TITLE 24, PART 6 | 2025 CODE CYCLE

Laboratories

Codes and Standards Enhancement (CASE) Proposal
Nonresidential | Laboratories

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May 10, 2023

Utility Sponsored Stakeholder Meeting – Round 2

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

- Overview of Code Change Proposal
- Summary of Stakeholder Feedback
- Cost-effectiveness, Energy Savings and Statewide Impacts
- Next Steps

Code Change Proposal

- Summary

Laboratory Proposed Code Changes (1 of 2)

L (laboratory) occupancy group no longer exempt from Title 24

- In addition to B (business), E (educational) and H (hazardous) already covered

Night Setback:

- Require unoccupied setback of lab airflow rates
  - Example: from 6 ACH (air changes per hour) occupied to 4 ACH unoccupied
  - With exceptions where higher rates are required for code, accreditation, or environmental health & safety (EH&S)
- Remove exception to VAV for min ventilation > 10 ACH
  - Constant volume still allowed if required by code, accreditation, or EH&S

Laboratory Proposed Code Changes (2 of 2)

Heat Recovery

Require exhaust air heat recovery for most large labs

- exception for some high-rise labs with limited roof space

Exhaust Fan Control

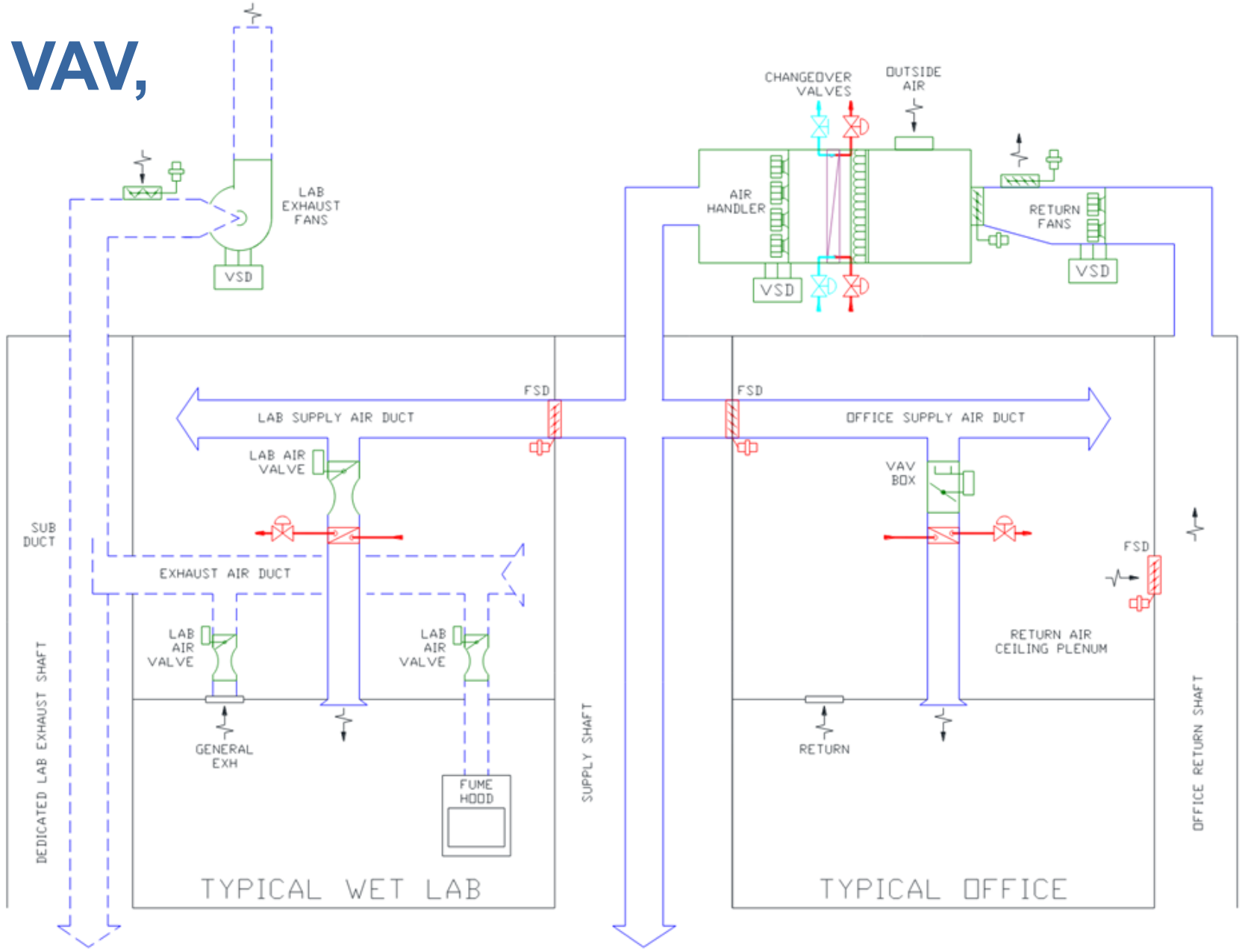
New exhaust fan power compliance option for VAV exhaust fans with higher w/cfm but able to turndown without wind monitoring or contaminant monitoring.

