

Round
2

Welcome to the California Statewide Codes and Standards Enhancement (CASE)
Team's Stakeholder Meeting on

**Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC
Controls (Air Efficiency, DOAS) Proposals**

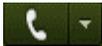
We will begin shortly.

In the meantime, please fill out the polls below.



Welcome: Connect Your Audio

Audio – there are **three** options for connecting to the meeting audio:

To view options, click on the  icon on the top ribbon, then select *Connect My Audio*.

- 1 Dial-out:** receive a call from the meeting. *Please note this feature requires a direct line.*
- 2 Dial-in:** dial-in to the conference via phone. Conference phone number and room number code provided. *Please then identify your line by entering your unique user ID on your phone.*
- 3** Use the **microphone** from your computer/device.



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Using Microphone (Computer/Device)

Join Listen Only

Above: audio conference settings pop-up box

2022 TITLE 24 CODE CYCLE, PART 6

Second Utility-Sponsored Stakeholder Meeting

Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)

Statewide CASE Team

April 14, 2020

Meeting Guidelines

Part 1 of 4 - Muting

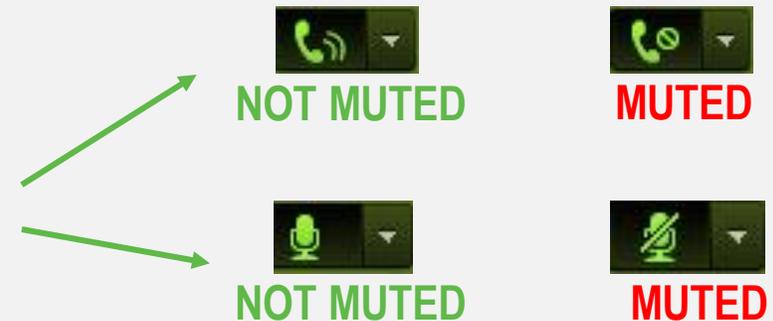
Muting Guidelines:

To keep meetings running smoothly, all participants will be **muted upon entry**.

Please wait for instructions and/or permission to unmute yourself during designated Q&A periods, when participant lines are open.

Two Options to Mute:

- 1 **Manually** mute your device, or;
- 2 Mute your phone or microphone **icon** in the top ribbon of the Adobe Connect window.



Meeting Guidelines

Part 2 of 4 - Pairing

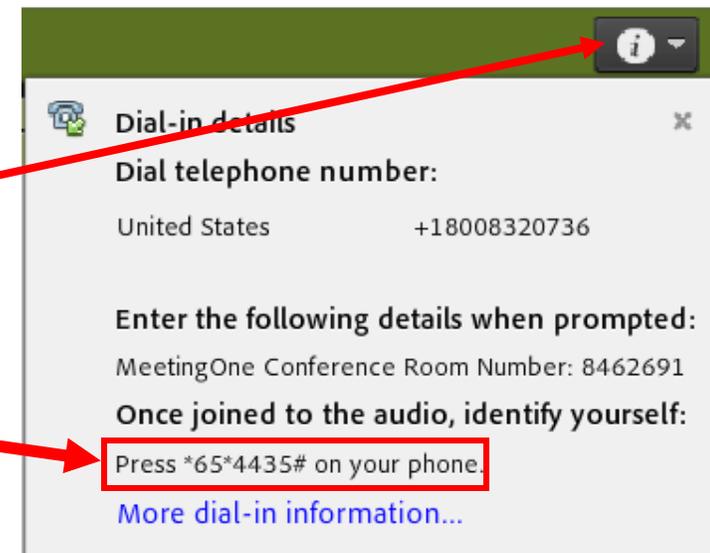
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- Please keep yourself [MUTED](#).
- Navigate to the (i) button in the top right of your screen.
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Steps to Pair Line:

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- 2 Identify your line using your unique code.



Meeting Guidelines

Part 3 of 4 - Participation

Participation Guidelines:

- **Questions & Comments**

- Click **“Raise Hand”** if you would like to speak. Those with a hand raised will be called on by the speaker.
- The Title 24 Advocacy team will then **unmute** your line, enabling others to hear your audio.
- All questions and comments are also welcome via the chat window.

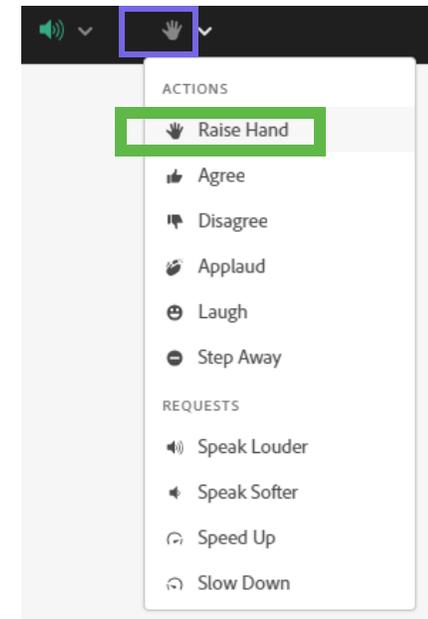
- **Other Meeting Feedback**

- Provide live meeting feedback from the **top toolbar drop-down**.



Above: feedback view for Adobe Connect [app users](#).

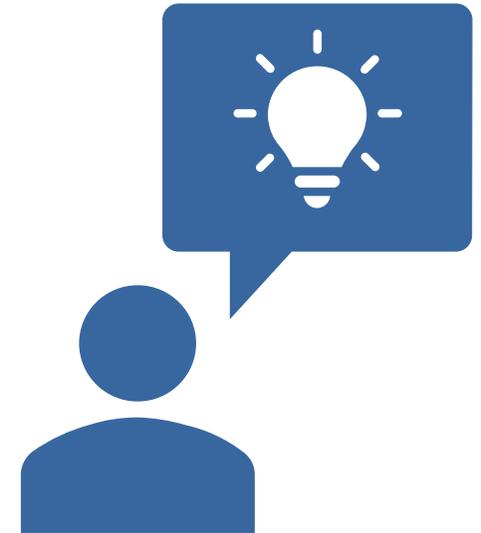
Below: feedback view for [HTML users](#).



Meeting Guidelines

Part 4 of 4 – Discussion Ground Rules

- **We want to hear your thoughts.**
 - Supporting and opposing viewpoints are welcome.
- **When making comments, please:**
 1. Raise your hand; you will be unmuted and called on;
 2. Clearly state your name and affiliation prior to speaking; and
 3. Place yourself back on mute when done speaking.
- **Calls are recorded** for note development, recordings will not be publicized.
- Notes and presentation material will be posted on Title24Stakeholders.com/events.



Agenda

1	Meeting Guidelines	<i>8:30 am</i>
2	Opening Remarks from the California Energy Commission	<i>8:35 am</i>
3	Overview & Welcome from the Statewide Utility Team	<i>8:40 am</i>
4	Presentation I: HVAC Controls	<i>8:45 am</i>
5	Presentation II: Reduced Infiltration	<i>9:50 am</i>
6	Wrap Up & Closing	<i>10:45 am</i>

Opening Remarks: California Energy Commission





Policy Drivers: Building Standards

The following policy documents establish the goal for new building standards:

- **2008 CPUC/CEC Energy Action Plan** – ZNE for residential buildings by 2020 and nonresidential buildings by 2030
- **SB 100** – Clean electricity by 2045
- **B-55-18** – Governor Jerry Brown’s Executive Order to achieve carbon neutrality
- **AB 3232** – Assess the potential for the state to reduce the emissions of greenhouse gases from the state’s residential and commercial building stock by at least 40 percent below 1990 levels by January 1, 2030

2022 Updated Standards Schedule



Estimated Date	ACTIVITY OR MILESTONE
November 2018 – November 2019	Updated Weather Data Files
November 2018 – December 2019	Metric Development
November 2018 - July 2019	Measures Identified and Approved
April 24, 2019	Present the Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data Workshop
August 2019 – November 2019	First Round of Utility-Sponsored Stakeholder Workshops
January 2020	Research Version of CBECC Available with new weather data files and updated metric
March 2020 – April 2020	Second Round of Utility-Sponsored Stakeholder Workshops
March 10, 2020	Staff Workshop on the proposed changes for the ATTCP program
March 26, 2020	Staff Workshop on the EDR1
March 2020 – May 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
July 2020 – August 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
August 2020 – October 2020	Commission-Sponsored Staff Workshops
September 2020 – November 2020	Express Terms Developed (including New Multifamily Section)
February 2021	45-Day Language posted and sent to list serve, Start of 45-Day review/comment period
March 2021	Lead Commissioner Hearing
July 2021	Adoption of 2022 Standards at Business Meeting
September 2021	Final Statement of Reasons Drafted and Approved
July 2021	Adoption of CALGreen (energy provisions) - Business Meeting
December 2021	Approval of the Manuals
October 2021	Final Rulemaking Package delivered to CBSC
December 2021	CBSC Approval Hearing
January 2021	Software, Compliance Manuals, Electronic Documents Available to Industry
January 1, 2023	Effective Date

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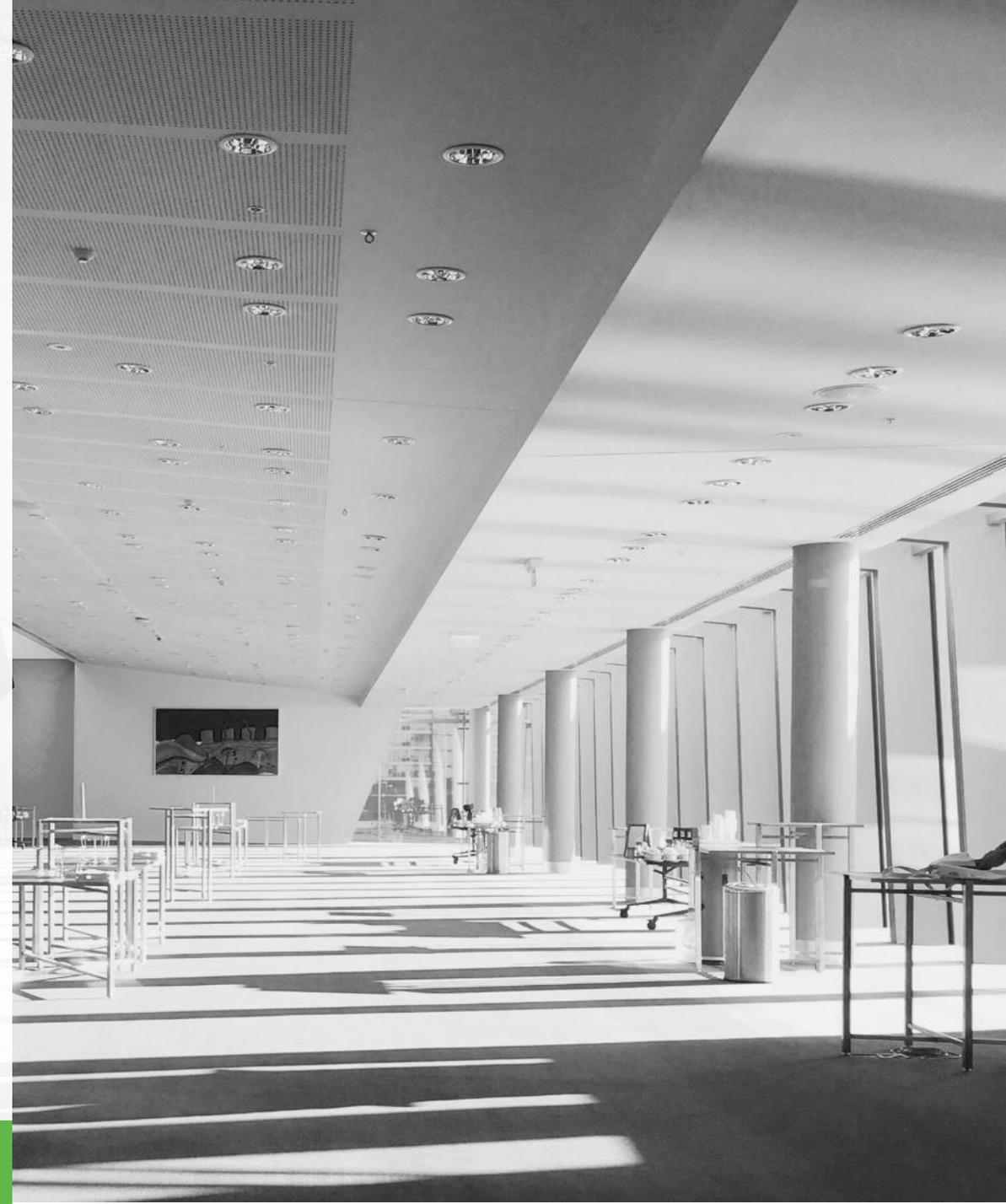


More information on pre-rulemaking for the 2022 Energy Code at:

<https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency>

Title 24, Part 6 Overview

Kelly Cunningham
Codes and Standards
Pacific Gas & Electric



Statewide Utility Codes and Standards Team

Actively support the California Energy Commission in developing proposed changes to the Energy Code (Title 24, Part 6) to achieve significant statewide energy use reductions through the development of code change proposals for the 2022 cycle that are:

Feasible | Cost effective | Enforceable | Non-proprietary



Utility-Sponsored Stakeholder Meetings

- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- **Sign up** to receive email notifications



Stay Informed

Receive email notifications about upcoming meetings, notes and presentations from past meetings, and announcements about the California Energy Commission's rulemaking process.

Sign Up

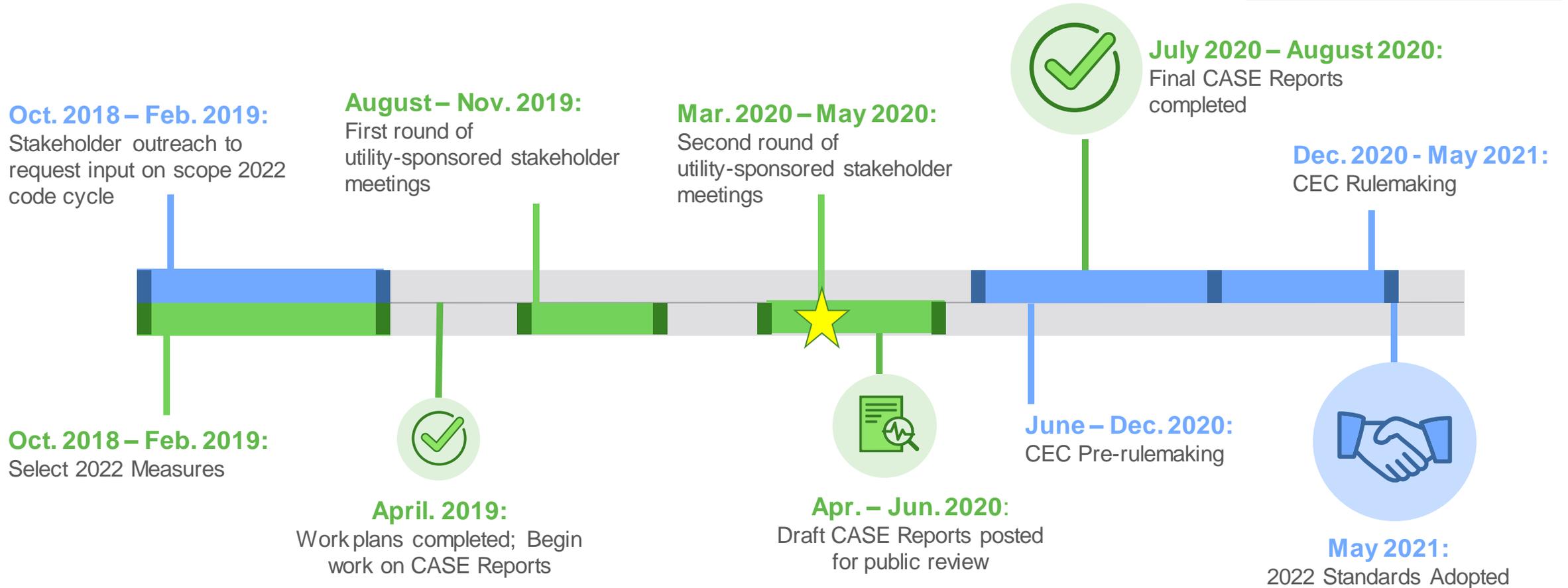
Second Round Utility-Sponsored Stakeholder Meetings

Meeting Topic	Building Type	Date
<i>Lighting</i>	<i>NR/MF</i>	<i>Tuesday, March 3, 2020</i>
<i>Single Family Whole Building</i>	<i>SF</i>	<i>Thursday, March 5, 2020</i>
<i>Nonresidential and Single Family HVAC Part 1: Data Centers, Boilers, Air Distribution, Variable Capacity</i>	<i>NR/SF</i>	<i>Thursday, March 12, 2020</i>
<i>Water Heating and Multifamily All Electric Package</i>	<i>MF</i>	<i>Tuesday, March 17, 2020</i>
<i>Single Family Grid Integration</i>	<i>SF</i>	<i>Thursday, March 19, 2020</i>
<i>Multifamily HVAC and Envelope</i>	<i>MF</i>	<i>Wednesday, March 25, 2020</i>
<i>Covered Processes Part 1: Refrigeration System Opportunities</i>	<i>NR</i>	<i>Thursday, April 2, 2020</i>
Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)	NR	Tuesday, April 14, 2020
<i>Covered Processes Part 2: Controlled Environmental Horticulture</i>	<i>NR</i>	<i>Thursday, April 16, 2020</i>
<i>Nonresidential Envelope Part 1: High Performance Envelope</i>	<i>NR</i>	<i>Thursday, April 23, 2020</i>
<i>Multifamily Restructuring</i>	<i>MF</i>	<i>Thursday, May 7, 2020</i>

Sign up for all meetings at title24stakeholders.com/events/

2022 Code Cycle – Key Milestones

- CEC Milestone
- Utility Team Milestone





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Learn how to comply with California's building and appliance energy efficiency standards

www.EnergyCodeAce.com

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to help you decode Title 24, Part 6 and Title 20



This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities Commission.

