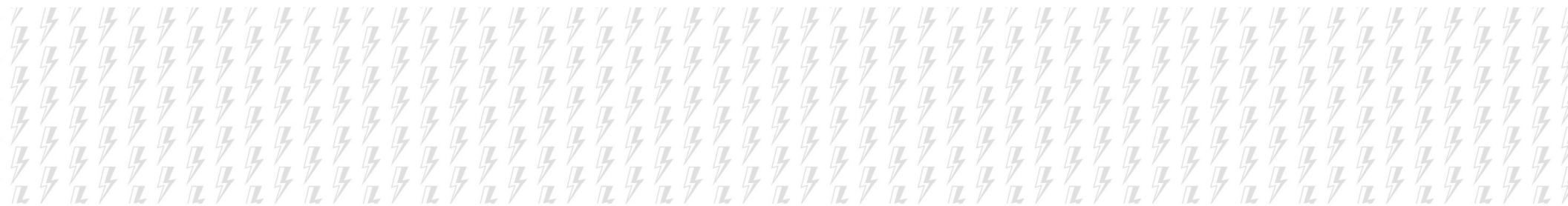


2028 Pre-Rulemaking Workshop

Nonresidential Fenestration

Jose Perez, Electric Generation System Specialist, Building Standards Development Unit

June 24, 2026



Acknowledgement & Thanks

A big thanks to the Nonresidential Fenestration CASE Team:



Items covered in this presentation

- Window – U-factor (newly constructed buildings/additions)
- Window – U-factor & RSHGC (alterations)
- Key assumptions and prototypes used
- Cost effectiveness
- Questions



Existing 2025 Code Requirements & 2028 Proposal

U-factor



➤ Newly Constructed Buildings/Additions Code Sections:

- 301.3.4 [140.3(a)5]
 - Table 301.3(3) [Table 140.3-B]
- 301.5.1.2 [141.0(a)1]

Project Type	Window Type	2025 Requirement	Proposed Requirement	Climate Zones
New Construction/Additions	Fixed	0.36	0.34	1-4 & 16
	Operable	0.46	0.43	1-5, 9-16

Existing 2025 Code Requirements (Alterations) & 2028 Proposal



➤ Alterations Code Sections:

- 301.5.2.2 [141.0(b)2A]
 - Table 301.5(1) [Table 141.0-A]

Window Type	Requirement	Climate Zones
All types	U-Factor = 0.47	1, 2, 4 & 6-16
	U-Factor = 0.58	3 & 5
	RSHGC = 0.41	1, 3, 5 & 16
	RSHGC = 0.31	2, 4 & 6-15

➤ Alterations Requirements:

- 100% replacement of fenestration types will require compliance with the new construction/addition requirements based on window type
- Separate requirements for individual fenestration types when <100% of the fenestration type is replaced.
 - Fixed
 - Operable
 - Glazed door
 - Storefront/Curtainwall

Cost Effectiveness

Benefit-Cost Ratio (BCR)



Key Assumptions

- New Construction/Additions
 - Fixed windows – simulated across CZs 1-8, 10 & 16
 - Operable Windows – simulated in all climate zones
- Alterations
 - Prototypes for existing buildings were developed based 2025 Energy Code requirements
 - Greater savings for older buildings with older windows.
- Software & Prototypes
 - 2028 CBECC research version
 - Used available prototypes found within the software package.





Cost Effectiveness

- A measure is cost effective when the BCR is greater than 1.0.
- Climate zones with BCR greater than 1.0:
 - **Newly Constructed Buildings/Additions**
 - Fixed Windows
 - Climate Zones 1-4 & 16
 - Operable Windows
 - Climate Zones 1-5, 9-16
 - **Alterations**
 - Fixed Windows
 - Climate Zones 1-5 & 10-16
 - Storefront/Curtainwall
 - Climate Zones 3-6 & 8-16
 - Glazed Door
 - Climate Zones 3 & 5

Questions



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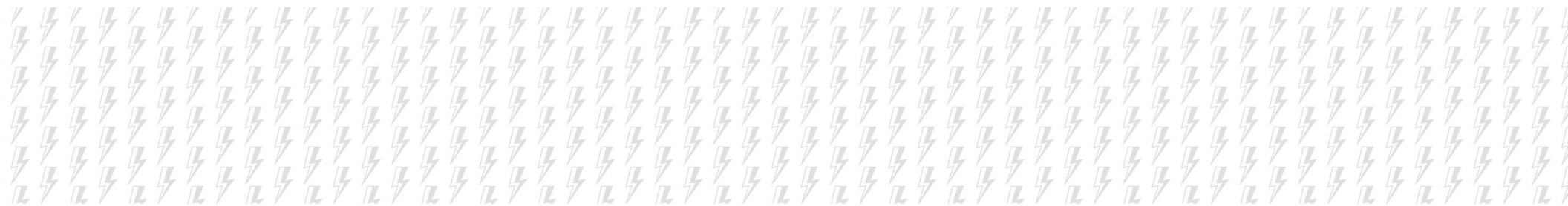
Contact information: Jose.Perez@energy.ca.gov

Thank you for participating!