Reheat Limits

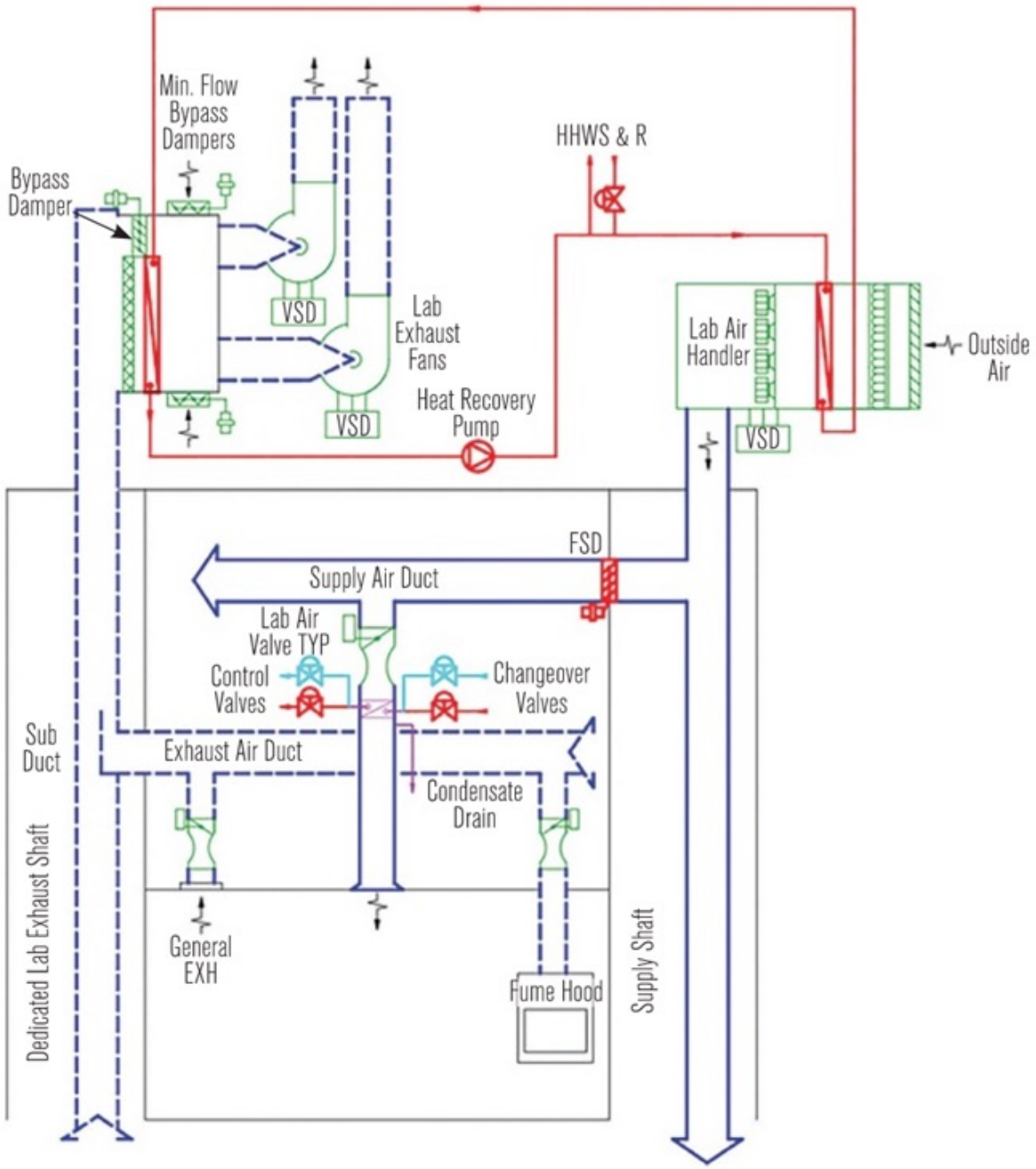
Limit reheat, effectively requiring heating and cooling at each zone for labs (e.g., 4-pipe VAV boxes)