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The **Codes and Standards Reach Codes Program** provides technical support to local jurisdictions considering adopting a local energy and efficiency ordinance

www.LocalEnergyCodes.com

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Thank You

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Meeting Guidelines Reminder

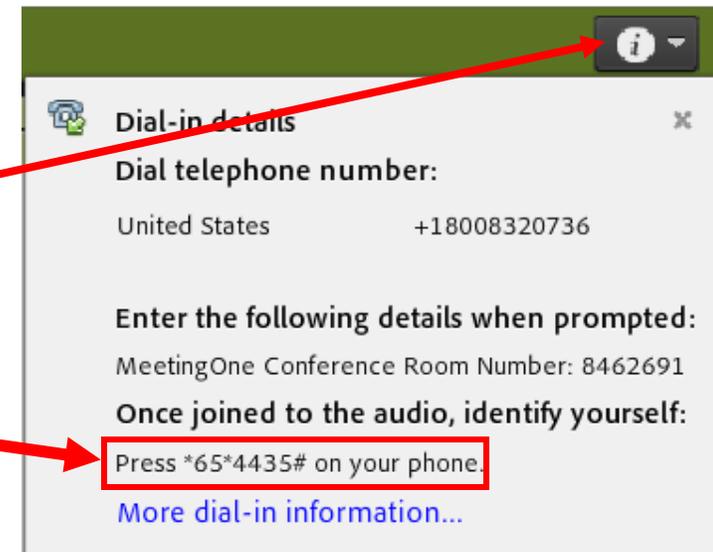
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2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

HVAC Controls

Codes and Standards Enhancement (CASE) Proposal
Nonresidential | HVAC Controls

Tim Minezaki, *Energy Solutions*
Neil Bulger, *Red Car Analytics*
April 14, 2020

Agenda

1 Today's Objectives

2 Proposal Background

3 Summary of Changes

4 Cost and Energy Calculations

5 Questions and Next Steps



Proposal Background



Code Change Proposal Summary

Measure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Dedicated Outdoor Air Systems (five submeasures)	Prescriptive	Y	Section 140.4 (new sections)	CEC-NRCC-MCH-E CEC-NRCA-MCH-02 CEC-NRCA-MCH-06
Exhaust Air Heat Recovery	Prescriptive	Y	Section 140.4 (new section)	CEC-NRCC-MCH-E
VAV Deadband Airflow	Prescriptive	Y	Section 140.4(d)	CEC-NRCC-MCH-E
Expand Economizer Requirements (three submeasures)	Prescriptive	Y	Section 140.4(e)	CEC-NRCC-MCH-E

Description of Changes

- DOAS:
 - Expanded to all system capacities
 - Added Economizer Exception
- Expand Economizer Requirements:
 - Adjusted Economizer Requirements
 - Added ASHRAE clean-up language
 - Dropped two submeasures

Code Change Proposal: Additional Resources

First-Utility Sponsored Meeting

The Statewide CASE Team held its first utility-sponsored stakeholder meeting for this topic on **October 15, 2019 (VAV Deadband Airflow & DOAS)** and **November 5, 2019 (Expand Economizer Requirements)**



Resources on Title24stakeholders.com

Presentation slides and **Submeasure summary** documents available that cover the following ([link](#)):

- ✓ Measure Background
- ✓ Market Overview & Analysis
- ✓ Technical Feasibility
- ✓ Compliance & Enforcement
- ✓ Draft Code Language

Also available in the **resources tab** in today's presentation.



**Submeasure A: Dedicated Outdoor Air
Systems (DOAS)**

Submeasure B: Exhaust Air Heat
Recovery

Submeasure C: VAV Deadband Airflow

Submeasure D: Expand Economizer
Requirements

Today's Objectives

The focus of today's meeting includes:

1. **Present** Technical Feasibility
2. **Review** Energy and Cost Calculations
3. **Review** Preliminary Market Analysis
4. **Review** Draft Economizer Exception Analysis

Code Change Proposal Summary

Measure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Dedicated Outdoor Air Systems (DOAS) (five submeasures)	Prescriptive	Y	Section 100.1 Section 120.1 Section 140.4 (e) Section 140.4 (p) (new sections)	CEC-NRCC-MCH-E CEC-NRCA-MCH-02 CEC-NRCA-MCH-06

Measure Overview

- Prescriptive efficiency measures for DOAS, which covers Outside Air (OA) units, Heat Recover Ventilators (HRV), Energy Recovery Ventilators (ERV), Direct Expansion DOAS (DX-DOAS), etc if 100 percent only OA.

Description of Changes

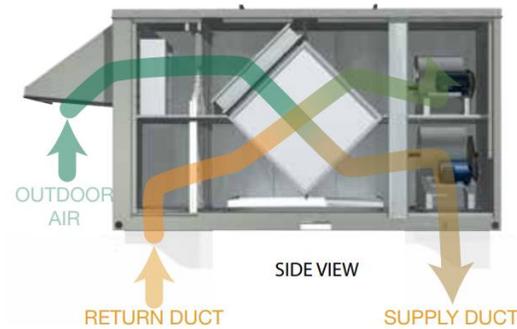
- Reduced Demand Control Ventilation (DCV) and Occupancy Shut Off Limits to 1,000 cubic feet per minute (cfm) for any DOAS units.
- Expanded to all system capacities of DOAS units. Previously only units > 3,000 cfm.
- Added Economizer Exception for cooling systems with DOAS that increases design ventilation by 50%, includes heat recovery, and can control to bypass heat recovery to provide free cooling.

Common Definition for Dedicated Outdoor Air System

Dedicated Outdoor Air Systems (DOAS) would include **any** system designed to supply 100 percent outdoor air that could be one of the following:



*Directly ducted air
outdoor air or
Filtered Only air*



*Heat Recovery
Ventilators*



*Energy Recovery
Ventilators*



*DX-DOAS or
Custom DOAS*

Prescriptive Efficiency Elements for DOAS

1. Ventilation energy recovery and increased airflow capacity capabilities.
 - A. 60% sensible energy recovery ratio.
 - B. 150 percent of outdoor ventilation airflow required.
 - C. Bypass or free cooling controls.
 - D. Meet all control requirements for spaces with DCV or occupancy controls.
2. DOAS unit capable of modulating fan speed control.
3. DOAS unit under 5hp not to exceed 1.0 W/cfm fan power.
4. Space terminal unit fans for cooling and heating to cycle to off.
5. Limit DX-DOAS reheat temperature to 60F when in cooling mode.

EXCEPTION for systems without heat recovery, like many DX-DOAS units:

Where comfort cooling systems serving same spaces meets 140.4 (e) Economizers.

Prescriptive Efficiency Elements for DOAS

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EXCEPTION for zone units which supply ventilation air:

Require multi-speed fans and can reduce fan power.

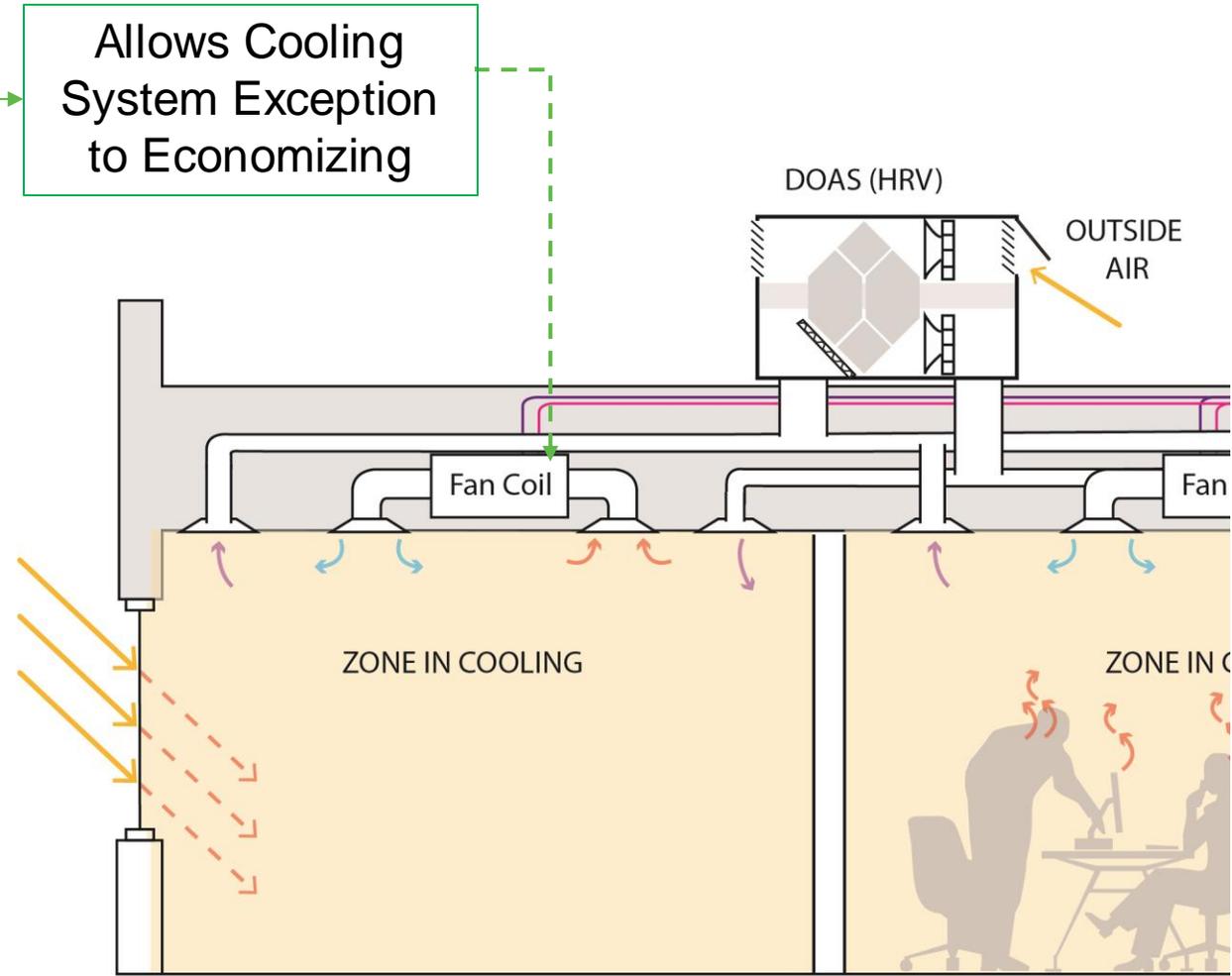
Additional Exception for Space Cooling Air Economizer

- Applies to cooling systems serving the same spaces as the DOAS unit.
 - Only allowed for buildings less than 150,000 sf or 5 stories, which use typically use air-cooled compressor systems.
 - Only allowed in all climate zones.
 - DOAS would need to be 150% of ventilation for all spaces at all times.
1. DOAS above 1,000 cfm to modulate flow for DCV and Occupancy Shut-off spaces.



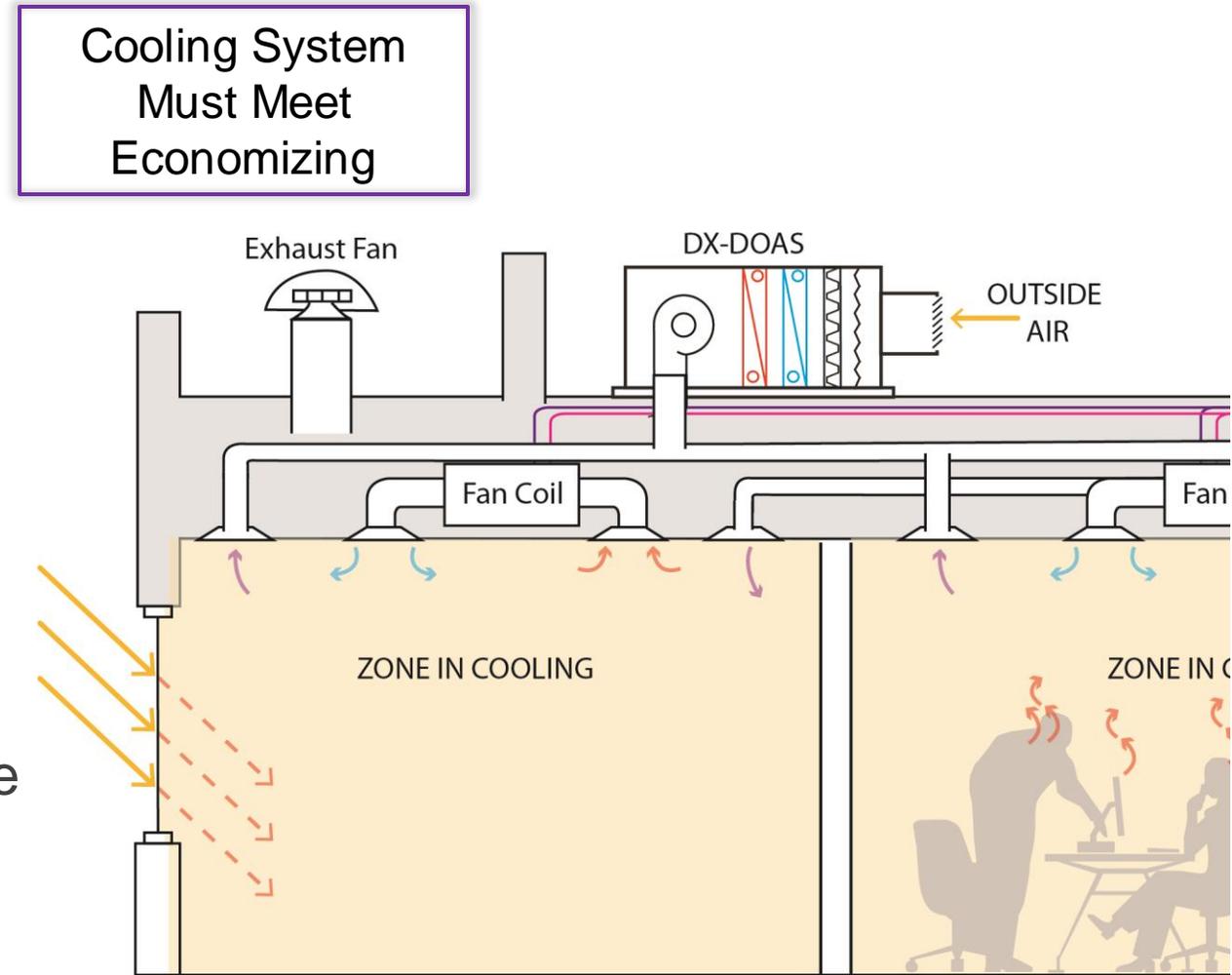
Example of DOAS With Heat Recovery

1. Ventilation heat recovery with free-cooling bypass capabilities, designed to provide 150% OA.
2. DOAS unit fan with modulating capabilities.
3. DOAS unit fans below 5 hp, have a maximum 1 W/cfm, for all others must meet prescriptive power limits.
4. Terminal unit heating/cooling fans cycle to off.
5. Limits reheat supply air to 60F with active DX-DOAS cooling.



Example of DOAS Without Heat Recovery

- ~~1. Ventilation heat recovery with free-cooling bypass capabilities, designed to provide 150% OA.~~
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DOAS in Existing Energy Codes

Energy Codes Outside California	Summary of DOAS Requirements
Washington State Energy Code	Sets DOAS as the primary prescriptive pathway for nonresidential buildings with detailed criteria on DOAS unit and H/C system controls.
IECC 2018 Energy Code	Includes DOAS as an enhanced energy efficiency credit in a list of additional efficiency packages to be selected. The code stipulates what type of DOAS unit and controls this would include.
ASHRAE 90.1 2019	Sets efficiency criteria on components only and does not specify DOAS as a prescriptive section explicitly. <ul style="list-style-type: none">• General fan power requirement• Supply air reset controls for units with dehumidification• Requirements on exhaust air heat recovery

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
 - Incremental costs
 - Maintenance costs
 - Energy cost savings
- Cost-effectiveness



Methodology for Energy Impacts Analysis

- DOAS savings evaluated based on market typical DOAS configurations since the system is not currently regulated in Title 24.

Tools Used	EnergyPlus 9.01, CBECC-Com
Building Prototypes Used	Small Office, Medium Office, Primary School, Secondary School, Retail Stand Alone, Retail Large, Hotel Small
Climate Zones Modeled	Each Climate Zone, 1 through 16
DOAS Configurations	Applied to select prototypes based on size and function. DOAS types: DX-DOAS, HRV, HP-DOAS Cooling: VRF, FPFC, Mini Splits, RTU

Definition of Market Reference and Proposed Conditions



Market Reference Conditions

- No ventilation heat recovery
- Zone cooling and heating fans run when occupied
- DX-DOAS reheats to neutral Supply Air Temperature (SAT), 65F.
- HRV assume neutral SAT.



Proposed Conditions

- Sensible ventilation heat recovery with bypass controls.
- Zone cooling and heating fans cycle off and on
- DX-DOAS reheats to 60F.
- HRV assume neutral SAT.