2028 Energy Code – Pre-Rulemaking

Luminaire Classification & Indoor Lighting Power Density
Sahar Daemi, Electric Generation System Specialist
June 24, 2025



Luminaire Classification and Power & Altered Indoor Lighting Systems



Luminaire Classification and Power

2028 Proposed change

➤ 601.2.1 [Section 130.0(c)] Luminaire classification, and power. Underwriters Laboratories (UL) lighting types are:

➤ **UL Type A**

- Wattage = Maximum rated ballast wattage
- No credit for lower-wattage TLED

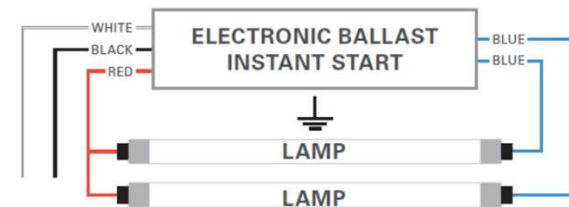
➤ **UL Type B**

- Fixed Wattage = labeled wattage of lamp
 - Variable wattage = maximum field-adjustable wattage
- Credit for lower-wattage TLED

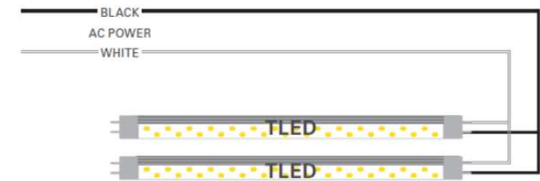
➤ **UL Type C**

- Fixed Wattage = labeled wattage of driver
- Variable wattage = maximum field-adjustable wattage
- Wattage Credit for lower-wattage TLED

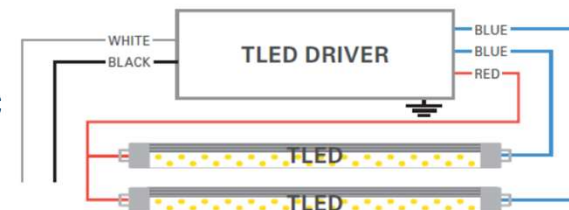
UL Type A



UL Type B



UL Type C





Luminaire Classification and Power

2028 Proposed Changes

- 601.2.1.1 [130.0(c)] Luminaire classification, and power in Nonresidential [NR] Occupancies Not Including *Group R occupancies* [R]
 - 601.2.1.1.1 Luminaires with removable line voltage lamps or removable line voltage LED light engines.
 - 601.2.1.1.2 Inseparable solid-state luminaires (SSL) with remotely mounted drivers.
 - 601.2.1.1.4 [new] Luminaires with ballasts powering SSL lighting.
 - 601.2.1.1.7 [new] Current limiters or supplementary overcurrent protection.



Altered Indoor Lighting Systems

2028 Proposed Changes

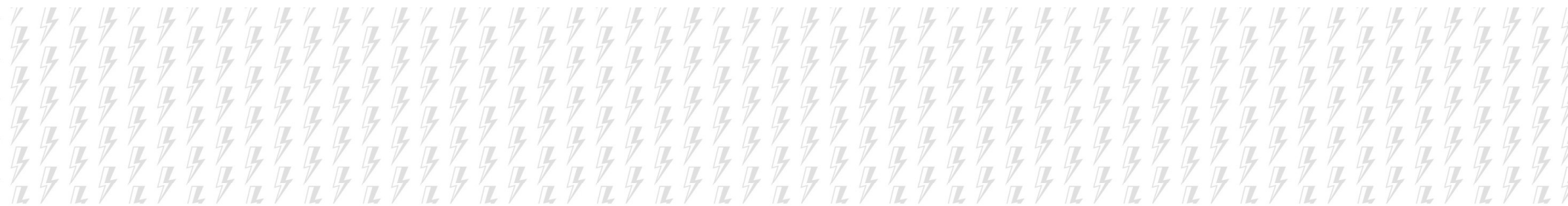
➤ 601.5.2.2.4.3 [Section 141.0(b)2lii] Altered indoor lighting systems

■ 2025 current requirement:

- A tenant space of $\leq 5,000 \text{ ft}^2$, the total wattage of the altered luminaires be at least 40% lower, and the alteration shall comply with Table 601.5-A [*Table 141.0-F*].

■ 2028 proposed requirement:

- The total wattage of the altered luminaires shall be no greater than 3,000 watts per alteration project.



Lighting Power Density (LPD)



Lighting Power Density (LPD)

Background information

- No significant LPD reductions since 2022 Code Cycle.
- Lighting efficacy has improved between 6% to 15%.
- Align with recent guidance adopted in ASHRAE 90.1-2025 and 2027 IECC.
- Aligned with IES recommendation and professional judgments.
- Tailored lighting was moved into the area category method.