- exception for humid climates, vivaria, BSL3/4

Schematic: 2-Pipe VAV, no Heat Recovery



Schematic: 4-Pipe VAV, with Heat Recovery



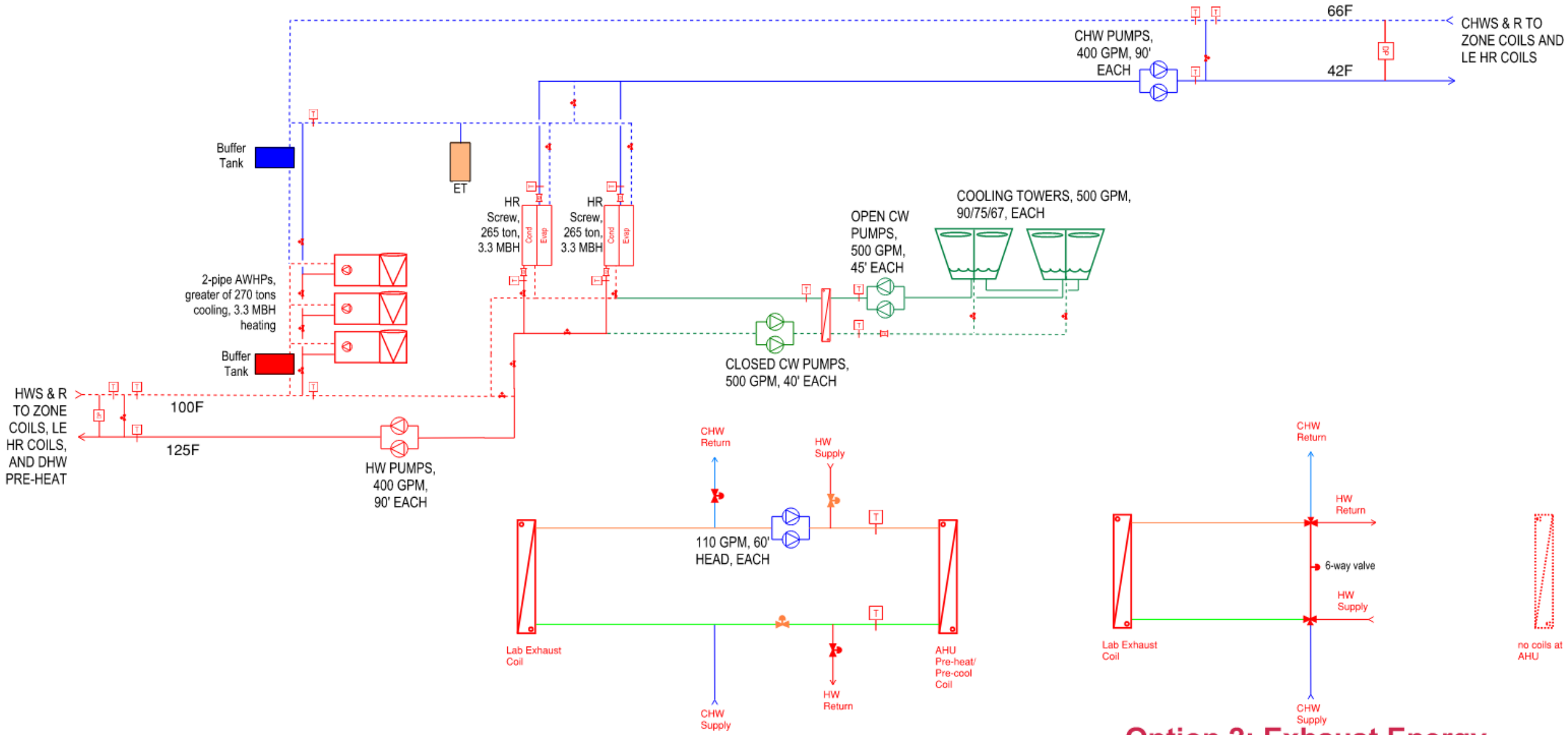
Summary of Stakeholder Feedback

- Summary of Feedback Received
- Measure Evolution

Summary of Feedback Received: Heat Recovery

1. Space Constraints: HR coils in exhaust plenum are ~500 fpm, versus ~2000 fpm without coils. High rise labs may not have space on the roof for larger plenums.
   - Response: HR reduces roof space required for heat pumps. We reviewed labs with HR and found sufficient space if total exhaust <= 20 cfm/ft2. Added exception above 20 cfm/ft2.
2. Lab exhaust heat recovery to a heat recovery chiller can be just as efficient.
   - Response: Added exception for lab exhaust to heat recovery chiller.

Lab Exhaust to Heat Recovery Chiller



Option 1: Exhaust Energy Recovery to Chiller and AHU

Option 2: Exhaust Energy Recovery just to Chiller

Draft Code Change Language: Heat Recovery

140.9(c)6 Exhaust Air Heat Recovery. Buildings with greater than 10,000 CFM of laboratory exhaust shall include an exhaust air heat recovery system that meets the following:

1. A sensible energy recovery ratio of at least 45% at heating design conditions and 25% at cooling design conditions
2. Heat is recovered from at least 75% of all lab exhaust air
3. The system includes a run-around coil pump or other means to disable heat recovery
4. The system includes a bypass damper or other means so that the exhaust air pressure drop through the heat exchanger does not exceed 0.4”w.g when heat recovery is disabled.

Exception 1 to Section 140.9(c)6: Additions or alterations to existing laboratory exhaust systems that do not include exhaust air heat recovery.