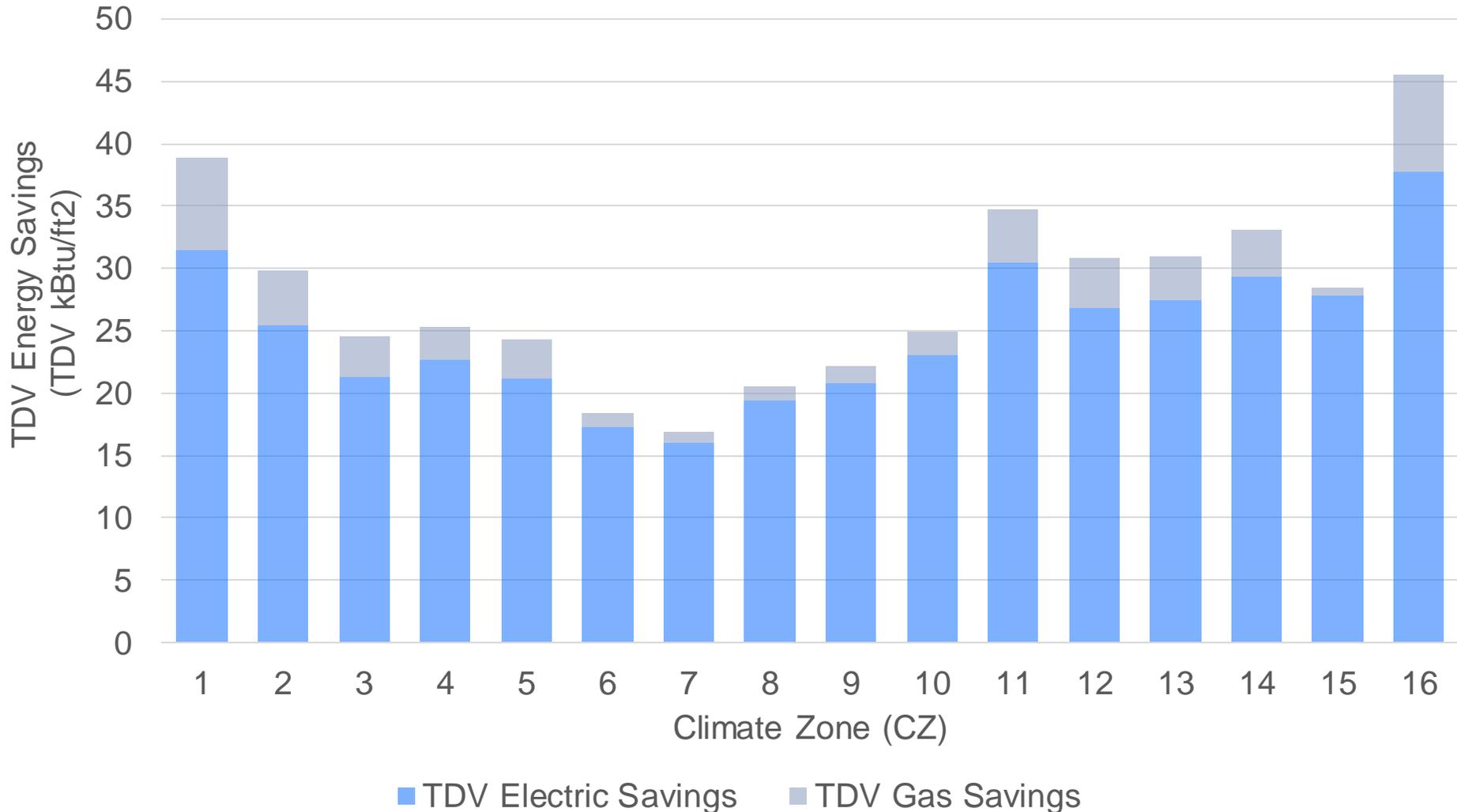
2023 Construction Forecast: New & Existing Buildings

Building Type	Total Statewide New Construction Permitted in 2023 (million sf)	Percent of Sector Impacted by Proposal	Total Statewide Existing Stock in 2023 (million sf)	Percent of Sector Impacted by Proposal	Statewide Impacted by Proposal in 2023
Small Office	10.4	15.0%	476.5	0.15%	2.3
Large Office	36.3	7.5%	1,665.4	0.08%	4.0
Restaurant	5.4	0.0%	238.9	0.00%	0.0
Retail	31.8	11.9%	1,490.5	0.17%	6.3
Grocery Store	8.4	0.0%	394.2	0.00%	0.0
Non-refrigerated Warehouse	30.0	0.0%	1,402.3	0.00%	0.0
Refrigerated Warehouse	1.6	0.0%	75.6	0.00%	0.0
Schools	12.4	18.0%	725.0	0.30%	4.4
Colleges	6.5	12.7%	380.0	0.20%	1.6
Hospitals	9.3	0.0%	488.7	0.00%	0.0
Hotel / Motel	10.7	17.0%	451.8	0.30%	3.2
Total	162.8		7,789.0		21.7

- New construction was based on market data from 2010-2020 permits; 15% office, 14% retail, 18% schools.
- Alterations based on same market data from 2010-2020 permits; 3% office, 4% retail, 6% school. Applied whole market 5% estimate to buildings which annually renovate systems. EXAMPLE: Small offices = 5% x 3% = 0.15%

Energy Savings Results: Small Office in all Climate Zones

First Year TDV Energy Savings (kBTU/ft²)



Small Office Prototype:

Three DOAS Configurations

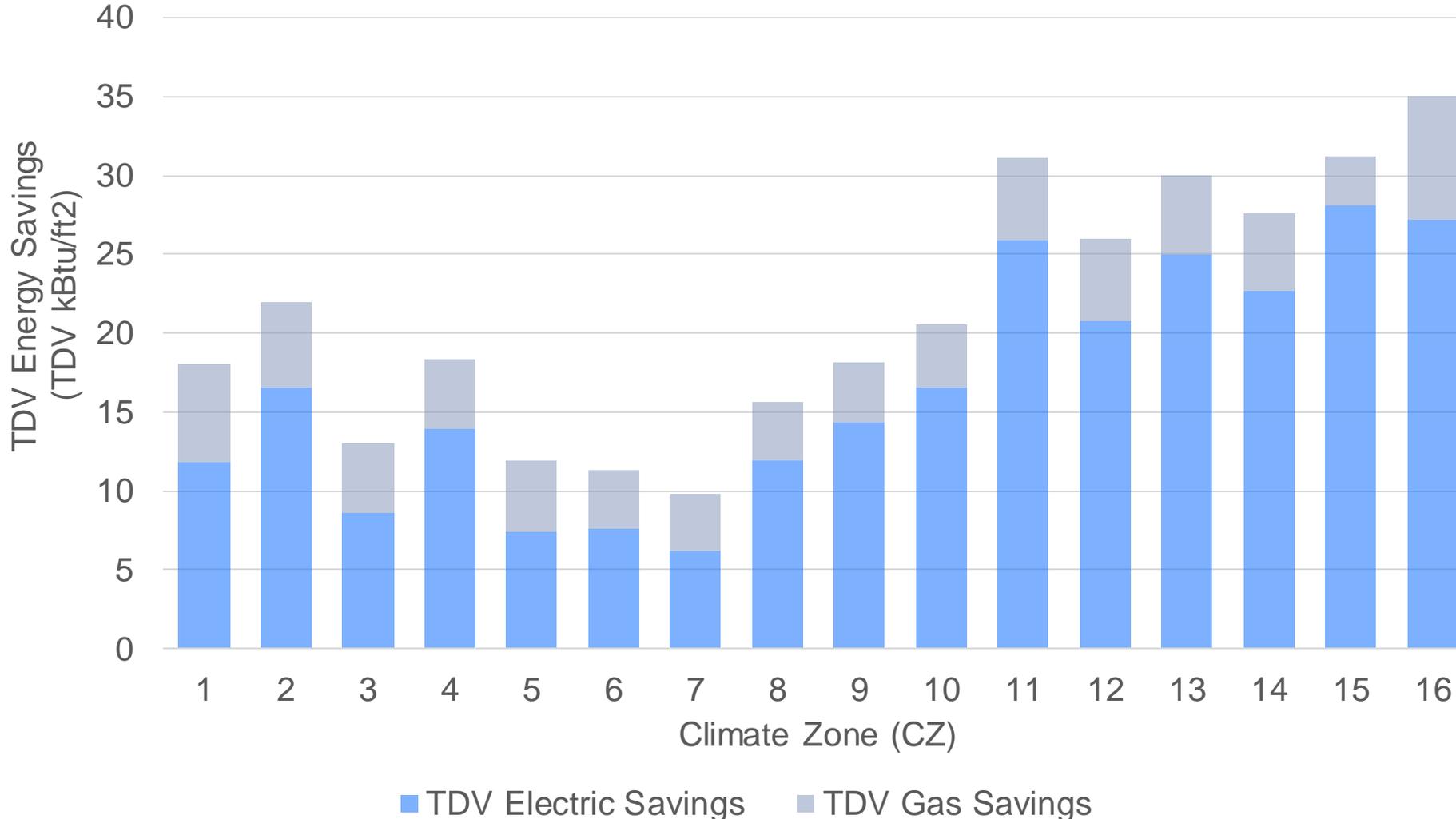
- 1 HRV with Zone Mini-Splits
- 1 HRV with Zone RTU/Gas
- 1 HRV with Zone VRF

Market Reference Configurations

- No Heat Recovery
- Zone Fans On when Occupied

Energy Savings Results: Secondary School in all Climate Zones

First Year TDV Energy Savings (kBTU/ft²)



Secondary School Prototype:

Two DOAS Configurations

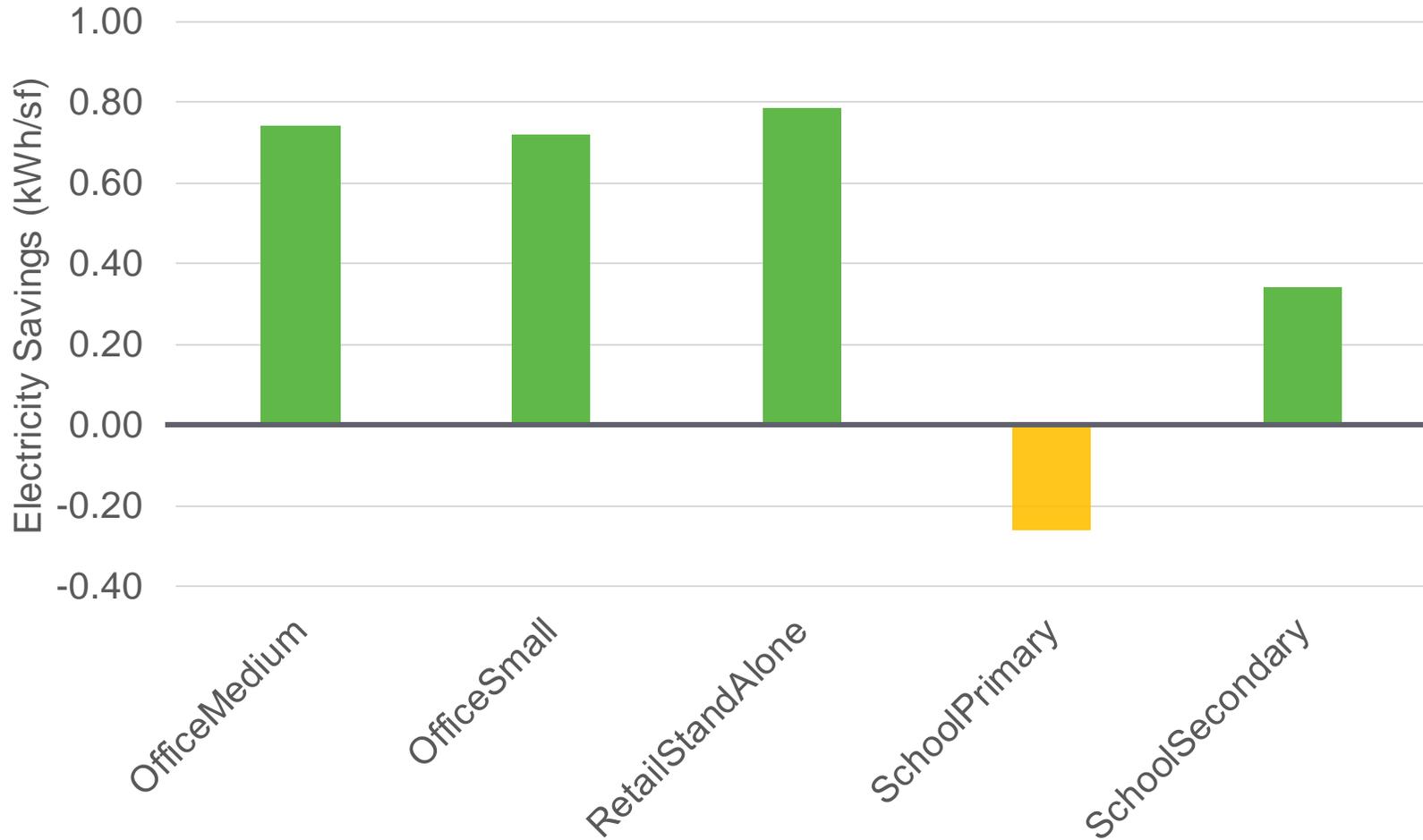
- 2 DX-DOAS with VRF
- 2 HP-DOAS with VRF
- VRF found to be most conservative system in energy use.
- Commonly utilized in market for DOAS in schools.

Market Reference Configurations

- No Heat Recovery
- Zone Fans On when Occupied

Energy Savings Results: All Building Types, Climate Zone 4

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 4

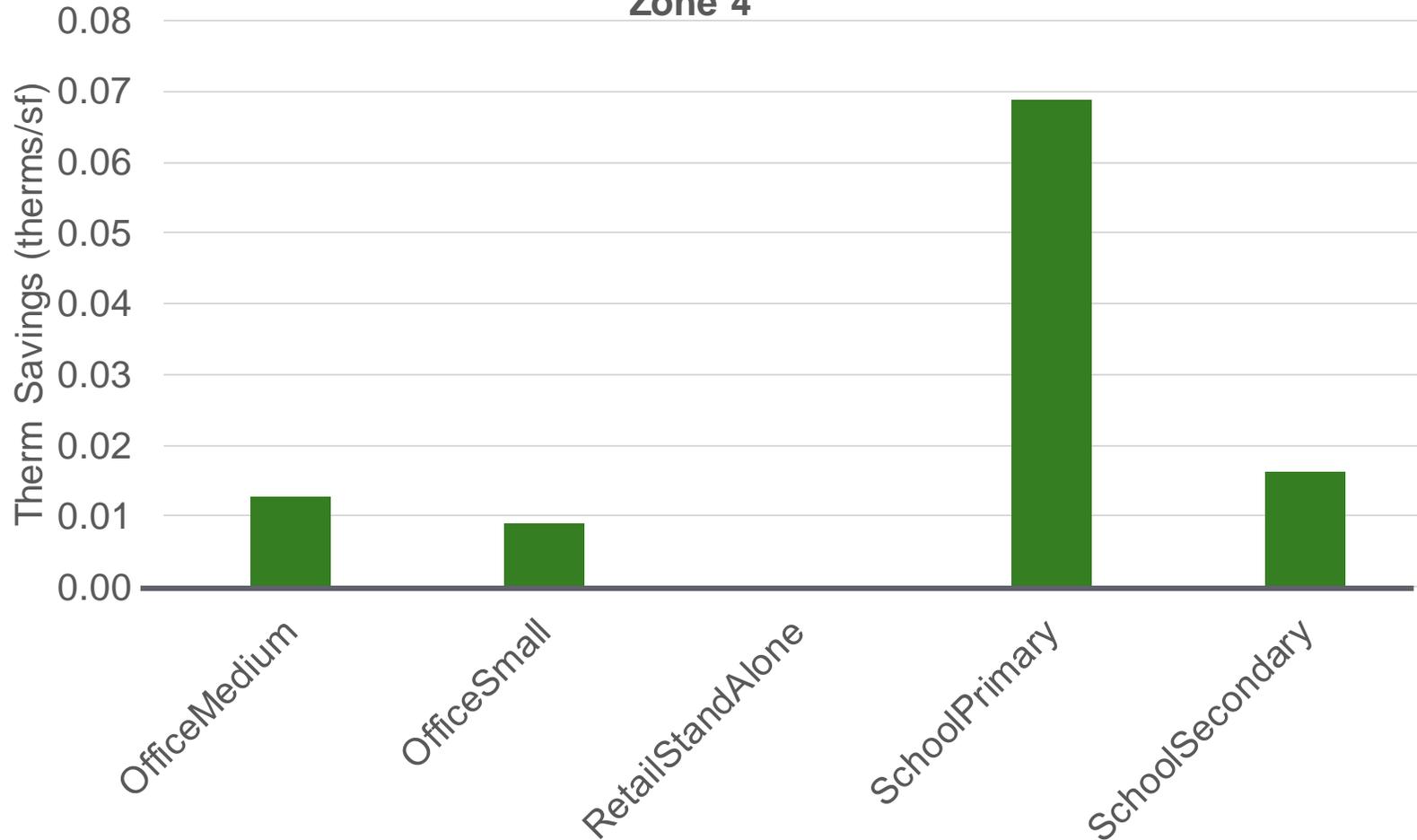


0.78
kWh/sf
Retail

-0.26
kWh/sf
School Primary from
increased fan pressure
drop of heat recovery

Energy Savings Results: All Building Types, Climate Zone 4

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 4



0.07
therms/sf
School Primary

Incremental Cost Assumptions

Incremental Cost Item	Assumptions	Normalized Cost
Bypass or free cooling controls with energy recovery DOAS units.	<p>Eight product cost estimates were normalized to \$7.4/cfm for the DOAS unit.</p> <p>An additional 15% assumed.</p>	<p>\$1.11/cfm</p> <p>Scaled based on building cfm/sf</p>
Modulating fan speed controls.	<p>ECM cost study data, for 5 hp system +\$918.</p> <p>Data scaled to \$/hp and then to \$/cfm based on standard pressures for DOAS.</p>	<p>\$0.039/cfm</p> <p>Scaled based on building cfm/sf</p>
Additional duct work or duct configurations to enable terminal unit fans to cycle off.	<p>Cost estimates of system installations, ventilation duct work \$0.7/sf, zone duct work \$7.0/sf. Assumed 50% increase in ventilation duct work.</p>	<p>\$0.35/sf</p>
Total	(Schools for Example)	\$0.57/sf

Poll

Do you agree with these **incremental costs**?

- A. They seem too low.
- B. They should be increased some.
- C. They seem reasonable.
- D. They are too high.

Construction Forecast Assumptions

Prototype	Percent of New Construction
Office	15%
Schools	18%
Hotel/Motel	17%
Retail	14%

Prototype	Percent of Alterations
Office	3%
Schools	6%
Hotel/Motel	6%
Retail	4%

6.1% of New Construction based on building types assumed.