Lighting Power Density (LPD)

2028 Proposed Changes

- Update the prescriptive requirements for allowed LPD.
- Table 601.3-B [*Table 140.6-B*] Complete Building Method table.
- **[NR]** Table 601.3-C1 [*Table 140.6-C1*] Area Category Method.
 - New or modified space types and building types
 - Revisit data moved over from tailored lighting into area category
 - Updates related to IES recommended practice, product updates, luminaire efficacy, and light loss factors
- **[R]** Table 601.3-C2 [*Table 140.6-C2*] Area Category Method.





Lighting Power Density (LPD)

Proposed 2028 LPDs (Sample)

Primary Function Areas	2028 Allowed Proposed Baseline LPD (W/ft ²)	2028 Additional Lighting Power (W/ft ²)	2025 Allowed General LPD (W/ft ²)	2025 Additional Lighting Power (W/ft ²)	2028 Total LPD Reduction (W/ft ²)
Data center: Computer room (new)	0.45	0.25	0.55	0.25	0.1
Educational, civic: Multipurpose room (art, music etc.)	0.6	0.3	0.75	0.25	0.1
Education/Business: Classroom, Training,	0.55	0.00	0.60	0.00	0.05
Office Area: ≤ 250 square feet	0.55	0.25	0.65	0.2	0.05
Office Area: > 250 square feet	0.50	0.25	0.60	0.2	0.05
Office: Conference Room	0.60	0.25	0.75	0.25	0.05

For more function areas see the CASE report



Lighting Power Density (LPD)

Cost effectiveness

- Comparison of 2022 and 2028 inverse lumen method models
- Incremental cost is calculated by subtracting the 2028 system cost from the 2022 system cost.
- 30 year life cycle energy cost savings is calculated from prototypical space watts reduction.
- If system has negative incremental cost, the benefit to cost ratio is infinite.



Lighting Power Density (LPD)

Cost effectiveness

- Comparison of 2022 and 2028 inverse lumen method models.

Primary Function Areas	Wattage Reduction (W)	30 Year PV Savings LSC (2029 PV\$)	Incremental Cost Including Replacements and Negative Residual Cost (\$)	B/C ratio
Data center: Computer room (new)	29	\$585	-\$650	Infinite
Educational, civic: Multipurpose room (art, music etc.)	125	\$1,991	-\$2,314	Infinite
Education/Business: Classroom, Training,	29	\$466	-\$396	Infinite
Office Area: ≤ 250 square feet	10	\$174	-\$192	Infinite
Office Area: > 250 square feet	46	\$784	-\$670	Infinite
Office: Conference Room	122	\$2,081	-\$3.328	Infinite



Lighting Power Density (LPD)

Statewide savings

- The statewide market probability adjustment factors were applied.
- Savings derated to 58% for new construction and 43% for alterations.

Construction Type	Annual Construction (Million ft ² /yr)	First-year Electricity Savings (GWh/yr)	Peak Electrical Demand Saving (kW)	30-Year LSC Savings (Million 2029 PV\$)
New Construction	88.6	17.6	1,597	\$135
Additions and Alterations	286.4	61.5	5,449	\$467
Statewide total	375.1	79.1	7,047	\$602



Additional Clarification/Questions

➤ Altered indoor lighting systems

- **601.5.2.2.4** [Section 141.0(b)2I] - 80% of power requirements and Table **601.5-A**
- **Question:**
When doing a lighting alteration do you typically replace the controls?

➤ Controls for outdoor lighting

- **601.2.3.2** [Section 130.2(c)]
- Outdoor Lighting Controls for Public EV Fast-Charging Infrastructure
- We have received comment from Tesla on SuperCharger area



Thank you for participating!

Comments for Today's workshop

Due date: July 17, 2026, by 5:00 PM

Submit the comments to:

<https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03>

Contact information: **Sahar.Daemi@Energy.ca.gov**



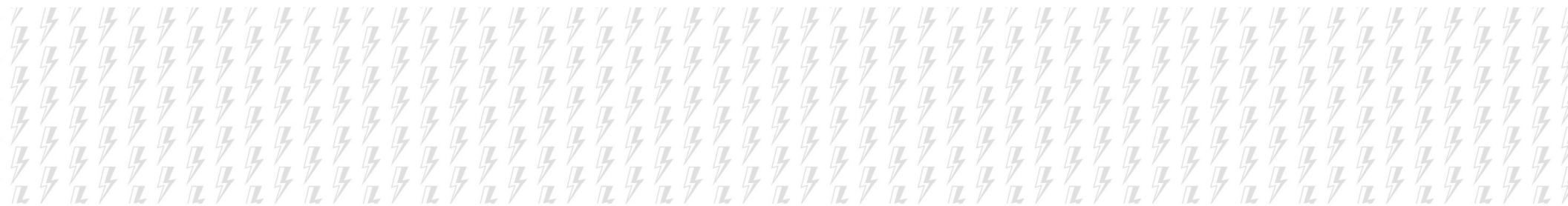
2028 Energy Code – Pre-Rulemaking

*Indoor Lighting Control
Sahar Daemi, Electric Generation System Specialist
June 24, 2025*