Exception 2 to Section 140.9(c)6: Buildings where the total laboratory exhaust rate exceeds 20 cfm/ft2 of roof area.

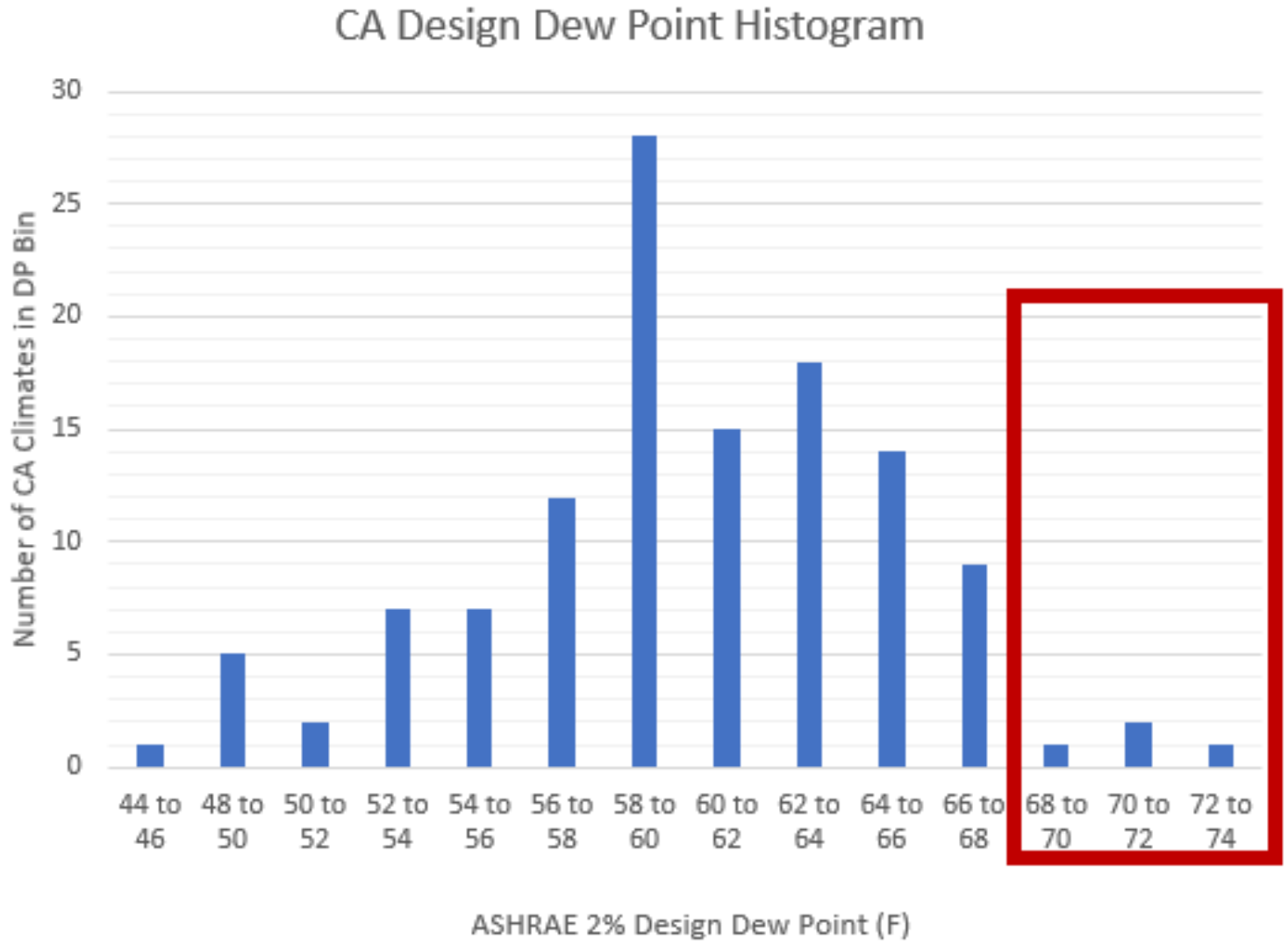
Exception 3 to Section 140.9(c)6: Buildings in Climate Zones 6 or 7 in jurisdictions where gas heating is allowed

Exception 4 to Section 140.9(c)6: Buildings with an exhaust air heat recovery system and heat recovery chillers designed to provide at least 40% of the peak heating load from exhaust heat recovery.

Summary of Feedback Received: Reheat Limitations

1. Humidity Control: Zones requiring humidity control will need 2 zone coils (rather than a single changeover coil), increasing the cost
   - Response: New exceptions added for CA climates where ASHRAE 62.1 requires humidity control and for vivaria and BSL3+. Also, LCCA includes cost of 2 zone coils for 10% of zones.
2. Condensate Pumps – Pumps at zones adds cost and risk of failure.
   - Response: Most zones will have gravity drains (no pump). LCCA includes cost of pumps and alarm monitoring at 50% of zones.
3. Boiler/Heat Pump Savings - LCCA took credit for boiler downsizing, which is not always the case
   - Response: Boiler downsizing credit removed from LCCA

CA Climates Requiring Humidity Control per Addendum k to ASHRAE Standard 62.1-2019



Draft Code Change Language: Reheat Limits

140.9(c)5 Reheat Limitation. Air handlers serving multiple space conditioning zones shall not include mechanical cooling and each zone shall include heating and cooling capacity, such as 4-pipe VAV, to prevent cooling at the air handler and reheating at the zones.