Assuming only 5% of Existing Buildings undergo an alteration.

0.11% of Existing Buildings.

Draft report includes only those prototypes simulated and their associated construction types. Office small, office medium, retail stand alone, retail large, hotel small,

Market growth based on online construction database of projects with DOAS from 2012 to 2020, applied to statewide construction forecast for only those building types simulated.

Poll

Do you agree with this forecast for DOAS buildings?

- A. They seem too low.
- B. They seem reasonable, slightly low.
- C. They seem reasonable.
- D. They are too high.

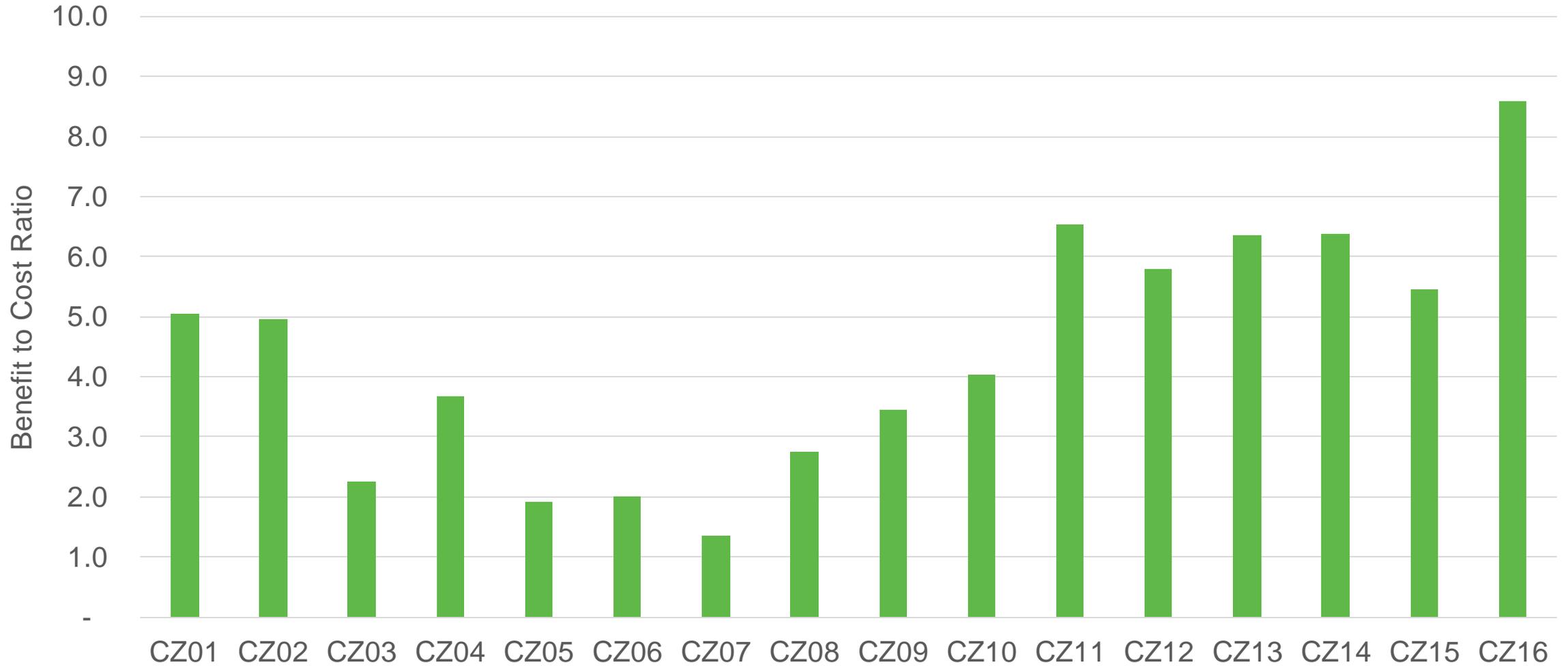
Statewide Energy Savings

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/ yr)	TDV Energy Savings (TDV kBtu/yr)
New Construction	5.0	2.2	0.13	200.2
Additions and Alterations	4.1	1.8	0.13	172.5
Total	9.1	4.0	0.26	372.6

Source: Statewide CASE Team

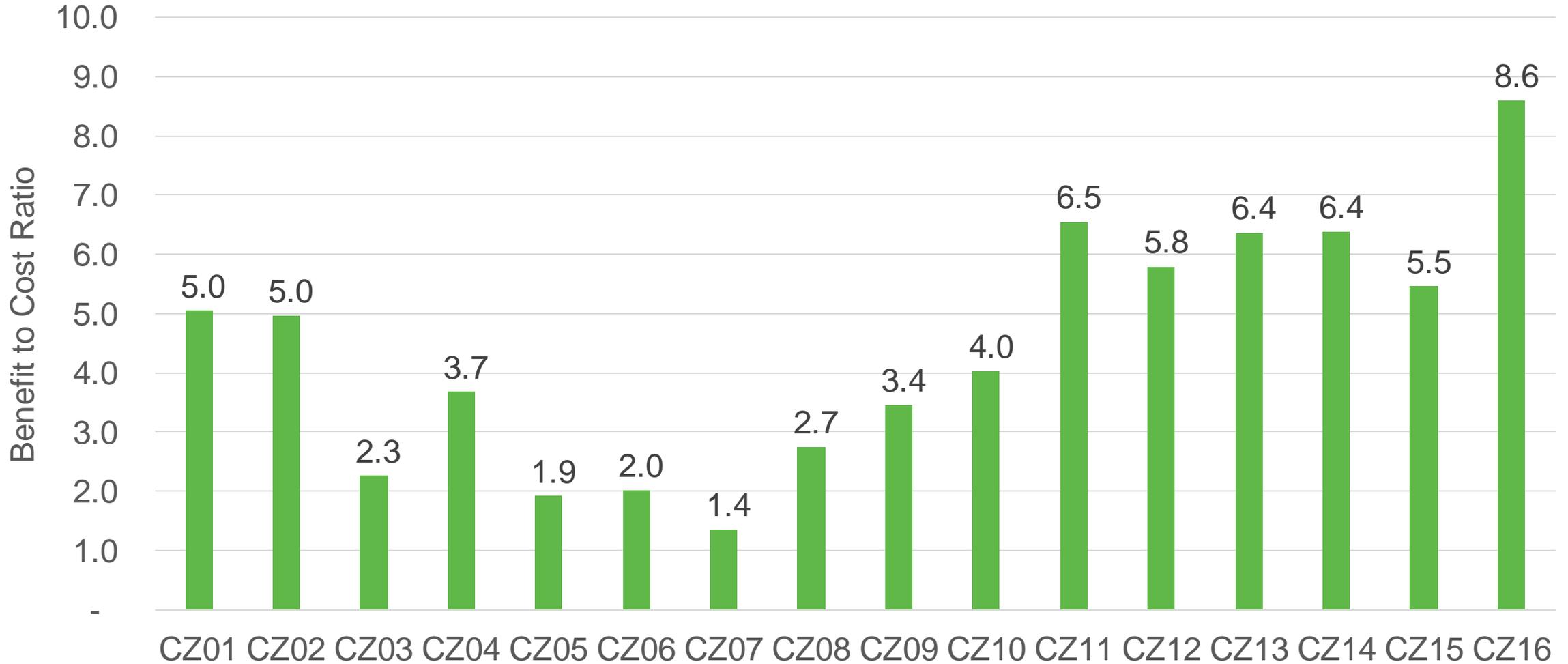
Statewide Benefit to Cost Ratio

Medium Office in all Climate Zones



Statewide Benefit to Cost Ratio

Primary Schools in all Climate Zones



Definition of Economizer Reference and Proposed Conditions



Economizer Reference Conditions

- Economizer on all systems.
- Two speed fans for single zone packaged units.
- DCV and Occupant Sensor Controls for Required Spaces
- Fan pressure by component by fan system size.



Proposed Conditions

- Sensible ventilation heat recovery with bypass controls.
- 150% of Ventilation Air by Space
- DCV and Occupant Sensor Controls for Required Spaces
- Fan pressure by component by fan system size.

Economizer Exception Energy Analysis

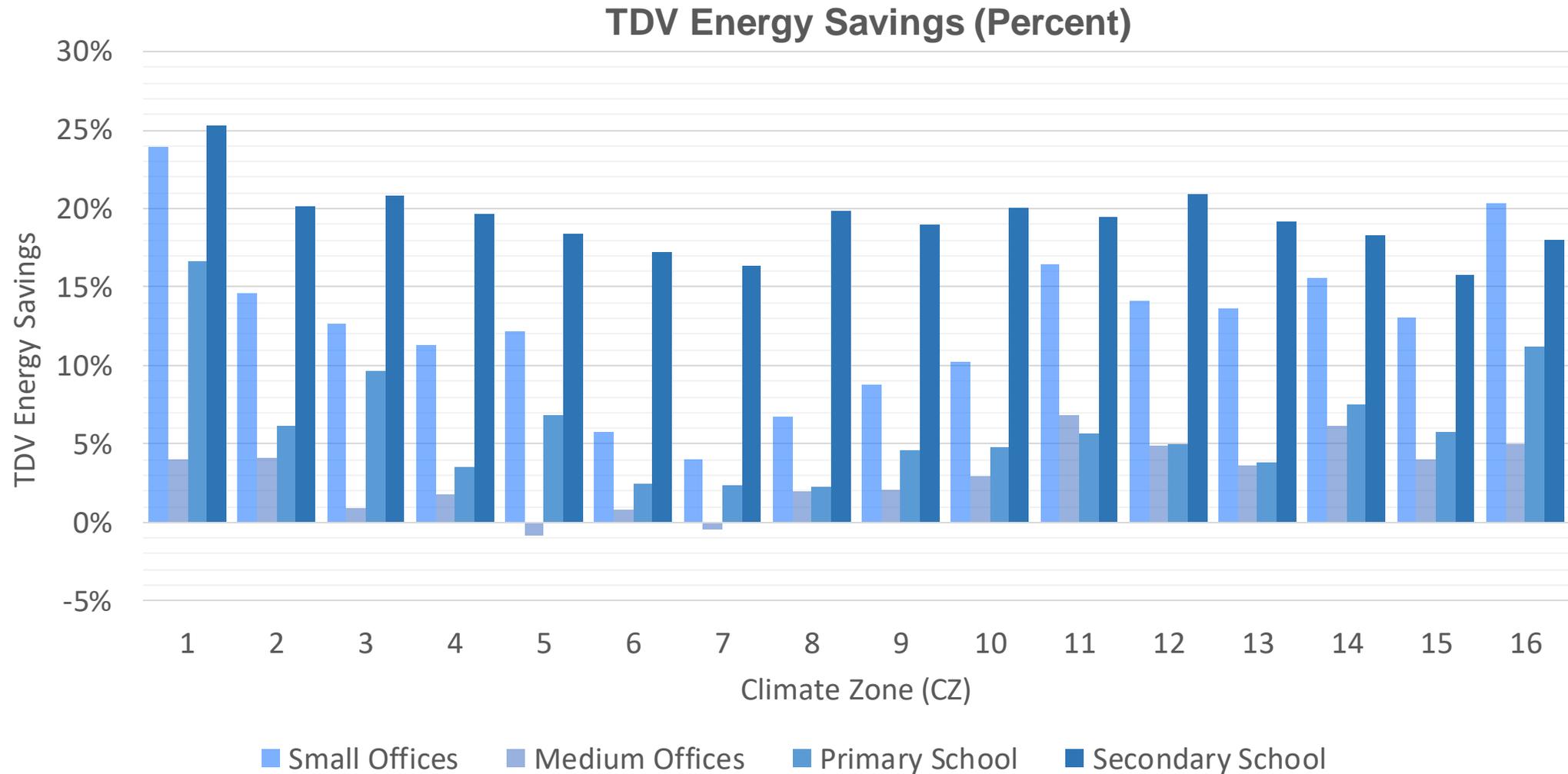
TDV energy use by building, system, and climate zone were compared between Mixed-Air and DOAS systems.

HVAC Configuration	Office Small	Office Medium	School Primary	School Secondary	Retail Stand Alone	Hotel Small
Mixed-Air Economizer						
SZVAV RTU with Economizers	X		X		X	
SZVAV HP with Economizers	X					
VAV Reheat, DX, Economizers		X		X		X
VAV Reheat, CHW, Economizers				X		
DOAS Systems						
HRV-DOAS with VRF	X	X			X	X
DX-DOAS with VRF	X	X	X	X		X
HP-DOAS with VRF		X		X		X
HRV-DOAS with Mini Splits	X					
HRV-DOAS with RTUs	X					
HRV-DOAS with FPFC		X				

Air Economizer Exception, Energy Analysis

Economizer were added to each system prototype.

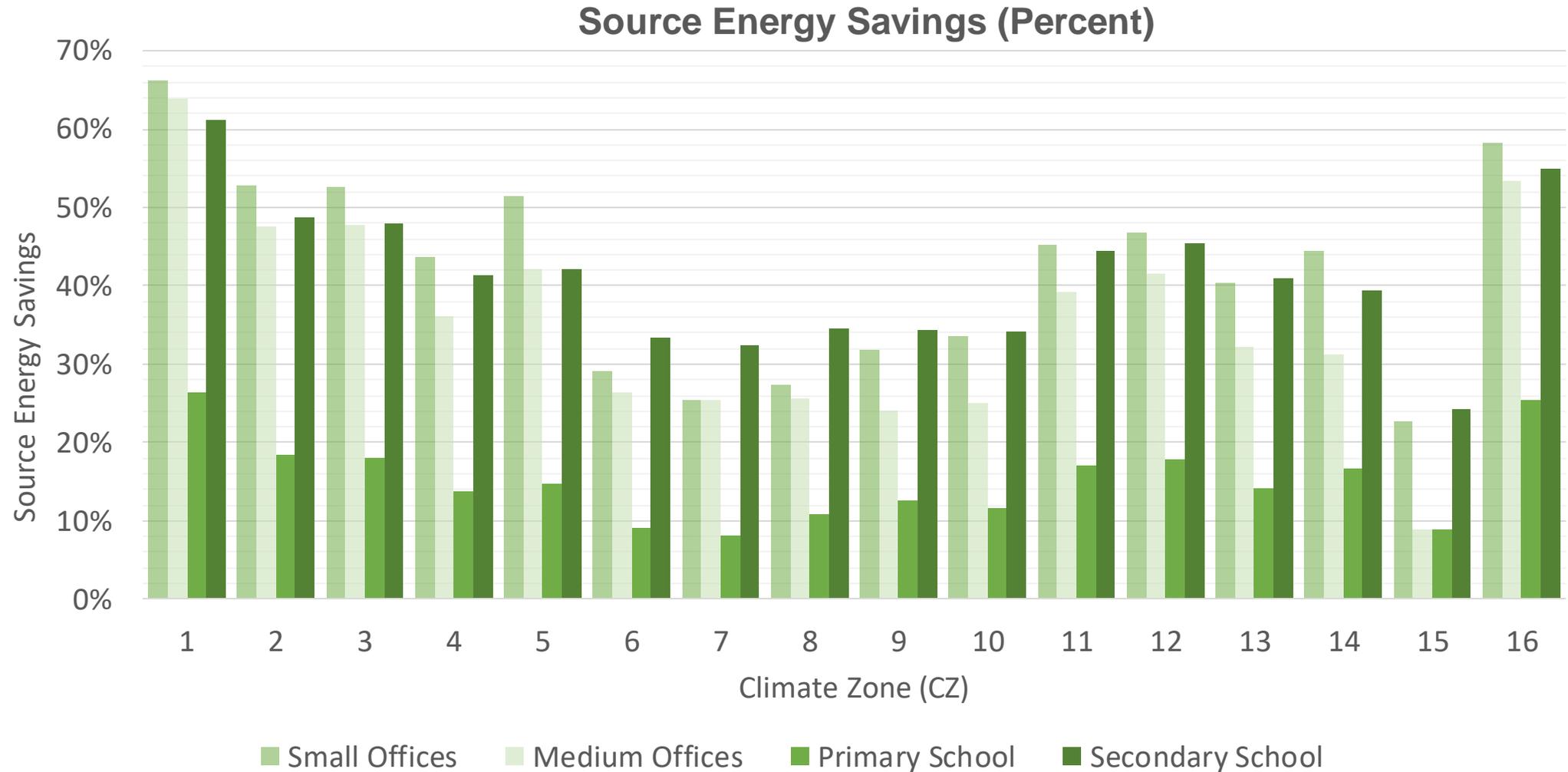
Only compares DX-VAVR and SZVAV type systems due to <150,000 sf or 5 stories.



Air Economizer Exception, Energy Analysis

Economizer were added to each system prototype.

Only compares DX-VAVR and SZVAV type systems due to <150,000 sf or 5 stories.



Next Steps | Additional Resources Available

- **Compliance Enforcement**

- Modifications to forms CEC-NRCC-MCH-E for key features of the DOAS unit will be developed.