Outline

- ✓ Multilevel Lighting Control
- ✓ Continuous Dimming for all Daylight Responsive Controls
- ✓ Parking Garage Daylight Adaptation Zones Nighttime Controls
- ✓ Occupant Sensor Control for more spaces
- ✓ Reducing Delay time for Occupant Sensor Control



Multilevel Lighting Controls & Continuous Dimming for Daylight Responsive Controls



Multilevel Lighting Controls

2025 Code Requirements

- 601.2.2.2 [130.1(b)] - Multilevel lighting controls are required for
 - General lighting of any enclosed space with a size of area ≥ 100 ft² and
 - Connected lighting load ≥ 0.5 W/ ft²

- Multilevel lighting controls requires continuous dimming from 100% to 10% or lower of lighting power

- Current requirement
 - Based on legacy light sources
 - Trigger based on lighting power density



Multilevel Lighting Controls

2028 Proposed Changes

- The manual dimmer requirement is for nonresidential occupancies.
- Clarify when manual dimmers are required using clear language.
- Exception for space areas where manual dimmer is not applicable.
- Using wattage instead of evaluating lighting power density.
- Proposed 50 watts trigger for requiring manual dimmers.
- Scene controllers may also comply with this requirement.
- **Unit savings: 0.091 to 0.583 kWh per watt controlled for new construction, additions and alterations.**





Continuous Dimming for Daylight Responsive Controls

Section 601.2.2.4 [130.1(d)]

➤ **2025 current requirement:**

- Only require continuous dimming in daylit zones where multilevel lighting controls are required
- Daylight responsive controls requires on/off switching

➤ **2028 proposed changes:**

- Require continuous dimming for all daylight responsive controls
- A new exception would be added for spaces where continuous dimming would not generate meaningful energy savings

➤ **Per-unit savings:**

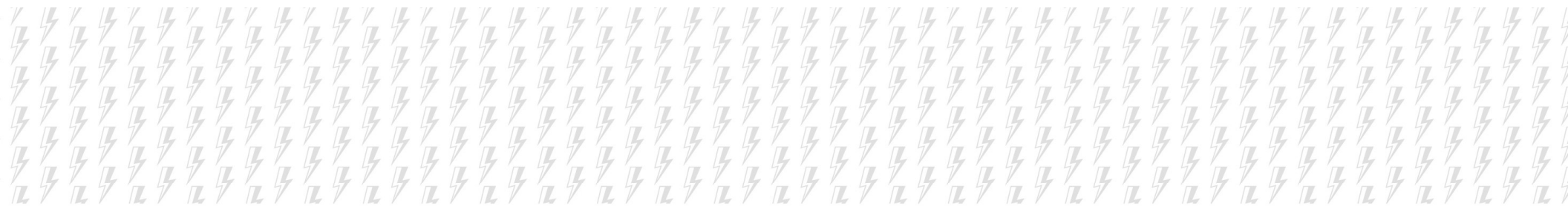
- 0.414 to 1.814 kWh/yr, depending on the space type, daylit zone, and climate zone



Cost-effectiveness

- **Manual dimmer for nonresidential buildings**
 - The benefit-to-cost ratios are ranging from **1.32 to 10.93**, depending on space type
- **Continuous dimming for daylight responsive control**
 - The benefit-to-cost ratios for spaces showing cost-effectiveness range from **1.40 to 4.68**, depending on space type, daylit zone type, and climate zone
- **First-year statewide savings**
 - Multiplying the per-unit savings by the estimated percentage of spaces

	Impacted floor space (Mft ²)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction and Additions	19.574	4.859	0.265	\$26.28
Alterations	79.620	20.037	1.077	\$109.23
Total	99.194	24.895	1.342	\$135.50



Parking Garage Daylight Adaptation Zones Nighttime

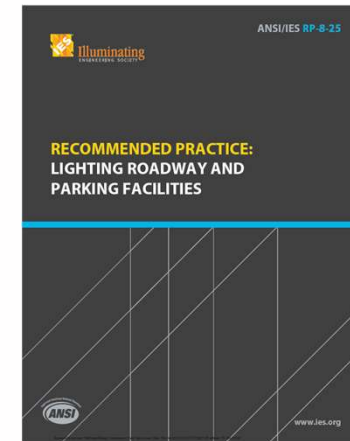


Parking Garage Daylight Adaptation Zones Nighttime

Current and proposed changes

➤ Current code requirement (2025)