Exception 1 to Section 140.9(c)5: Additions or alterations to existing air handling systems serving existing zones without heating and cooling capacity.

Exception 2 to Section 140.9(c)5: Systems in locations where the outdoor dew point temperature is greater than or equal to 66°F at the ASHRAE 2% annual dehumidification design condition.

Exception 3 to Section 140.9(c)5: Systems dedicated to vivarium spaces or to spaces classified as Biosafety Level 3 or higher.

Draft Code Change Language: Night Setback

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

(c) Prescriptive requirements for laboratories and factories ~~laboratory and factory exhaust systems~~.

140.9(c)1 Airflow reduction requirements. ~~For buildings with~~ laboratory ~~exhaust~~ systems ~~where the minimum circulation rate to comply with code or accreditation standards is 10 ACH or less, the design exhaust airflow~~ shall be capable of reducing ~~zone~~ space and fume hood exhaust and makeup airflow rates to the greater of

a) 6 ACH_{10} (1.0 cfm/ft2) or lower, (ACH_{10} is air changes per hour for a 10 foot high ceiling.)

b) the regulated minimum occupied circulation rate to comply with code, accreditation, or facility environmental health & safety department requirements~~, or~~

c) the minimum required to maintain occupied pressurization requirements~~, whichever is larger.~~

Variable exhaust and makeup airflow shall be ~~coordinated~~ automatically controlled to achieve the required space pressurization at varied levels of demand and fan system capacity.

Laboratory exhaust systems shall also include occupancy sensors, and/or other controls as necessary, to further reduce zone exhaust and makeup airflow rates to unoccupied rates no higher than the greater of:

a) 4 ACH_{10} (0.67 cfm/ft2) or lower,

b) the regulated minimum unoccupied circulation rate to comply with code, accreditation, or facility environmental health & safety department requirements, or

c) the minimum required to maintain unoccupied pressurization requirements.

~~**Exception 1 to Section 140.9(c)1:** Laboratory exhaust systems serving zones where constant volume is required by the authority having jurisdiction, facility environmental health & safety department or other applicable code.~~

Exception 1~~2~~ to Section 140.9(c)1: New zones on an existing constant volume exhaust system.

Draft Code Change Language: Night Setback (proposed)

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c) the minimum required to maintain unoccupied pressurization requirements.

Exception 1 to Section 140.9(c)1: New zones on an existing constant volume exhaust system.

Draft Code Change Language: Exhaust Fan Control (without deletions)

140.9(c)3 Fan System Power Consumption. All newly installed fan exhaust systems serving a laboratory or factory greater than 10,000 CFM, shall meet subsection A and either B, or C:

A. System shall meet all discharge requirements in ANSI Z9.5-2022 Section 6.4
B. The exhaust fan system power shall not exceed 0.85 watts per cfm of exhaust air for systems with air filtration, scrubbers, or other air treatment devices. For all other exhaust fan systems the system power shall not exceed 0.65 watts per cfm of exhaust air. …
C. Exhaust system shall comply with all of the following:
    i. The sum of the occupied minimum circulation rates of the spaces served by the fan system shall be less than 60% of the fan system design flow rate
    ii. The design exhaust fan system power shall not exceed 1.3 watts per cfm of exhaust air when operating under full load design conditions.
    iii. The system shall include variable speed controls so that exhaust system fans shall draw no more than 40% of the design fan power when the exhaust stack air flow rate is operating at 60% of design flow rate.
    iv. The stack flow shall be no higher than the larger of:
        a) The space exhaust flow rate, or
        b) The minimum acceptable stack flow rate
    v. Exhaust system design and control results in calculated outdoor contaminant concentrations in compliance with applicable federal, state, or local regulations.
    vi. The minimum acceptable stack flow, as defined using the procedures and system definitions included in ANSI Z9.5 (2022) Appendix 3, shall be one of the following:
        a) Less than 60% of the design stack flow rate during normal operation (simple turndown control system), or
        b) dynamically reset based on measured wind speed and/or wind direction and assumes worst case emissions rate and shall be less than 60% of the design stack flow rate for at least 70% of the hours during a Typical Meteorological Year (TMY) for the site (wind responsive control system); or
        c) dynamically reset based on measured contaminant concentration and shall be less than 60% of the design stack flow rate when measured contaminants in the exhaust system plenum are below the threshold contaminant concentration value (monitored control system)

EXCEPTION 1 to Section 140.9(c)3: Fan exhaust systems complying with 140.4(c)1

EXCEPTION 1 to Section 140.4(c)1 (Fan Power Budget): Laboratory or factory fan exhaust systems greater than 10,000 CFM complying with 140.9(c)3.