- **Acceptance Tests**

- Modifications to existing tests for OA, Air Economizer to include Bypass, and DCV:
 - **CEC-NRCA-MCH-02**
 - **CEC-NRCA-MCH-05**
 - **CEC-NRCA-MCH-06**

- **Code Language**

- See posted draft language



Submeasure A: Dedicated Outside Air
Systems

**Submeasure B: Exhaust Air Heat
Recovery**

Submeasure C: VAV Deadband Airflow

Submeasure D: Expand Economizer
Requirements

Today's Objectives

The focus of today's meeting includes:

1. **Recap** Measure Overview
2. **Discuss** Technical Feasibility
3. **Review** Energy and Cost Calculations
4. **Discuss** Market Analysis
5. **Review** Code Language (if Time)

Exhaust Air Heat Recovery Measure Overview

- This proposal looks to **align** with ASHRAE Standard 90.1 2019 and IECC 2018 by providing prescriptive requirements based on:
 - Outdoor air fraction
 - Design supply airflow rate
 - Climate Zone
 - Hours of operation
 - Devices will specify a 60% sensible recovery ratio
- Title 24, Part 6 does not contain any existing requirements for exhaust air recovery devices.
- CALGreen Section A5.203.1.1.5: requires exhaust air heat recovery for some climate zones if the units use $\geq 80\%$ OA and $\geq 200+$ CFM airflow

History in Standard 90.1:

2004 - 2010: First exhaust air heat recovery requirements are required on systems $>5,000$ CFM

2010-2013: Table 6.5.6.1 added to specify requirements based on CFM, % OA, and Climate Zone

2013-current: Table split into two, based on hours of operation

Technical Feasibility

Exhaust Air Heat/Energy Recovery

- Device uses exhaust air to indirectly precondition incoming ventilation air
- Saves energy by reducing the heating/cooling load on the incoming ventilation air, will work best at extreme temperatures.
- Uses the temperate exhaust air that would otherwise be released

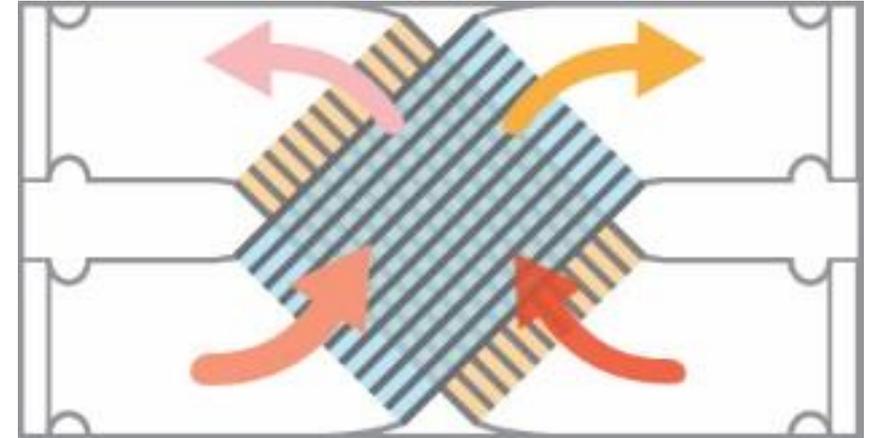
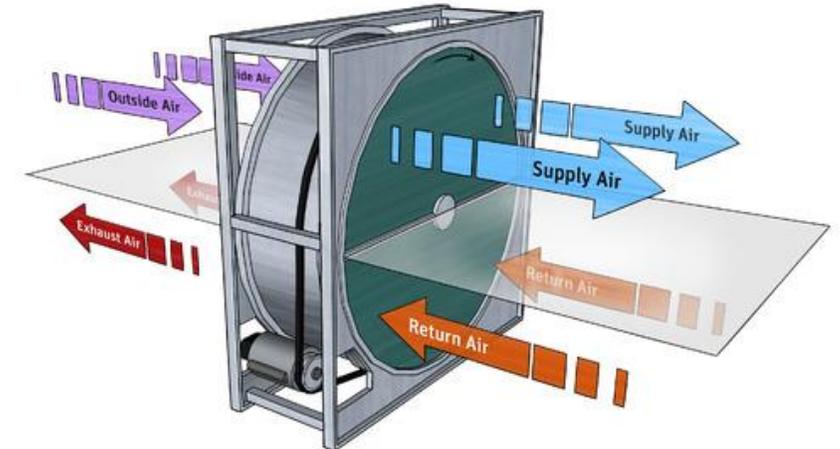


Plate type heat recovery



Wheel type heat recovery

Technical Feasibility

- Two main categories of heat recovery devices:
 - Heat Recovery Ventilator (HRV):
heat recovery only
 - Energy Recovery Ventilator (ERV):
heat + humidity recovery
- Economizer Bypass:
 - Systems will require an economizer bypass in order to take advantage of California's dry mild weather

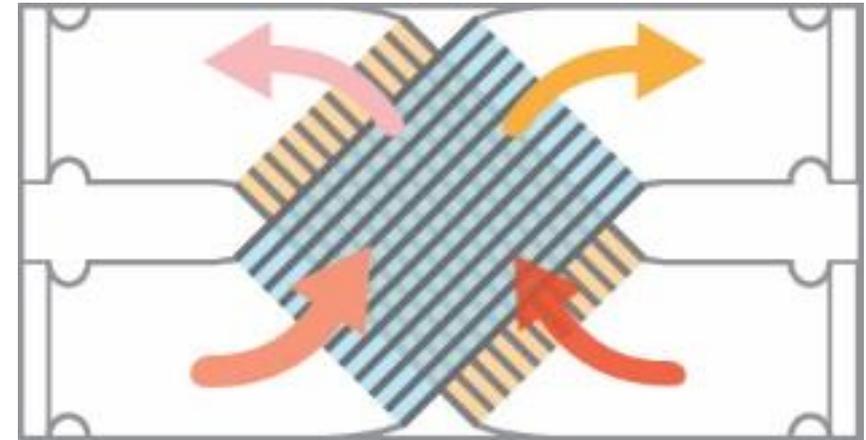
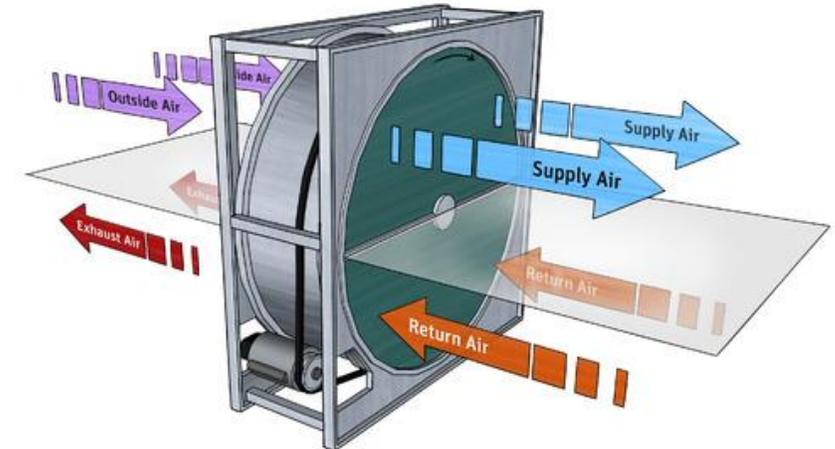


Plate type heat recovery



Wheel type heat recovery

Current Requirements of ASHRAE 90.1 (< 8,000 hours)

Table 6.5.6.1.2-1 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less than 8000 Hours per Year

Climate Zone	% Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
Climate Zone	Design Supply Fan Airflow Rate, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 5C	NR	NR	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥28,000	≥26,500	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
0A, 1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5500	≥4500	≥3500	≥2000	≥1000	≥120
7,8	≥4500	≥4000	≥2500	≥1000	≥140	≥120	≥100	≥80

NR—Not required

Based on the current ASHRAE Standard 90.1, we expect this to be applicable to CA's most extreme climates for systems less than 8,000 operating hours

Current Requirements of ASHRAE 90.1 (8,000+ hours)

Table 6.5.6.1.2-2 Exhaust Air *Energy* Recovery Requirements for Ventilation Systems Operating Greater than or Equal to 8000 Hours per Year

Climate Zone	% Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9000	≥5000	≥4000	≥3000	≥1500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2500	≥2000	≥1000	≥500	≥140	≥120	≥100	≥80
4A, 5A, 6A, 6B, 7, 8	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

NR—Not required

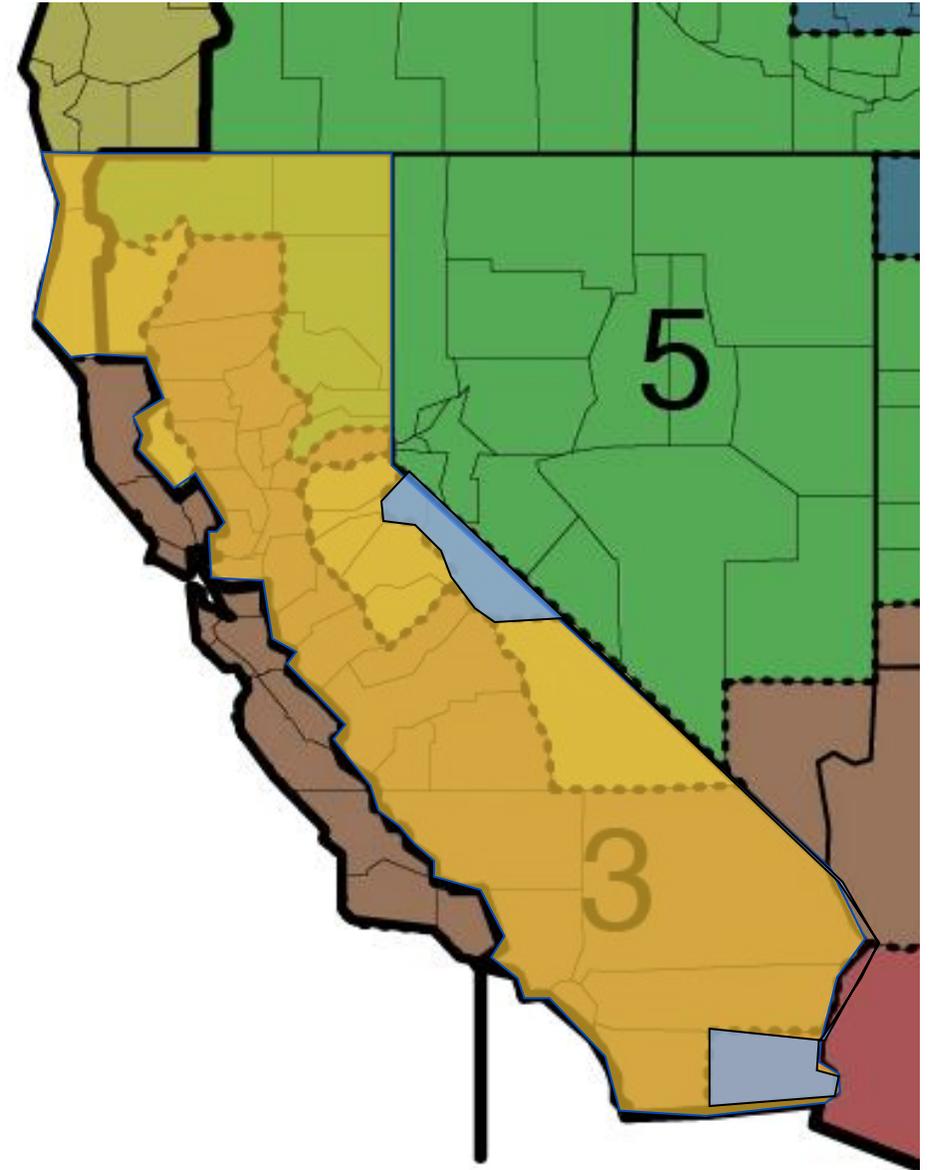
For systems 8,000+ hours, several additional climates would be applicable. However, most of California’s coasts (ASHRAE Zone 3C) would not be applicable

Impact of Climate

Applicable to mostly California's inland climates.

Applicable in 90.1 for:

- Systems < 8,000 hours/year
- Systems \geq 8,000 hours/year



ASHRAE/IECC Climate Zones

Impact of Climate

A 2016 study by the Energy Commission mapped the California CZs to their respective ASHRAE CZs. Based on that, the Statewide CASE Tram would expect the following locations would be applicable:

For above 8,000 hours,
- CZ01 & CZ07 to CZ16

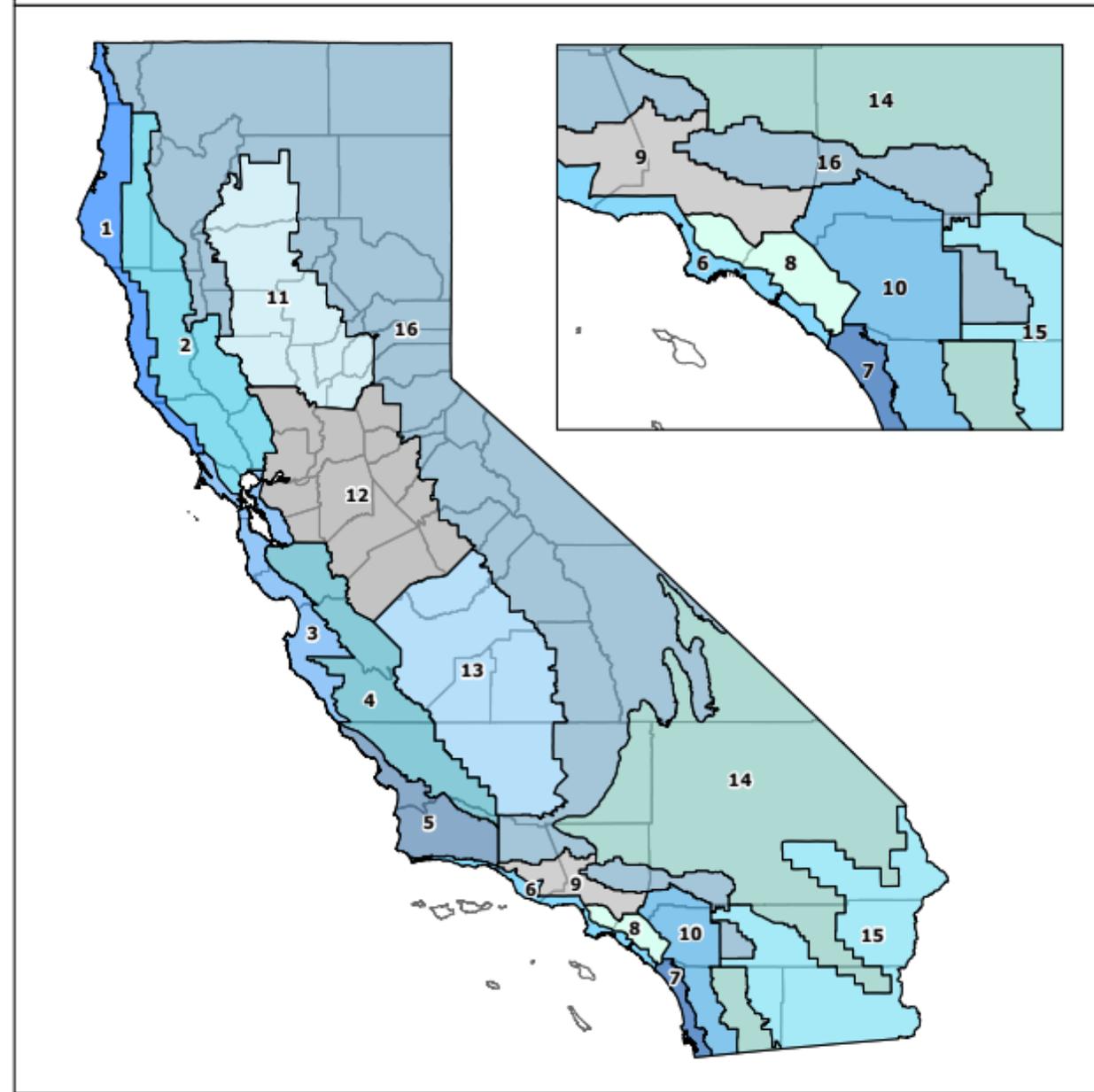
For below 8,000 hours,
- CZ15 & CZ16

California Climate Zone	Reference City	ASHRAE Zone	Std 90.1 8,000+ h	Std 90.1 < 8,000 h
1	Arcata	4c		N/A
2	Santa Rosa	3c	N/A	N/A
3	Oakland	3c	N/A	N/A
4	San Jose	3c	N/A	N/A
5	Santa Maria	3c	N/A	N/A
6	Torrance	3c	N/A	N/A
7	San Diego	3b		N/A
8	Fullerton	3b		N/A
9	Burbank-Glendale	3b		N/A
10	Riverside	3b		N/A
11	Red Bluff	3b		N/A
12	Sacramento	3b		N/A
13	Fresno	4b		N/A
14	Palmdale	4b		N/A
15	Palm Springs	2b		
16	Blue Canyon	4b/5b/6b		

Impact of Climate

Exhaust HR in California

- The benefits of heat recovery are balanced against both the fan penalty from increased static pressure and the energy required for rotating the heat recovery wheel.
- **Note: This measure will not be cost effective in all climates**



16 CEC Climate Zones

Title 24: Proposed Exhaust Air Energy Requirements (less than 8,000 hours)

TABLE 140.4-[X]1: Energy Recovery Requirements (ventilating systems operating less than 8,000 hours per year)

California Climate Zone	% Outdoor Air at Full Design Airflow							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
CZ01 - CZ14	NR	NR	NR	NR	NR	NR	NR	NR
CZ15	NR	NR	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
CZ16	≥28,000	≥26,500	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500

Title 24: Proposed Exhaust Air Energy Requirements (8,000 or more hours)

TABLE 140.4-[X]2: Energy Recovery Requirements (ventilating systems operating 8,000 hours or more per year)

California Climate Zone	% Outdoor Air at Full Design Airflow							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
CZ02 - CZ06	NR	NR	NR	NR	NR	NR	NR	NR
CZ01, CZ07 - CZ12, CZ15	NR	≥19,500	≥9,000	≥5,000	≥4,000	≥3,000	≥1,500	≥120
CZ13, CZ14	≥2,500	≥2,000	≥1,000	≥500	≥140	≥120	≥100	≥80
CZ16	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

Code Change Proposal Summary

Measure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Exhaust Air Heat Recovery	Prescriptive	Y	Section 140.4 (new sections)	TBD

Description of Changes

- Aligns with existing measures in ASHRAE 90.1-2019 and IECC 2018, utilizes five (out of nine) exceptions from ASHRAE.
- Devices will require a 60% sensible recovery ratio
- Very common measure in most of the U.S. – applicable to some parts of California
- Mostly saves heating energy
- Cooling savings is dependent on system type

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
 - Incremental costs
 - Maintenance costs
 - Energy cost savings
- Cost-effectiveness