- LPD of daylight adaptation zones in 601.3-C [Table 140.6-C] is 1.0 W/ft²
- Illuminating Engineering Society (IES) RP-8 Recommended Practice for Lighting Roadway and Parking Facilities



➤ Proposed change (2028)

- Affects new construction, additions, and alterations
- Reduces lighting in daylight adaptation to the same level as the rest of the parking area at nighttime
- Increases adaptation while reducing energy use





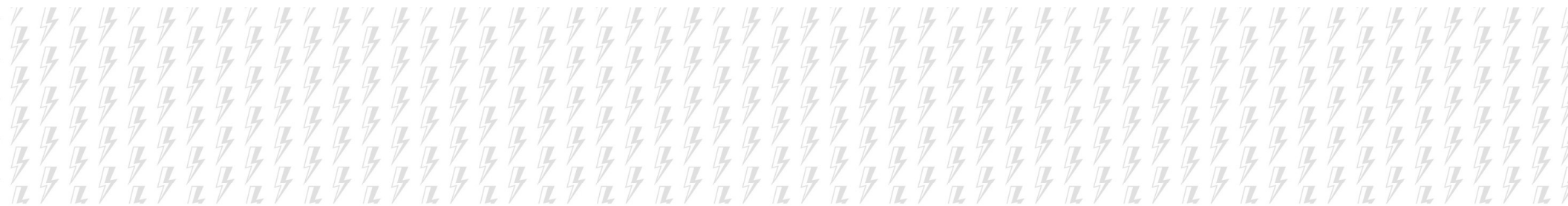
Parking Garage Daylight Adaptation Zones Nighttime

Cost-effectiveness

- Measured annual measure case adaptation zone demand
- Unit savings: 3.88 kWh/ft² per adaptation zone calculated for the first year
- Incremental first cost and energy savings calculation considered dimming and on/off switching
- Benefit-to-cost Ratio is ranging from **12.42 to 19.89**

First-year statewide savings

Construction Type	Impacted Floor Space (ft ²)	Electricity Savings (GWh)	Peak Electrical Demand Reduction (MW)	30yr Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	216,000	0.8	-	2.3
Alterations	651,233	2.5	-	6.9
Total	867,233	3.4	-	9.2



Require Occupant Sensing Controls in More Spaces



Require Occupant Sensing Controls in More Spaces

Interaction with HVAC controls requirements

- Expand occupant sensing lighting controls to additional space types.
- Previous indoor lighting requirement still exist for these new spaces.
- The lighting control requirements would also trigger compliance with additional HVAC control requirements.

Space Primary Function Type	Lighting Reduction	HVAC Interaction	HVAC Section
Computer room	Full-OFF	Occupied Standby	Section 401.2.1.2.5 <i>[Section 120.1(d)5]</i>
Lounge, breakroom, or waiting area	Full-OFF	Occupied Standby	Section 401.2.1.2.5 <i>[Section 120.1(d)5]</i>
Laboratory (classroom type only)	Partial-OFF	Airflow Reduction	Section 912.2.1 <i>[Section 140.9(c)1]</i>



Require Occupant Sensing Controls in More Spaces

Cost-effectiveness methodology

- Floor area where lighting occupancy controls and HVAC occupied standby controls would apply.
- First-year electricity savings: **0.00 to 0.033 kWh/ft²**
- Total average incremental first cost is \$395 and \$64 for Lighting and HVAC systems respectively.
- Benefit to cost ratio ranges from 0.59 to 1.67
 - Climate zones 1, 2, 5, 9, 11, 12, 13, 14, 16 are below 1
 - Other Climate zones 3, 4, 6, 7, 8, 10 are greater than 1



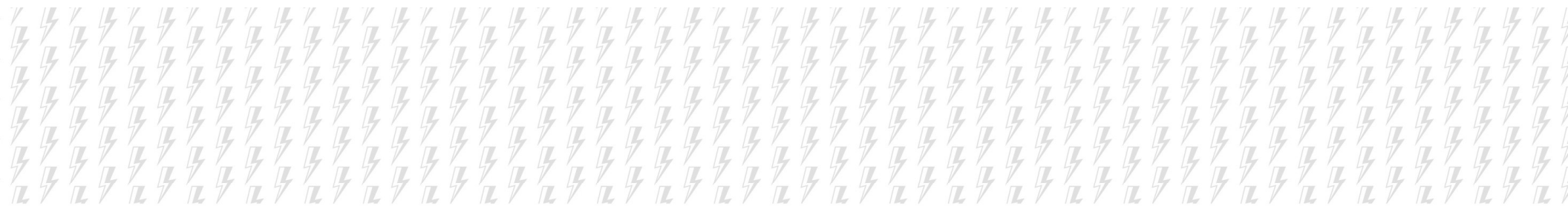
Require Occupant Sensing Controls in More Spaces

First-Year Statewide Impacts

First-year statewide savings

- The per-unit energy impacts multiplied by the CEC's Statewide Construction Forecasts.