Poll

Do you have any questions?

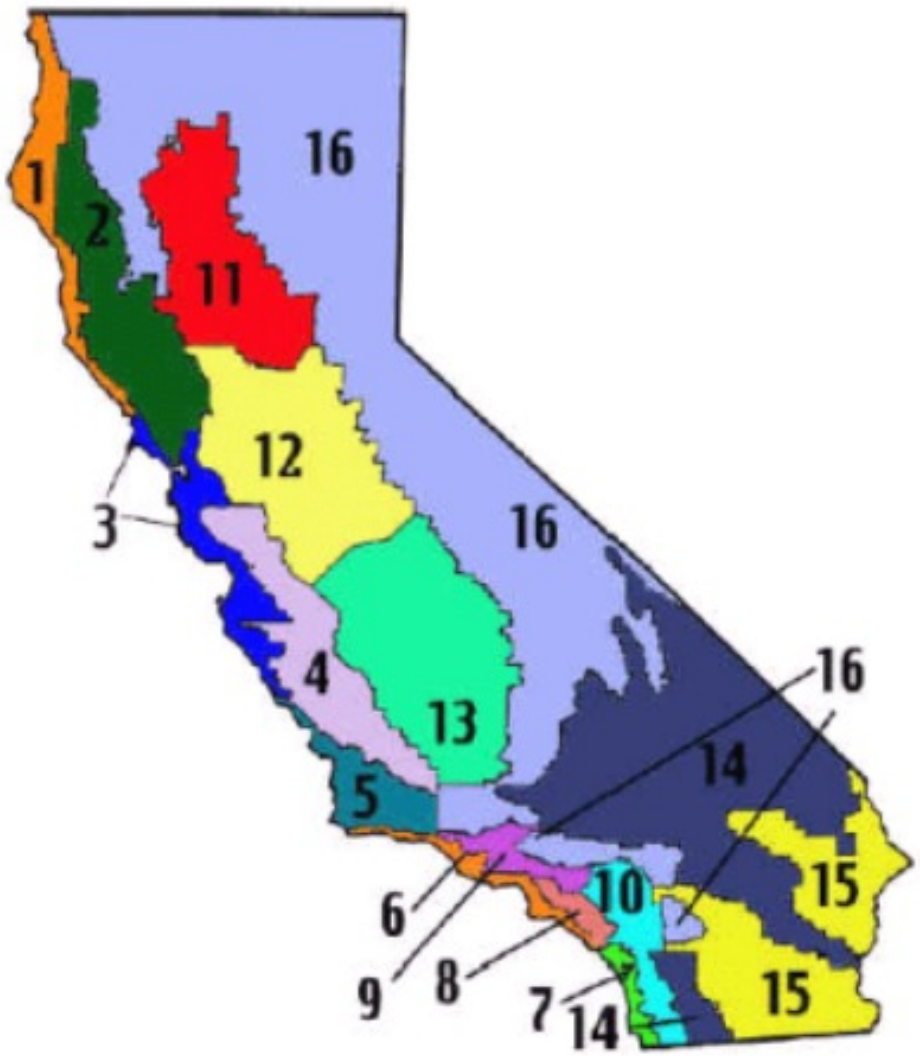
Do you have any objections?

Cost Effectiveness and Energy Savings

Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

California Climate Zones Map



Preliminary Energy Savings Estimates Per sf- Heat Recovery

Climate Zone	CZ2	CZ6	CZ7	CZ12
Annual Electricity Savings (kWh/yr)	.07	.03	.01	0.19
Annual Natural Gas Savings (Therms/yr)	13.8	0.23	0.07	11.5
Peak Demand Reduction (W)	0	0	0	0
Annual Life Cycle Energy Savings (kBTU/yr)	8.6	0.29	0.1	8.0
Annual Source Energy Savings (kBTU/yr)	12.5	0.27	0.1	10.5
Benefit to Cost Ratio	12.8	0.4	0.15	11.9

Key Assumptions:

- 0.25 sensible cooling effectiveness
- 0.45 sensible heating effectiveness
- Total building square footage: 17,876

Incremental Cost: Heat Recovery

An actual project that includes heat recovery was recently bid by several contractors. We redesigned the project without heat recovery and had one of the bidders re-estimate the project. The project has gas boilers. Therefore, we also redesigned it with heat pumps and had it estimated with and without heat recovery.