Methodology for Energy Impacts Analysis

Exhaust Air Heat Recovery

- This measure applied a heat recovery ventilator with 60% energy recovery ratio for sensible only recovery
- Compared annual energy consumptions between baseline and proposed designs

Tools Used	CBECC-Com EnergyPlus
Building Prototypes Used	HotelSmall, OfficeLarge, OfficeMedium, OfficeMediumLab, RetailLarge, SchoolSecondary
Climate Zones Modeled	All 16 climate zones

Assumptions for Energy Impacts Analysis

- This measure applied a heat recovery ventilator with 60% (sensible) energy recovery ratio.
- Added static pressure to airstream based on ASHRAE 90.1 Section 6.5.3.1 fan pressure drop adjustment table for energy recovery device (0.6” for supply and 0.6” for exhaust)
 - This is conservative assumption since the fan power budget pressure tables are likely to be updated for the 2022 cycle, decreasing the pressure drop to 0.5”.
- Outdoor air intake will bypass HRVs when outdoor conditions are suitable for economizer operation. However, the software assumes static pressure penalty is constant during bypass
 - This is a conservative assumption that will increase fan penalty

Definition of Baseline and Proposed Conditions (Exhaust Air Heat Recovery)



Baseline Conditions

- Minimally compliant with 2019 Code
 - No requirement for heat recovery
- Period of evaluation: 15 years



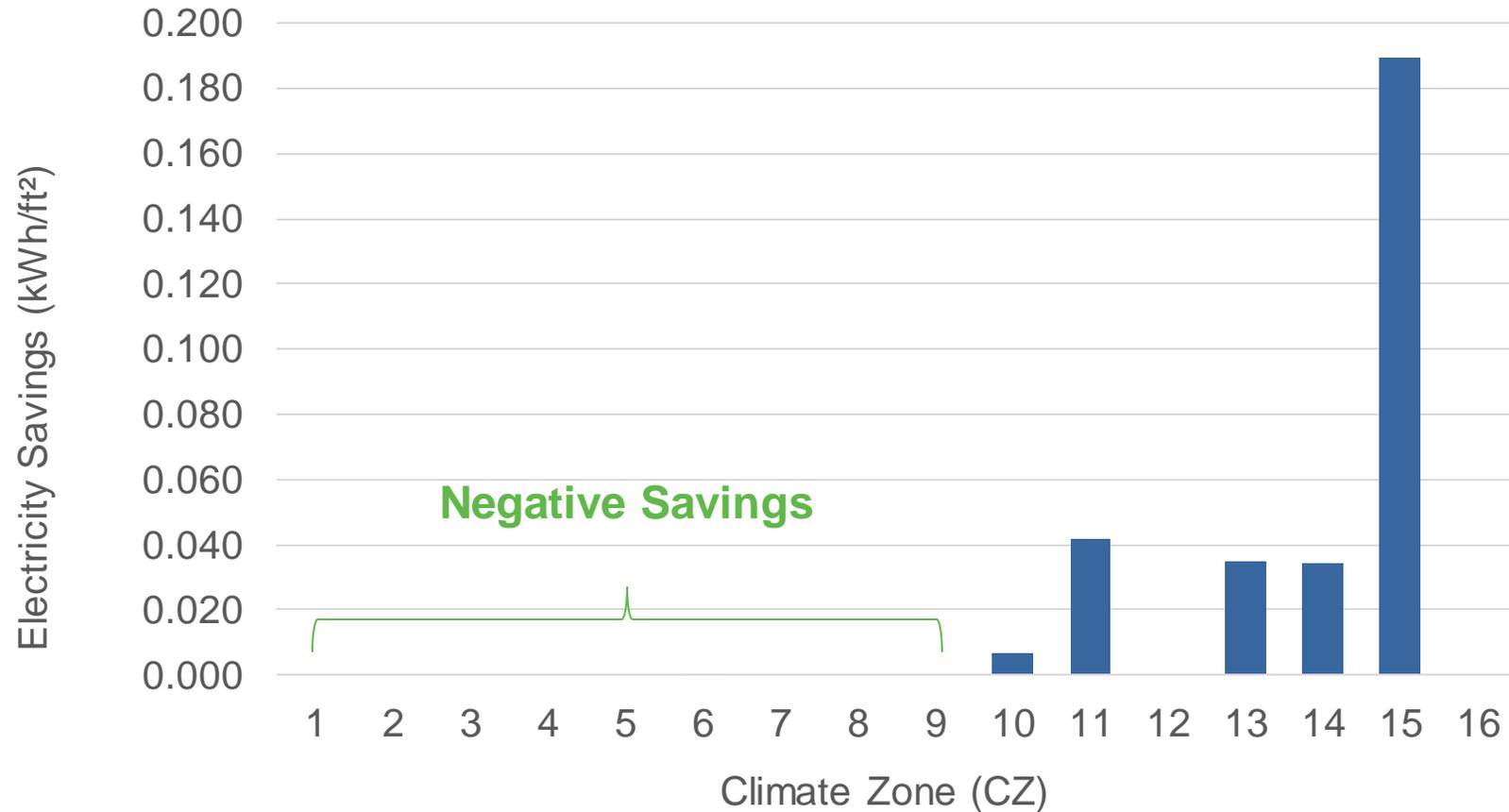
Proposed Conditions

- Required if a system meets four criteria: CFM, operating hours, OA%, and climate zone criteria
- 60% Sensible heat recovery and economizer bypass
- Period of evaluation: 15 years

Energy Savings Results:

Small Hotel Prototype: First year electricity savings by climate zone

First Year Electricity Savings (kWh/ft²)



Impact of Climate

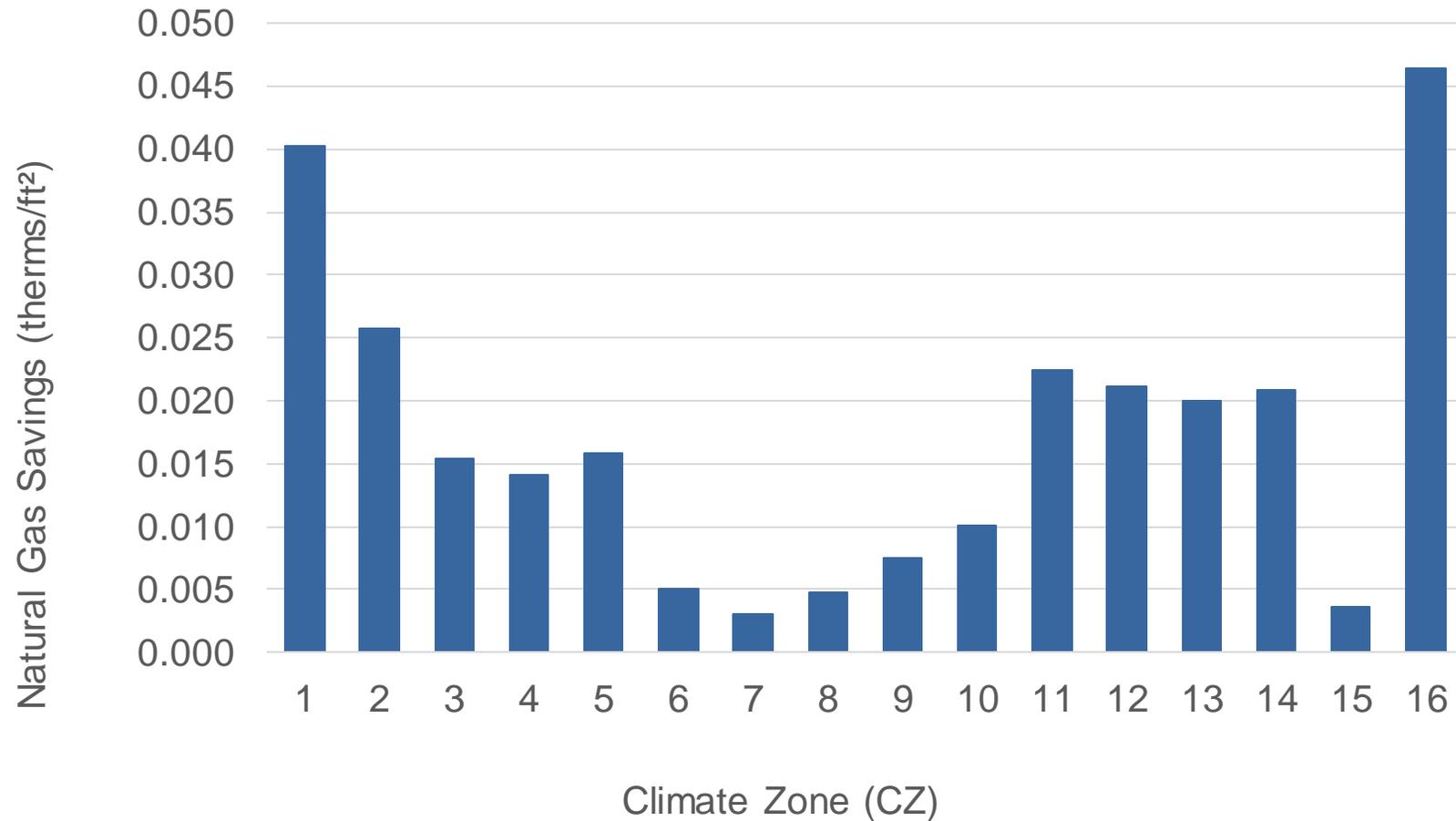
Electrical savings only present for some climate zones which obtain significant cooling savings.

Negative for several climate zones that cannot overcome fan penalty

Energy Savings Results:

Small Hotel Prototype: First year natural gas savings by climate zone

First Year Natural Gas Savings (therms/ft²)



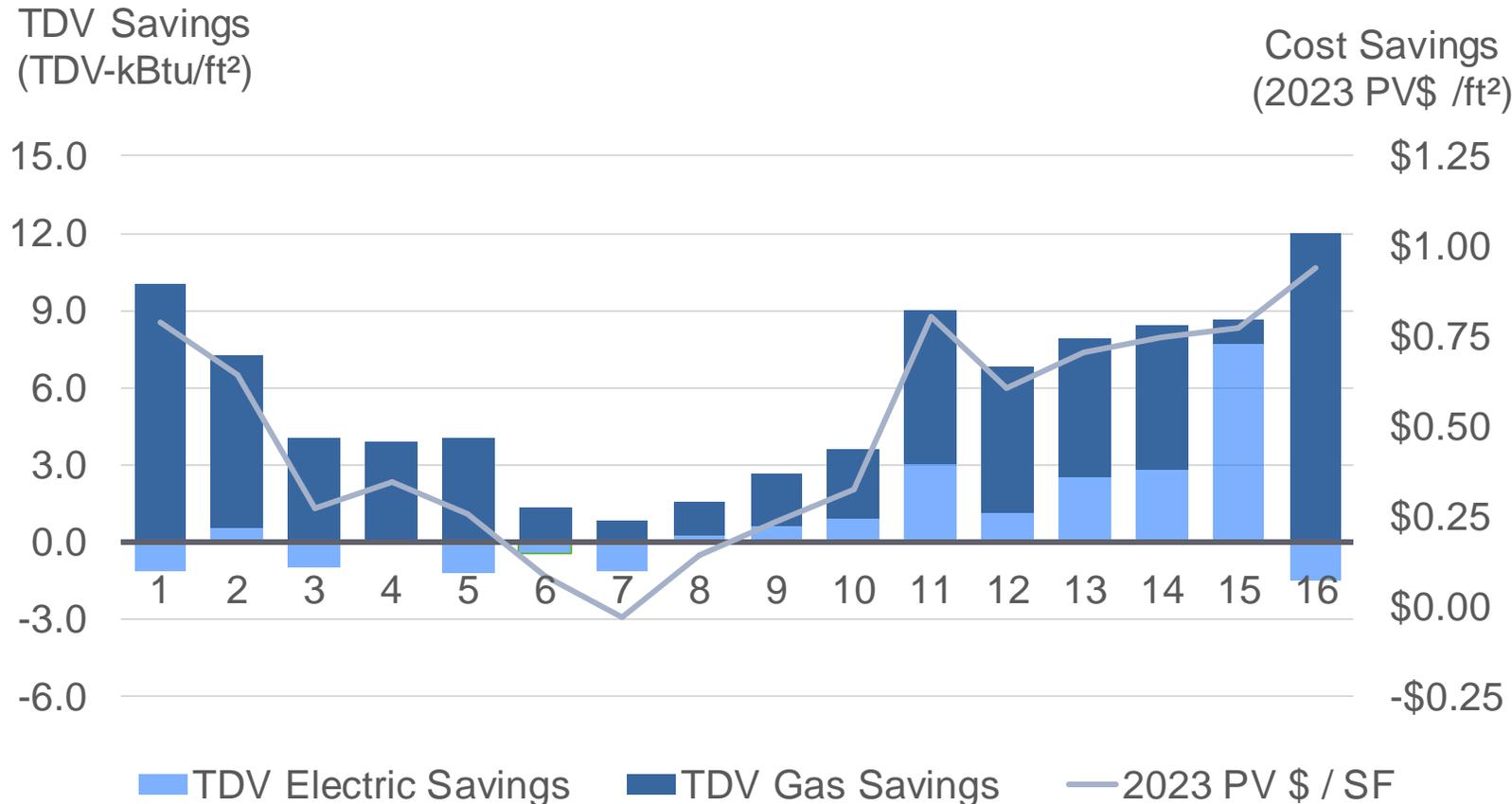
Impact of Climate

Looking at the gas savings, you can see that savings are much higher inland and in northern climates

Energy Savings Results:

Small Hotel Prototype: First year TDV energy savings by climate zone

First Year TDV Energy & Cost Savings



TDV Factor:

To look at both the electrical savings, electrical penalty, and the gas savings, we combine into Time-Dependent Value (TDV) metric

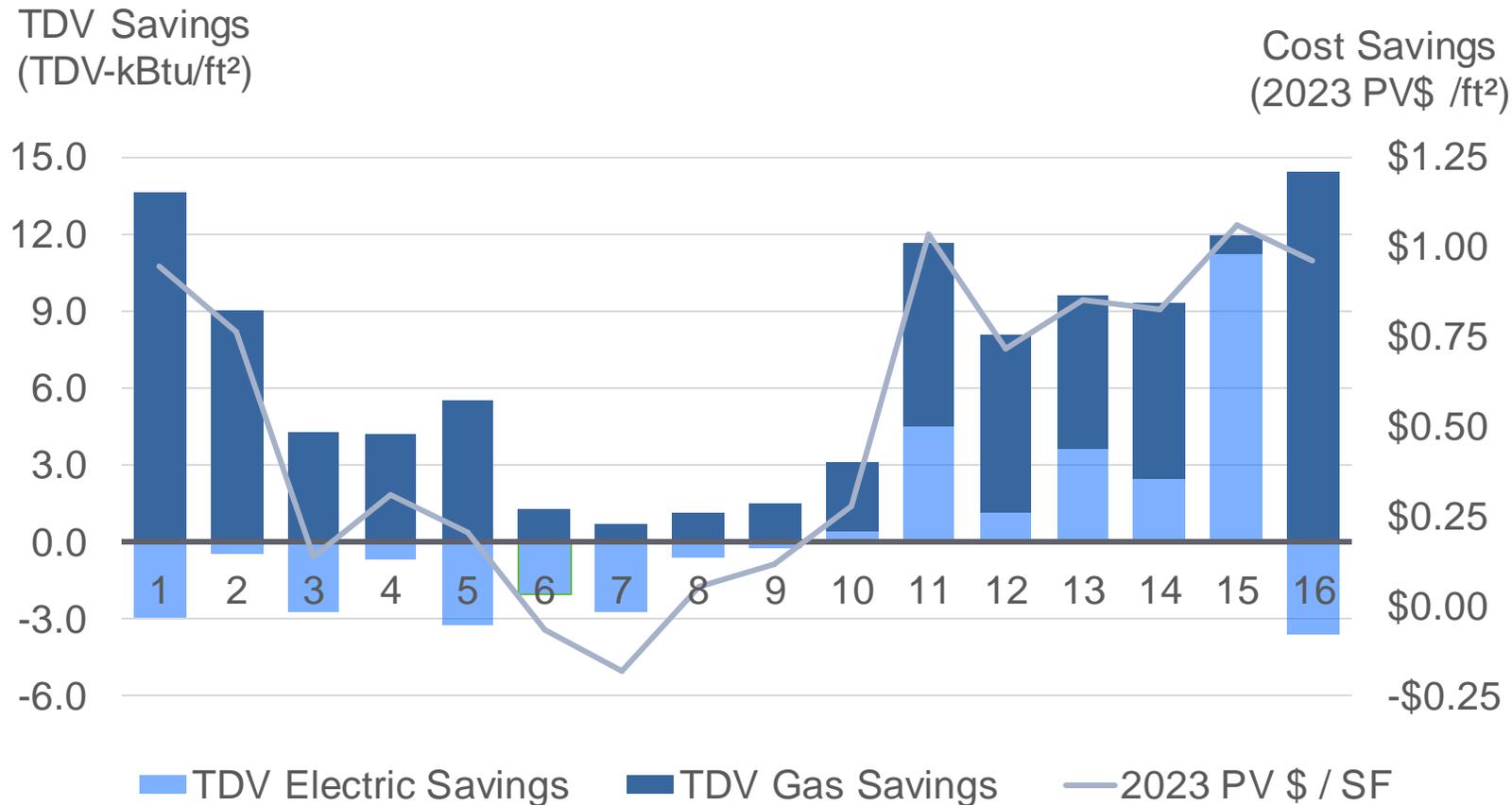
Small Hotel Prototype:

- 4 VAV AHUs common areas
 - SZACs guest rooms
- 700 – 8,000 CFM per AHU (depending on floor and CZ)
- **25 - 68% outside air**
- 5,900 hours/yr operation

Energy Savings Results:

Office Medium Prototype: First year TDV savings by climate zone

First Year TDV Energy & Cost Savings



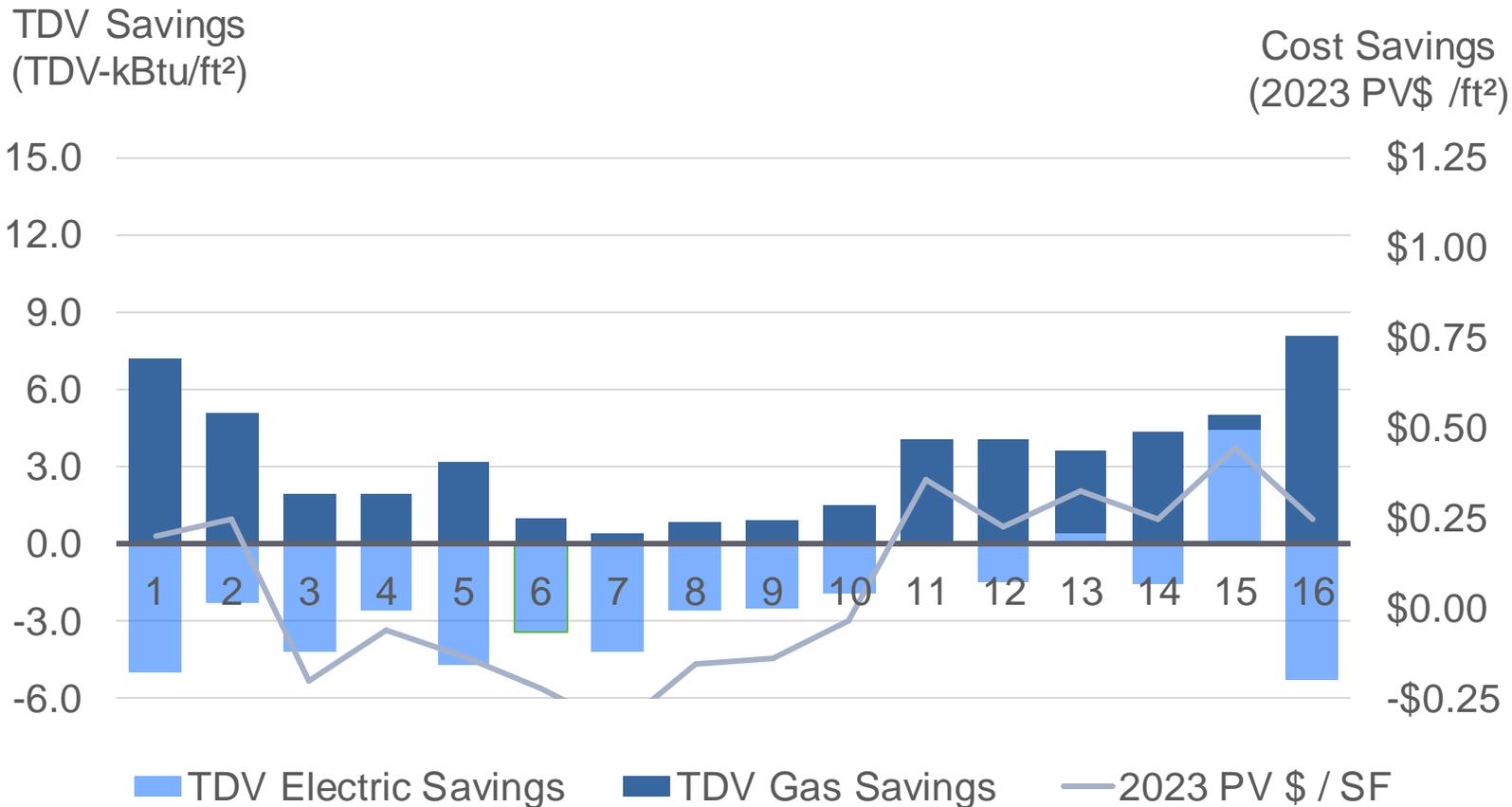
Office Medium Prototype:

- 3 VAV AHUs
- 11,000 – 15,000 CFM per AHU (depending on floor and CZ)
- 18 - 24% outside air
- 5,900 hours/yr operation

Energy Savings Results:

Office Large Prototype: First year TDV savings by climate zone

First Year TDV Energy & Cost Savings



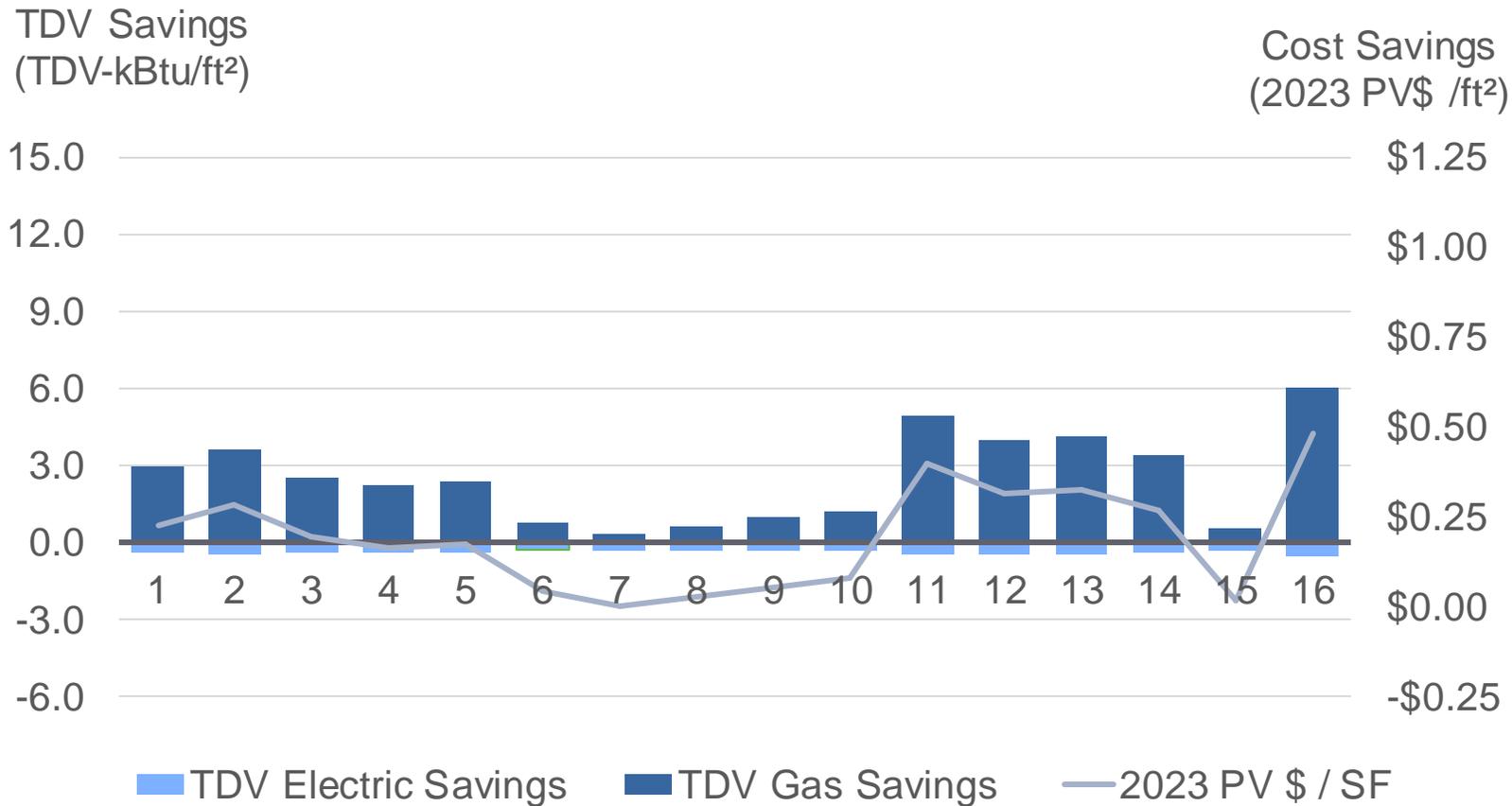
Office Large Prototype:

- 5 VAV AHUs
- 25,000 – 185,000 CFM per AHU (depending on floor and CZ)
- 15 - 23% outside air
- 5,900 hours/yr operation

Energy Savings Results:

Secondary School Prototype: First year TDV savings by climate zone

First Year TDV Energy & Cost Savings



School Secondary Prototype:

- 2 VAV AHUs
- 60,000 – 133,000 CFM per AHU (depending on floor and CZ)
- 37 - 55% outside air
- 4,014 - 5,900 hours/yr operation (depending on zone)

Incremental Per Unit Cost

Over 15 Year Period of Analysis

Incremental first cost was determined from manufacturer data and RSMeans. Costs include heat recovery ventilator with bypass dampers with controls and labor costs for a built-up system.

Do these costs seem appropriate to you?
If not, can you provide cost data? We would like to hear from you

Size (cfm)	Total Cost	Cost per CFM
1,000	\$6,775	\$6.78
2,000	\$7,925	\$3.96
4,000	\$9,175	\$2.29
6,000	\$10,700	\$1.78
8,000	\$11,800	\$1.48
10,000	\$14,200	\$1.42
20,000	\$25,700	\$1.29
25,000	\$31,400	\$1.26
30,000	\$34,800	\$1.16
40,000	\$48,000	\$1.20
50,000	\$56,000	\$1.12

Incremental Per Unit Cost

Over 15 Year Period of Analysis

Prototype	Avg Cost per Building	\$ per square-foot
HotelSmall	\$35,800	\$0.84
OfficeLarge	\$271,000	\$0.54
OfficeMedium	\$71,100	\$1.33
OfficeMediumLab	\$78,000	\$1.45
SchoolSecondary	\$161,000	\$0.77

After pricing out all impacted air handlers for each prototype and climate zone, average costs by square foot are shown above.

Note: These cost estimates are conservative as they do not take into account complexities from air handler design trade-offs such as downsized cooling capacity.

Title 24: Proposed Exhaust Air Energy Requirements (less than 8,000 hours)

TABLE 140.4-[X]1: Energy Recovery Requirements (ventilating systems operating less than 8,000 hours per year)

California Climate Zone	% Outdoor Air at Full Design Airflow							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
CZ01 - CZ14	NR	NR	NR	NR	NR	NR	NR	NR
CZ15	NR	NR	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
CZ16	≥28,000	≥26,500	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500

Cost-Effectiveness Analysis (less than 8,000 hours)

California CZ	ASHRAE CZ	Benefits – to – Cost Ratio							
		10 - 20 %OA	20 - 30 %OA	30 - 40 %OA	40 - 50 %OA	50 - 60 %OA	60 - 70 %OA	70 - 80 %OA	> 80% OA
CZ02 – CZ06	3C	Not Applicable for CZ01 – CZ14							
CZ15 (Benefits-to-Cost ratio)	2B	N/A	N/A	N/A	N/A	2.4	2.1	1.6	1.2
CZ16 (B/C ratio)	4B/5B/6B	8.7	12.1	5.3	3.7	3.8	4.0	3.2	2.0

Based on these cost numbers, we found that the ASHRAE Standard 90.1 requirements were cost-effective in California, in some cases by large margins. The table above shows the Benefits-to-Cost ratio for CZ 15 (Palm Springs) and CZ16 (Blue Canyon).

Title 24: Proposed Exhaust Air Energy Requirements (8,000 or more hours)

TABLE 140.4-[X]2: Energy Recovery Requirements (ventilating systems operating 8,000 hours or more per year)

California Climate Zone	% Outdoor Air at Full Design Airflow							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
CZ02 - CZ06	NR	NR	NR	NR	NR	NR	NR	NR
CZ01, CZ07 - CZ12, CZ15	NR	≥19,500	≥9,000	≥5,000	≥4,000	≥3,000	≥1,500	≥120
CZ13, CZ14	≥2,500	≥2,000	≥1,000	≥500	≥140	≥120	≥100	≥80
CZ16	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

Cost-Effectiveness Analysis (8,000 or more hours)

California CZ	ASHRAE CZ	Benefits – to – Cost Ratio							
		10 - 20 %OA	20 - 30 %OA	30 - 40 %OA	40 - 50 %OA	50 - 60 %OA	60 - 70 %OA	70 - 80 %OA	> 80% OA
CZ02 – CZ06	3C	Not Applicable for CZ02 – CZ06							
CZ1 CZ07 – CZ12 (avg B/C ratio)	4C / 3B	N/A	1.7	2.1	2.5	3.1	3.5	3.1	1.6
CZ13, CZ14 (B/C ratio)	4B	7.6	9.9	4.4	3.0	2.8	3.3	2.8	1.9

For higher-occupied scenarios (8,000 hours), we also found CZ01 and CZ07 to CZ14 to be cost-effective. Again, note the large cost-effectiveness numbers at the low OA-percentage bins.

Poll

This measure originally looked to align with ASHRAE 90.1's requirements. However, based on the high benefit to cost ratio for results (above 4.0 for several scenarios), should we investigate more stringent requirements for this measure?

- A. Yes (comments welcome)
- B. No (comments welcome)

Proposed Code Changes

- Draft Code Change Language

Proposed Code Change Overview

- **Updated** draft code language for this submeasure is available in the **resources tab**.
- **NEW** Section in 140.4 for Exhaust Air Heat Recovery includes the following:
 - Table describing applicable systems based on %OA, CFM, Climate Zone, and Hours of Operation.
 - Four Exceptions based on ASHRAE Standard 90.1 Language that are applicable for California Climates



Submeasure A: Dedicated Outside Air
Systems

Submeasure B: Exhaust Air Heat
Recovery

Submeasure C: VAV Deadband Airflow

Submeasure D: Expand Economizer
Requirements

Today's Objectives:

The focus of today's meeting includes:

1. **Cover** Measure Summary
2. **Review** Energy Measures and Cost Calculations

Code Change Proposal Summary

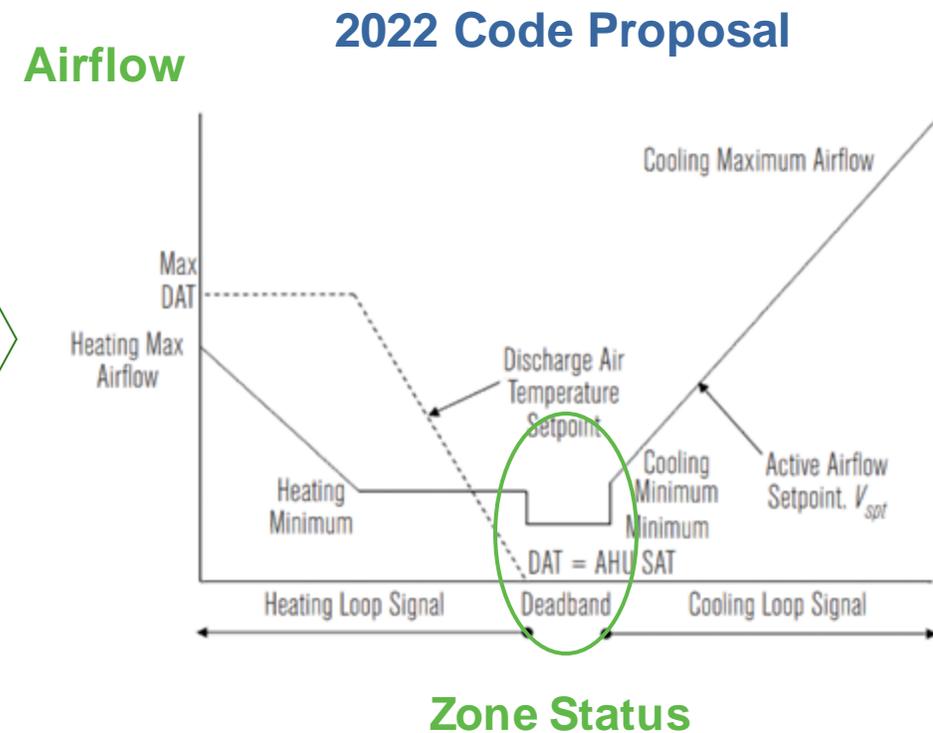
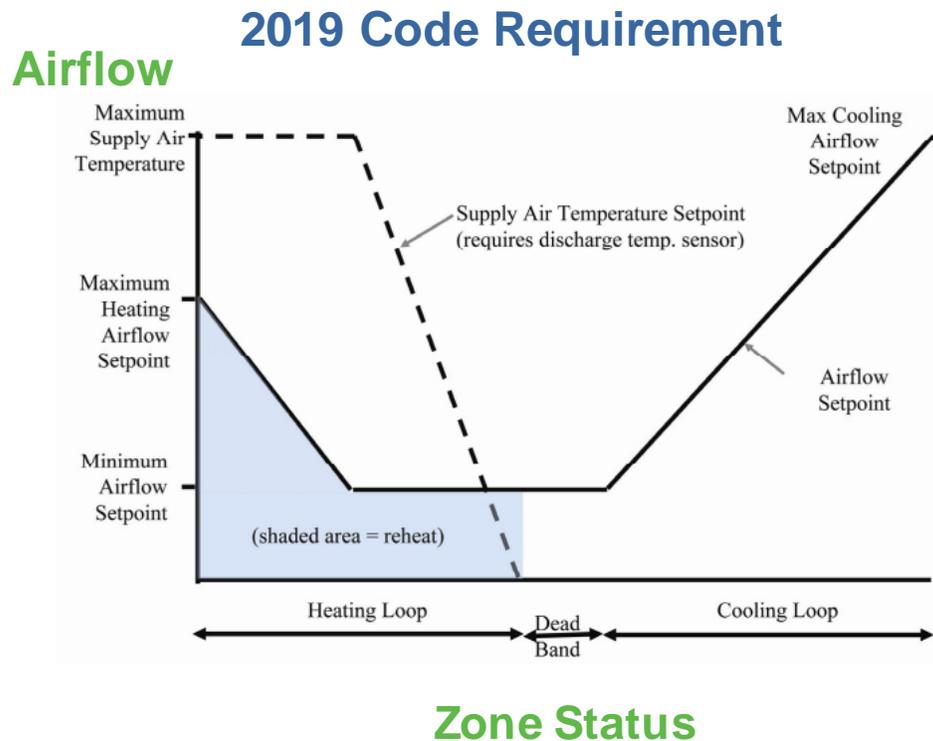
Measure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
VAV Deadband Airflow	Prescriptive	Y	Section 140.4(d)	CEC-NRCC-MCH-E