Construction Type	Impacted Floor Space (ft ²)	Electricity Savings (GWh)	Peak Electrical Demand Reduction (MW)	30yr Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	66,957,900	0.6	0	4
Alterations	290,725,650	2.6	0.2	18
Total	357,683,550	3.2	0.2	23



Reduce Occupant Sensing Control Delay Time



Reduce Occupant Sensing Control Delay Time

Current and Proposed changes

Current requirements:

- Maximum occupant sensing control time delay is 20 minutes
- ASHRAE 90.1-2025 reduced occupant sensing control time delay to 15 minutes
- Many occupancy sensors/controls already provide a 15-minute option for time delay

Proposed change:

- Reduce the maximum occupant sensing control time delay to 15 minutes
- Aligning HVAC occupied standby delay time to 15 minutes would cause additional HVAC energy savings





Reduce Occupant Sensing Control Delay Time

First-year statewide impacts

- Modeled based on full-load hour reduction estimate.
- Unit savings: 0.01 to 0.08 kWh/ ft², depending on building types.
- The proposed measure has no incremental first costs.
- Benefit-to-cost ratio is infinite.

First-year statewide savings

- The per-unit energy impacts multiplied by the CEC's Statewide Construction Forecasts.

Construction Type	Impacted Floor Space (ft ²)	Electricity Savings (GWh)	Peak Electrical Demand Reduction (MW)	30yr Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	137,517,975	7.8	0.4	405
Alterations	494,485,576	26.6	1.5	1,475
Total	632,003,551	34.4	1.9	1,880



Thank you for participating!

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Contact information: **Sahar.Daemi@Energy.ca.gov**



Controlled Environment Horticulture

Thao Chau, P.E., Associate Electrical Engineer, Building Standards Branch
June 24, 2026



Controlled Environment Horticulture Proposal

Proposal Structure

- Horticultural Lighting Efficacy
- Daylighting Controls for Greenhouses (new)
- Space Conditioning for Indoor Grow Facilities

Horticultural Lighting Efficacy





Current 2025 Code Requirements

Horticulture Lighting Efficacy

- Section 908.1.2 [120.6(h)2]
- Applies to new constructions, additions, and alterations of greenhouse and indoor grow facilities with an aggregate horticultural lighting load of 40 kW or greater
- Minimum Photosynthetic Photon Efficacy (PPE) is 2.3 ($\mu\text{mol/J}$)
- PPE applies to both full luminaires or removable, serviceable lamps



2028 Proposed Code Requirements

Horticulture Lighting Efficacy

- Increase the minimum Photosynthetic Photon Efficacy (PPE) to 2.5 ($\mu\text{mol/J}$)
- Update the PPE definition: product ratings account for
 - luminaire optical efficiency
 - thermal design impacts
- Clarify existing dimming and multilevel lighting control requirements



Cost Effectiveness Summary

Benefit-to-Cost Ratios Per Square Foot Canopy

New Constructions and Additions – Climate Zones 1-16			
Prototype	LSC Savings + Other PV Savings (2029 PV\$)	Total Incremental PV Costs (2029 PV \$)	Benefit-to-Cost Ratio
Indoor Cannabis	\$111.05	\$2.70	41
Indoor Leafy Greens/Microgreens/Herbs	\$40.64	\$0.00	N/A
Indoor Tomatoes/Vines/Flowering	\$38.69	\$0.31	122
Greenhouse Cannabis	\$17.38	\$0.44	39
Greenhouse Leafy Greens/Microgreens/Herbs	\$3.36	\$0.00	N/A
Greenhouse Tomatoes/Vines/Flowering	\$4.71	\$0.31	15



Cost Effectiveness Summary

Benefit-to-Cost Ratios per Square Foot of Canopy

Alterations – Climate Zones 1-16			
Prototype	LSC Savings + Other PV Savings (2029 PV\$)	Total Incremental PV Costs (2029 PV \$)	Benefit-to-Cost Ratio
Indoor Cannabis	\$111.66	\$2.70	41
Indoor Leafy Greens/Microgreens/Herbs	\$40.29	\$0.00	N/A
Indoor Tomatoes/Vines/Flowering	\$39.01	\$0.31	125
Greenhouse Cannabis	\$18.78	\$0.44	43
Greenhouse Leafy Greens/Microgreens/Herbs	\$4.11	\$0.00	N/A
Greenhouse Tomatoes/Vines/Flowering	\$5.53	\$0.31	18

Daylight Responsive Controls for Greenhouses





2028 Proposed Code Requirements

Daylight Responsive Controls for Greenhouses

➤ **New mandatory requirements**

- Applicable to new constructions, additions, and alterations
- Greenhouses with
 - Supplemental electric lighting
 - Horticultural lighting load $\geq 40\text{kW}$

➤ **Option 1:** Timeclock + photosynthetically active radiation (PAR) sensor-based control