Changes that make the basecase (no heat recovery) more expensive:

- Increasing the capacity of the chillers by approximately 23%
- Increasing the capacity of the cooling coils
- Increasing the capacity of the chilled water pumps
- Increasing the capacity of the boilers/heat pumps by approximately 38%
- Increasing the capacity of the hot water pumps
- Increasing the capacity of the VAV box reheat coils
- $500/yr incremental maintenance

Changes that make the basecase (no heat recovery) less expensive:

- Removing the exhaust air heat recovery coil
- Removing the heat recovery coil bypass damper
- Reducing the total pressure drop of the exhaust fans
- Eliminating the heat recovery pumps and associated piping
- Eliminating the heat recovery coil from the air handler
- Reducing the total pressure drop of the supply fans

incremental costs in $/ft2	vs. Gas Baseline	vs. Heat Pump Baseline
Chillers	$ (1.38)	$ (1.38)
HR coil	$ 1.68	$ 1.68
HR piping	$ 1.68	$ 1.68
HR pumps/VFDs	$ 0.14	$ 0.14
CHW pumps/VFDs	$ (0.55)	$ (0.55)
HW pumps/VFDs	$ (0.15)	$ (0.15)
Exhaust fans/VFDs	$ 0.28	$ 0.28
Terminal units	$ (0.30)	$ (0.30)
HW piping	$ (0.13)	$ (0.13)
CHW piping	$ -	$ -
Controls	$ 0.20	$ 0.20
Boilers	$ (0.99)	$ -
ASHPs	$ -	$ (9.28)
NPV of Ann. Maint.	$ 0.19	$ 0.19
TOTAL $/ft2	**$ 0.67**	**$ (7.62)**

Preliminary Energy Savings Estimates Per sf- Reheat Limitation

Climate Zone	CZ2	CZ6	CZ7	CZ12
Annual Electricity Savings (kWh/yr)	1.46	4.48	4.76	2.0
Annual Natural Gas Savings (Therms/yr)	17.6	40.85	43.9	27.7
Peak Demand Reduction (W)	0.08	0.41	0.45	0.2
Annual Life Cycle Energy Cost Savings (kBTU/yr)	17.1	46.94	50.2	25.3
Annual Source Energy Savings (kBTU/yr)	17.6	43.97	47.3	27.9
Benefit to Cost Ratio	1.11	3.03	3.25	1.64

Key Assumptions:

- 4 Pipe VAV
- Cooling and heating happen at terminal units
- Total building square footage: 17,876

Incremental Cost: Reheat Limitation (4-pipe VAV)

4-Pipe VAV was priced by contractors as an add alternate on two recent lab projects.
The base design was 2-pipe VAV reheat.

Project San Francisco (150,000 ft2)

Changes from baseline (2-pipe) to proposed case (4-pipe) include the following (blue make the proposed case less expensive, red make the proposed case more expensive)

- Chillers downsized from (2) 210 ton to (2) 185 ton chillers
- Downsized CHW pumps from 2 @ 255 gpm to 2 @ 230 gpm
- AHU coil reduced from 8 rows to 4 rows (because no cooling needed at AHU)
- Eliminated CHW piping to AHU
- Downsized HW piping, including mains, risers, taps on each floor
- Added CHW piping to zones
- Increased zone coils from 2-row to 8-row
- Added condensate drain pans to zone coils and condensate drain lines from drain pans to nearest discharge location
- Converted zone valves from 2-way HW valves to 6-way changeover valves.

HVAC Removed Equipment/Installations	$	(1,537,800)
HVAC Added Equipment/Installations	$	2,291,300
Electrical Removed Equipment/Installations	$	(88,300)
Electrical Added Equipment/Installations	$	88,300
Plumbing Removed Equipment/Installations		0
zones		245
condensate piping per zone	$	3,027
Plumbing Added Equipment/Installations	$	741,615
reduction in boiler capacity (btuh)		1,000,000
boiler cost/btuh	$	0.04
add back boiler reduction ($)	$	40,000
subtotal 2019	$	1,535,115
avg annual inflation since 2019		5%
subtotal 2023	$	1,865,942
building area (ft2)		154,975
incremental cost/ft2	$	12.04
incremental maint ($/yr)	$	-
maint NPV multiplier		19.6
NPV maintenance	$	-
incremental cost/ft2	$	12.04

Incremental Cost: Reheat Limitation (4-pipe VAV)

4-Pipe VAV was priced by contractors as an add alternate on two recent lab projects.
The base design was 2-pipe VAV reheat.

Project Pleasanton

- 100,000 ft2 office/lab building with 50,000 ft2 of lab spaces
- Separate systems for lab spaces
- Mechanical service contractors indicated there are no incremental maintenance and replacement costs for 4-pipe VAV vs 2-pipe VAV