- Combine a scheduling device with dimming control in response to instantaneous photosynthetic photon flux density (PPFD) levels

➤ **Option 2:** Daily light integral (DLI) control

- Automatically adjust supplemental lighting based on cumulative PPFD measured over the daily photoperiod to meet, but not exceed, a user-defined DLI target



Cost Effectiveness Summary

Benefit-to-Cost Ratios in Daylight Responsive Controls for Greenhouses

New Constructions and Additions – Climate Zones 1-16

Prototypes	LSC Savings + Other PV Savings (2029 PV\$)	Total Incremental PV Costs (2029 PV \$)	Benefit-to-Cost Ratios
Greenhouse Cannabis	\$242.48	\$3.76	65
Greenhouse Leafy Greens/Microgreens/Herbs	\$175.11	\$1.25	140
Greenhouse Tomatoes/Vines/Flowering	\$265.90	\$2.19	121



Cost Effectiveness Summary

Benefit-to-Cost Ratios in Daylight Responsive Controls for Greenhouses

Alterations – Climate Zones 1-16

Prototypes	LSC Savings + Other PV Savings (2029 PV\$)	Total Incremental PV Costs (2029 PV \$)	Benefit-to-Cost Ratios
Greenhouse Cannabis	\$238.99	\$3.76	65
Greenhouse Leafy Greens/Microgreens/Herbs	\$175.32	\$1.25	140
Greenhouse Tomatoes/Vines/Flowering	\$264.01	\$2.19	120



Statewide Energy and LSC Impacts

Daylight Responsive Controls for Greenhouses

New Constructions and Additions – Climate Zones 1-16

Prototypes	Statewide Impacted (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
Greenhouse Cannabis	0.08	3.19	141.17	N/A	0.93	\$18.76
Greenhouse Leafy Greens/Microgreen/Herbs	0.12	3.30	175.20	N/A	1.54	\$20.84
Greenhouse Tomatoes/Vines/Flowering	0.16	6.95	340.15	N/A	2.56	\$42.20



Statewide Energy and LSC Impacts

Daylight Responsive Controls for Greenhouses

Alterations – Climate Zones 1-16

Prototypes	Statewide Impacted (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (kW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
Greenhouse Cannabis	0.26	3.19	141.17	N/A	0.93	\$61.81
Greenhouse Leafy Greens/Microgreen/Herbs	0.40	3.30	175.20	N/A	1.54	\$69.76
Greenhouse Tomatoes/Vines/Flowering	0.53	6.95	340.15	N/A	2.56	\$140.07

Space Conditioning for Indoor Grow Facilities





Current 2025 Requirements

Space Conditioning for Indoor Grows

- Section 908.1.1 [120.6(h)1], mandatory indoor growing dehumidification, is the only space-conditioning requirement specific to Indoor grow facilities
- No other CEH-specific HVAC requirements
- Indoor growing spaces have been treated as directly conditioned nonresidential spaces
 - Non-residential mandatory and prescriptive requirements apply



2028 Proposed Requirements

Space Conditioning for Indoor Grows

- Mandatory-only framework for indoor growing
- Change process space definition to include CEH spaces
- Clarify requirements that apply to all indoor growing spaces:
 - Existing non-residential requirements that are appropriate as mandatory requirements for indoor growing spaces
- Establish new HVAC and dehumidification system requirements for high-intensity indoor growing spaces that serve at least 5,000 canopy square feet



2028 Proposed Requirements

Space Conditioning for Indoor Grow Facilities

For high-intensity indoor growing spaces that serve at least 5,000 canopy square feet

- Indoor growing-specific HVAC/D sizing requirements
- System requirements for either integrated HVAC/D or coordinated decoupled HVAC/D
- Coordinated controls for HVAC and dehumidification
- Commercial dehumidifier qualification
- Recovered heat requirements
- Acceptance testing by field technician to confirm controls are configured to comply with requirements



2028 Proposed Requirements

Load Calculation and System Sizing for Indoor Grows

- Apply only to indoor growing facilities with at least 5,000 ft² of plant canopy grown under at least 30W/canopy ft² of lighting
- Sized to meet design heating, sensible cooling, latent cooling, dehumidification, heat-rejection, heat recovery, and reheat loads.
- Sized to account for plant canopy area, horticultural lighting power and schedule, irrigation rates, evapotranspiration, grow-cycle stage, lights-on and lights-off operation, temperature and humidity setpoints, allowable tolerances, motor heat, and applicable outdoor design conditions.
- Representative mid-stage and late-stage grow-cycle conditions, including both lights-on and lights-off operation.