	2pVAV (current)	4pVAV	total incr. cost
CH-1 tons	165	145	$ (36,967)
CH-2 tons	191	168	$ (42,792)
CHWP-1 gpm	210	185	$ (2,844)
CHWP-2 gpm	210	185	$ (2,844)
delete cooling coil from AHU-1			$ (80,000)
reduce AHU-1 supply fan array from 5.25" TSP to 4.75"			$ (24,114)
delete CHW piping to AHU-1			$ (36,000)
HWP-1 gpm	91	60	$ (3,499)
HWP-2 gpm	91	60	$ (3,499)
downsize HW distribution piping			$ (6,228)
Add CHW piping risers			$ 74,000
Add CHW piping to 5th Floor zones			$ 144,600
CHW piping to 3 floors of zones			$ 433,800
unit price to increase zone coils from 2-row to 8-row			$ 2,020
unit price for condensate pan and condensate drain piping per zone			$ 2,500
option 1: unit price to convert 2-way reheat valves to 6-way valves			$ 3,750
option 2: unit price to upgrade from (1) coil/box to (2) coil/box, with a			$ 2,800
zone costs			$ 527,019
unit price for condensate pump, incl monitoring of high water switch			$ 800
condensate pumps			$ 28,800
NPV annual maint $/ft2			$ -
total cost			$ 824,834
total cost/ft2			$ 16.29

Preliminary Energy Savings Estimates Per sf ACH Setbacks

Climate Zone	CZ2	CZ6	CZ7	CZ12
Annual Electricity Savings (kWh/yr)	-0.16	0.23	0.27	0.07
Annual Natural Gas Savings (Therms/yr)	36.7	24.72	24.5	32.8
Peak Demand Reduction (W)	0	0.07	0.07	0.03
Annual Life Cycle Energy Savings (kBTU/yr)	19.7	15.79	15.9	19.6
Annual Source Energy Savings (kBTU/yr)	33.2	23.25	23	30.1
Benefit To Cost Ratio	19.7	15.8	15.8	19.6

Key Assumptions:

- Setback to 4 ACH from 6 PM to 7 AM
- Total building square footage: 17,876

Incremental Cost: ACH Setbacks

The cost of implementing air change setbacks in labs is relatively low. The estimated $1 per square foot cost is based on communications with Bay Area controls contractors and commissioning agents. The only additional costs are some programming of the building automation system and commissioning to verify that the setback is working correctly, based on $1000 per zone and 1,000 square feet per zone

Preliminary Energy Savings Estimates Per sf Exhaust Fan Control

Climate Zone	All
Annual Electricity Savings (kWh/yr)	1.7
Annual Natural Gas Savings (Therms/yr)	-
Peak Demand Reduction (W)	0.2
Annual Life Cycle Energy Cost Savings (kBTU/yr)	8.7
Annual Source Energy Savings (kBTU/yr)	0.8

Incremental Cost: Fan Control

Incremental cost not required. This is not a new requirement. It is a new optional compliance path that has lower energy use than other compliance paths. Therefore, incremental cost and cost-effectiveness analysis is not required.

Statewide Impacts

Methodology and Assumptions

- Statewide Energy Impacts Methodology and Results

Statewide Economic Impacts Methodology

The Statewide CASE Team estimates annual statewide impacts by multiplying **A x B x C**:

A. per-unit energy impacts (discussed in previous section)
B. number of units of new construction/additions/alterations of each applicable building type
C. portion of affected units in each climate zone

Example:

Per Unit Impacts

Savings type	**Savings** per square foot
Electricity	[X] kWh
Peak demand	[X] Watts
Natural gas	[X] Therms
GHG emissions	[X] Tons CO_2e

×

Affected New Construction

Climate Zone	**Large Office** sq ft	**Assembly** sq ft
1	100	20
2	1,000	1,500
…		
16	5,000	3,000

=

Statewide Energy Impacts

Climate Zone	**Elec Savings** (GWh)	…	**GHG savings** (MT CO_2e)
1	20		1,500
2	50		3,000
…			
16	100		2,000

2026 Construction Forecast

Construction Forecast Building Type		Newly Constructed Floorspace Impacted (%)	Existing Floorspace Impacted (%)
Residential	SF500	100%	100%
	SF2100	100%	100%
	SF2700	100%	100%
	Low-rise Garden	100%	100%
	Loaded Corridor	100%	100%
	High-rise Multifamily	100%	100%
	Mid-rise Multifamily	100%	100%
Nonresidential	Large Office	100%	100%
	Medium Office	100%	100%
	Small Office	100%	100%
	Large Retail	100%	100%
	Medium Retail	100%	100%
	Strip Mall	100%	100%
	Mixed-use Retail	100%	100%
	Large School	100%	100%
	Small School	100%	100%
	Non-refrigerated Warehouse	100%	100%
	Hotel	100%	100%
	Assembly	100%	100%
	Hospital	100%	100%
	Laboratory	100%	100%
	Restaurant	100%	100%
	Enclosed Parking Garage	100%	100%
	Open Parking Garage	100%	100%
	Grocery	100%	100%
	Refrigerated Warehouse	100%	100%
	Controlled-environment Horticulture	100%	100%
	Vehicle Service	100%	100%
	Manufacturing	100%	100%
	Unassigned	100%	100%

Poll

Do you have any questions?

Do you have any objections?

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the GoTo Webinar Questions Pane
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by May 25. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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