Energy Savings Methodology

Key Assumptions for Integrated HVAC/D Systems

- EnergyPlus model was created to simulate energy savings in 16 climate zones
- Current model (2025):
 - Humidistat-controlled standalone dehumidifiers
 - Thermostat-controlled single-state conditioning systems with resistance reheat
- Proposed model (2028): Integrated space conditioning system with
 - Integrated controls
 - Modulating hot gas and electric resistance reheat
 - Variable speed fans
 - Low/variable sensible heat ratio

Cost-Effectiveness Summary Per Canopy Square Foot

New Constructions and Additions

Benefit-to-Cost Ratios																
CZ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ratios	62	65	67	66	68	69	71	69	69	68	65	67	66	62	69	63



Comments and Contact Information

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Comments can be submitted to the pre-rulemaking docket 25-BSTD-03:
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Contact information: Thao.Chau@energy.ca.gov



2028 Pre-rulemaking Workshop

Nonresidential Swimming Pool and Spa Heating

Danny Tam, Associate Mechanical Engineer, Building Standards Branch

Existing Code Requirements



Mandatory requirements (Section 800.2, 110.4(b)):

Applicable to Single-family, Multifamily, and Nonresidential (NR) applications when new pool/spa heating system is installed:

- A solar pool heating system with collector surface area equal to 65% of pool surface area for NR and multifamily, and 60% for single family; or
- A primary heat pump pool heater meeting sizing requirement in JA16; or
- On-site renewable energy or site recovered energy providing at least 60% of the annual heating energy; or
- Combination of solar pool heater and heat pump pool heater; or
- Alternative pool heating system approved by California Energy Commission (CEC)



Existing Requirements – Cont.



Exceptions to 800.2, 110.4(b)

- Portable electric spas compliant with the Appliance Efficiency Regulations.
- Alterations to existing pools with existing heating system
- A pool/and or spa that is heated solely by a solar swimming pool or spa heating system.
- Heating systems used exclusively for permanent spa with natural gas availability or limited solar access



2028 Proposed Requirements

Mandatory requirements (Section 801, 141.0(b)1): with six options for compliance applicable to Nonresidential when pool heating system is replaced in **Climate Zones 2-16:**

- A solar pool heating system with collector surface area equal to **40%** of pool surface area; or
- A primary heat pump pool heater meeting sizing requirement in JA16; or
- On-site renewable energy or site recovered energy providing at least 60% of the annual heating energy; or
- Combination of solar pool heater and heat pump pool heater; or
- **Condensing gas pool heater $\geq$ 94% efficiency; or**
- Alternative pool heating system approved by CEC

2028 Proposed Requirements



Exceptions to 801, 141.0(b)1:

- Portable electric spas compliant with the Appliance Efficiency Regulations.
- A pool/and or spa that is heated solely by a solar swimming pool or spa heating system.
- Heating systems used exclusively for permanent spa with natural gas availability or limited solar access
- Hotel/motel and nonresidential buildings with Group R occupancies

Key Assumptions



- Pool heating schedule and frequency per National Renewable Energy Laboratory Solar Pool Heating Quantitative Survey
- Baseline heating provided by natural gas heater
- Pool heating is assumed to be year-round for year-round pools. Seasonal commercial pools are heated constantly during season of use
- Solar thermal heating provided by unglazed solar collectors with backup heating from natural gas heater

Software Used & Prototypes



- Analysis performed for indoor and outdoor pools, as well as covered and uncovered pools
 - Standard 60,000-gallon pools; and
 - Olympic-size 660,000-gallon pools
 - Swim school and exercise pool with elevated temperature (90 degrees F)
- Analysis performed per Enerpool Pro 3.0 simulation software using CEC 2028 climate files



Incremental Costs – Solar Thermal

Incremental First Cost

- Collector installation (unglazed)
- Plumbing integration (Supply & return piping, trenching, insulation)
- Mechanical additions (Additional booster pumps)

Prototype	Incremental First Cost (Equipment, Pump, Plumbing + Installation)
Standard 60,000 gallon Pool	\$19,640
Olympic-Sized 660,000 gallon Pool	\$113,940

Maintenance Costs

- Assumed to be 2% of First Cost per year
- Collector life 15 years
- Pump replacement every 7 years

Cost Effectiveness – Solar Thermal



- **Benefit-to-Cost Ratio is above 1 for all CZs**
- **Climate Zone 1 is not included in the proposed code change**

Climate Zone	Benefit-to-Cost Ratio
1	1.05
2	3.31
3	1.95
4	4.38
5	2.31
6	2.6
7	3.01
8	4.48
9	4.46
10	4.82
11	3.94
12	3.79
13	3.69
14	4.5
15	6.25
16	2.57

Statewide Savings



First-Year Statewide Savings	Measure Total
Electricity Savings (GWh)	--
Peak Electrical Demand Reduction (MW)	--
30-Year Present Valued LSC Savings (Million 2029 PV\$)	\$196.70
Natural Gas Savings (Million Therms)	2.46
Source Energy Savings (Million kBtu)	210.32
Avoided GHG Emissions (Metric Ton CO2e)	12,800
Monetary Value of Reduced GHG Emissions (\$2029)	1,576,994



Comments

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