Description of Changes

- Simplifies deadband airflow requirements
- Saves fan energy by allowing lower airflow in deadband
- Aligns with new changes to ASHRAE 90.1-2019

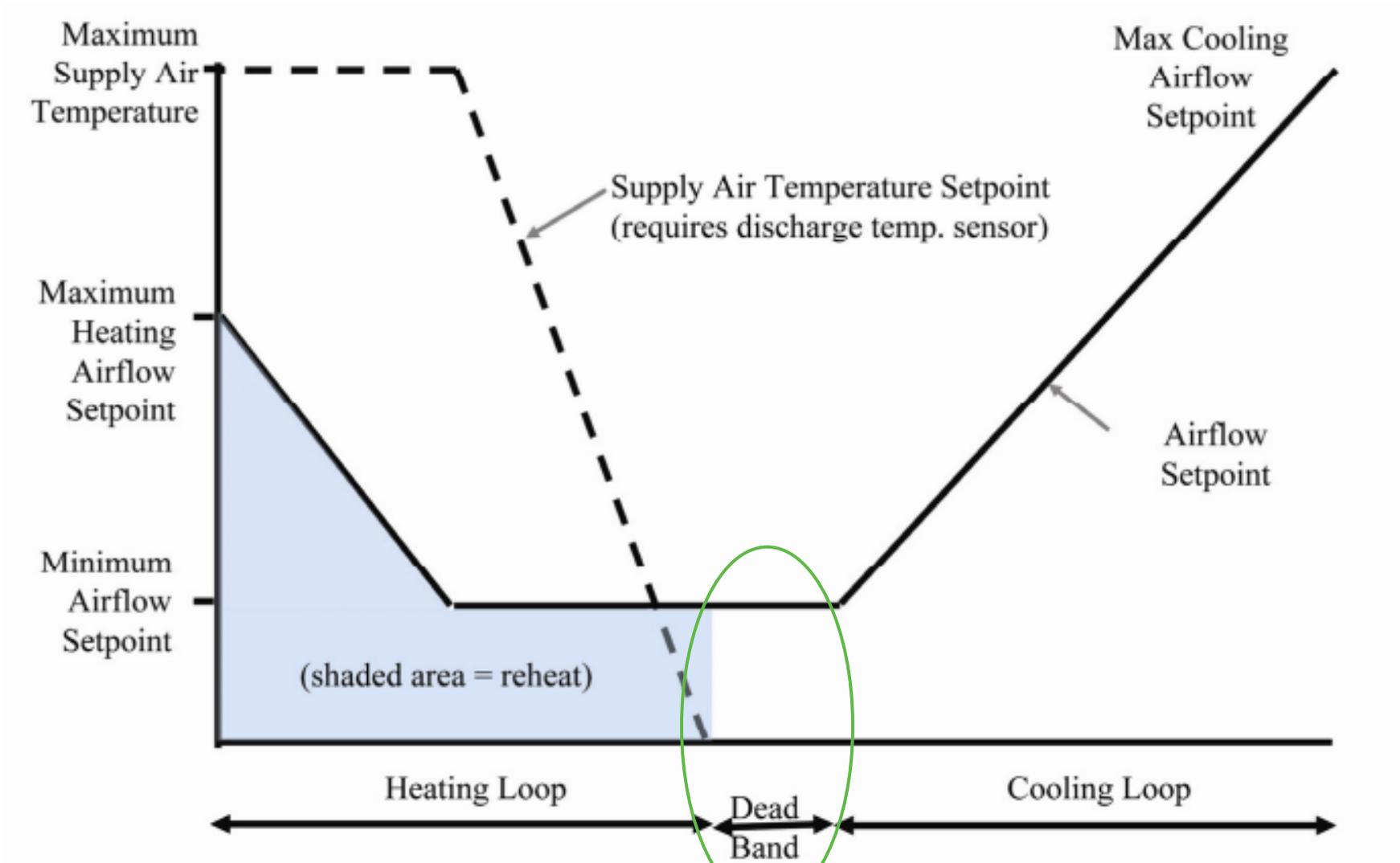
VAV Deadband Airflow Measure Summary

- This effort will adjust the VAV zone deadband airflow requirements.
- The graphics below are VAV controls diagrams which show the relationship the zone status (heating/deadband/cooling) status on the x-axis against the zone airflow on the Y-axis



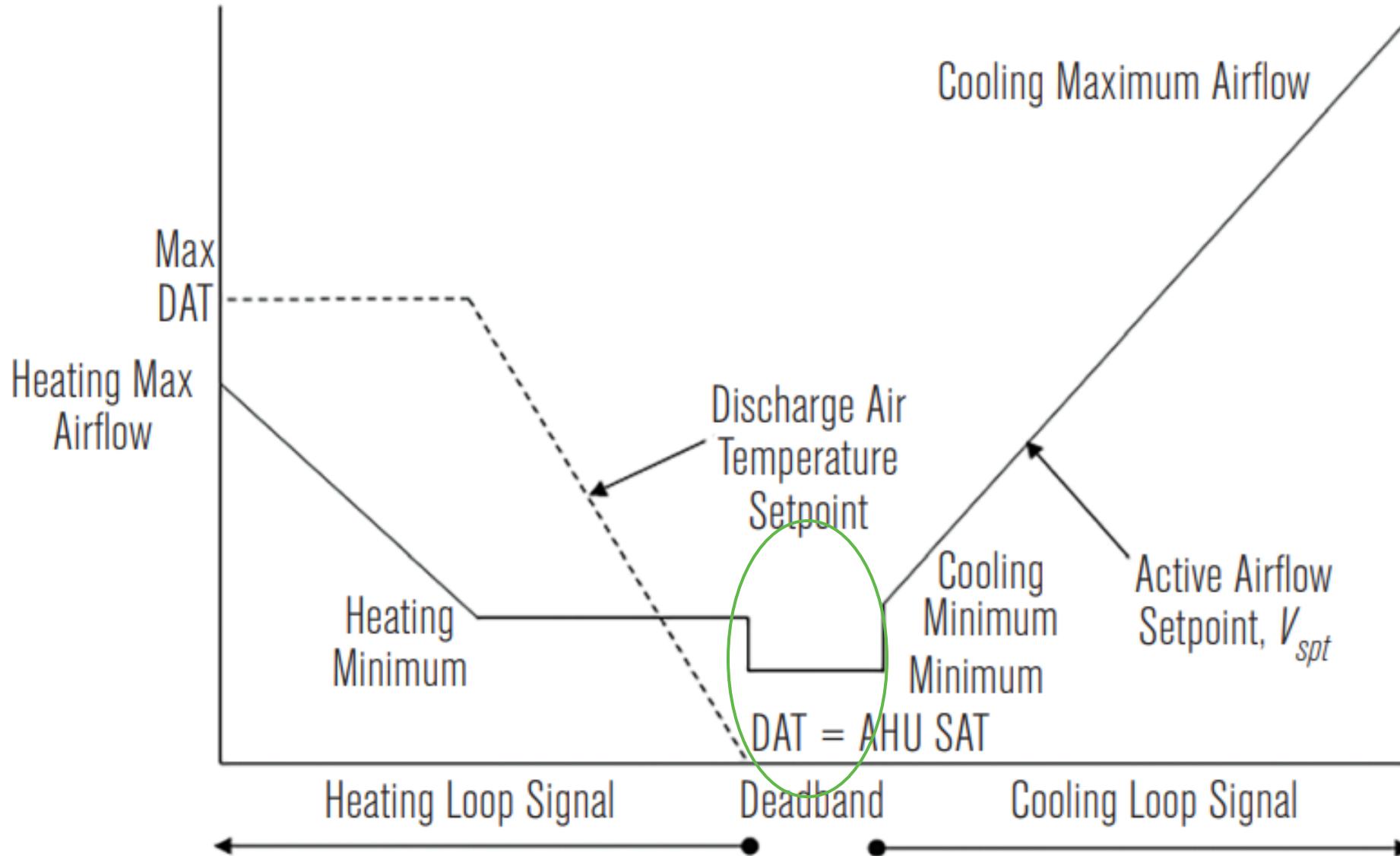
VAV Deadband Airflow Measure Summary

Representation of 2019 Title 24, Part 6 Deadband Requirements



Under current code the zonal deadband airflow is often unnecessarily high, requiring a 20% minimum.

VAV Deadband Airflow Measure Summary



This measure would allow the airflow to drop to outdoor ventilation minimums during deadband operation

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
 - Incremental costs
 - Maintenance costs
 - Energy cost savings
- Cost-effectiveness



Methodology for Energy Impacts Analysis

- This measure adjusted the airflow rate during deadband operation
- Compared annual energy consumptions between baseline and proposed designs

Tools Used	CBECC-Com EnergyPlus
Criteria for Prototype model	If prototype includes a VAV unit system (packaged, build-up, or packaged single-zone VAV)
Building Prototypes Used	Apartment High Rise (Dorms), Office Large, Office Medium Lab, Office Medium, School Secondary
Climate Zones Modeled	All 16 climate zones

Definition of Baseline and Proposed Conditions



Baseline Conditions

- Minimally compliant with 2019 code
- Period of evaluation: 15 years
- Airflow rate at deadband operation:
Larger of 20% of peak airflow rate
and design zone outdoor flowrate



Proposed Conditions

- Minimally compliant with 2019 code
- Period of evaluation: 15 years
- Airflow rate at deadband operation:
design zone outdoor flowrate

Incremental Per Unit Cost

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	\$0	Equipment Replacement	\$0
Installation	\$0	Annual Maintenance	(\$0)
Commissioning	\$0		
Other	\$0		
Total	\$0	Total	\$0

In our 1st stakeholder meeting, we asked if this was a no-cost measure and the majority of participants agreed. We are interested in hearing your feedback again.

Poll

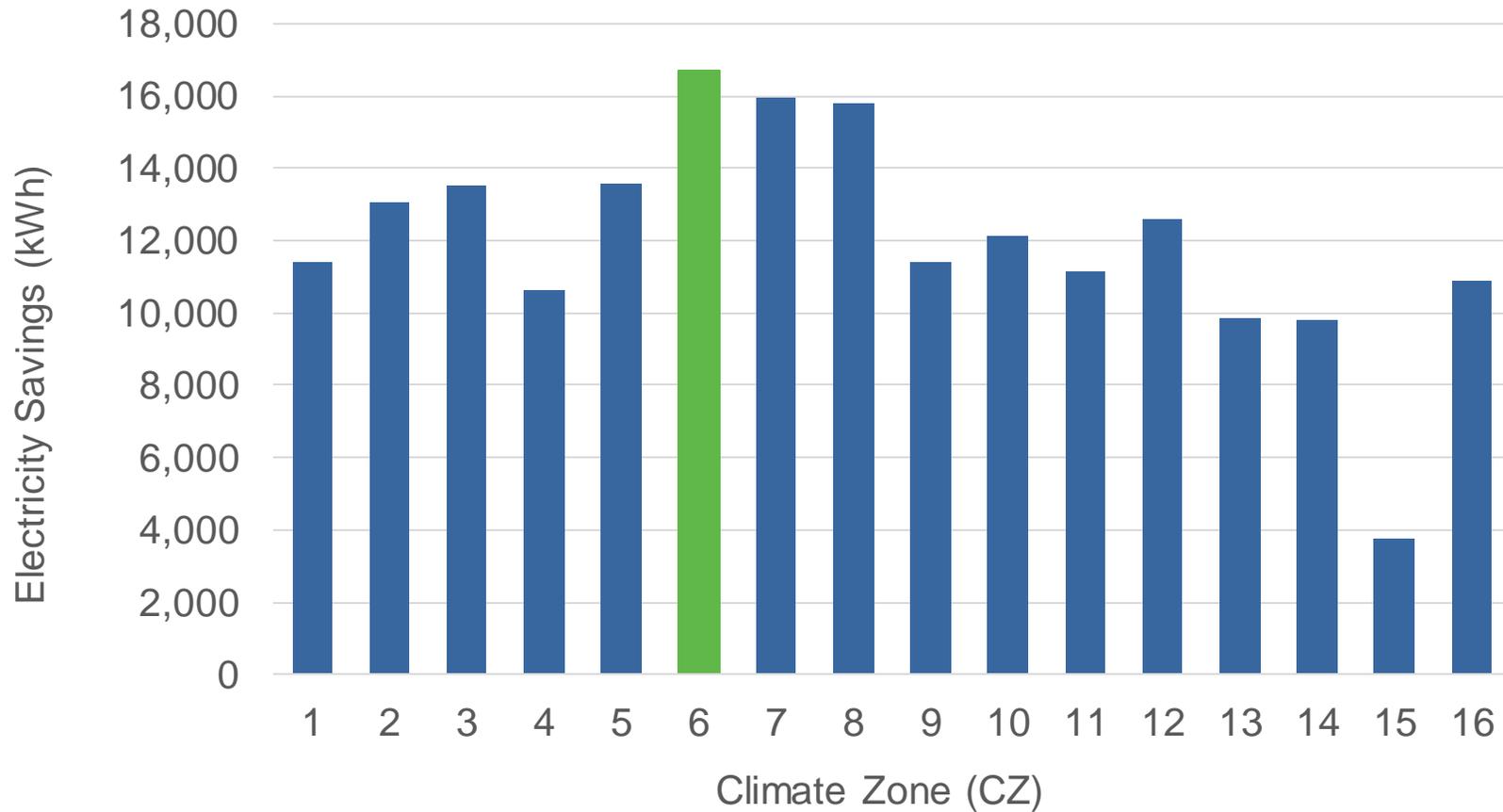
We believe this measure to be a no cost measure. Do you agree?

- A. Yes
- B. No
- C. Not Sure (please elaborate)

Energy Savings Results:

Office Large Prototype: First year savings by climate zone

First Year Electricity Savings (kWh)



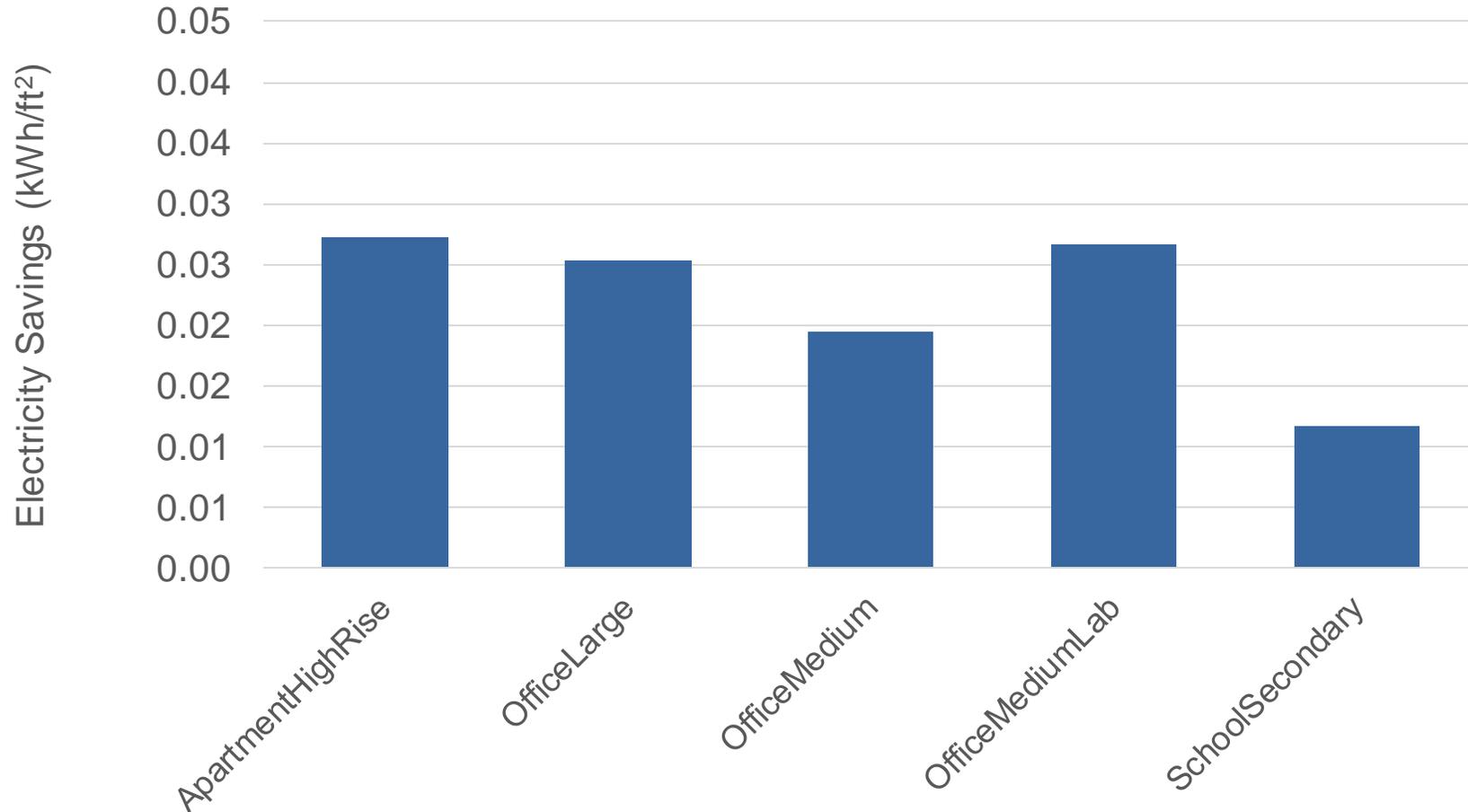
Prototype Office Large, CZ6:

Building Area: 498,637 SF
Cooling Capacity: 2,183 tons
Airflow Rate: 455,378 CFM

Energy Savings Results (kWh/ sq-ft):

All Applicable Building Types Climate Zone 12

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 12



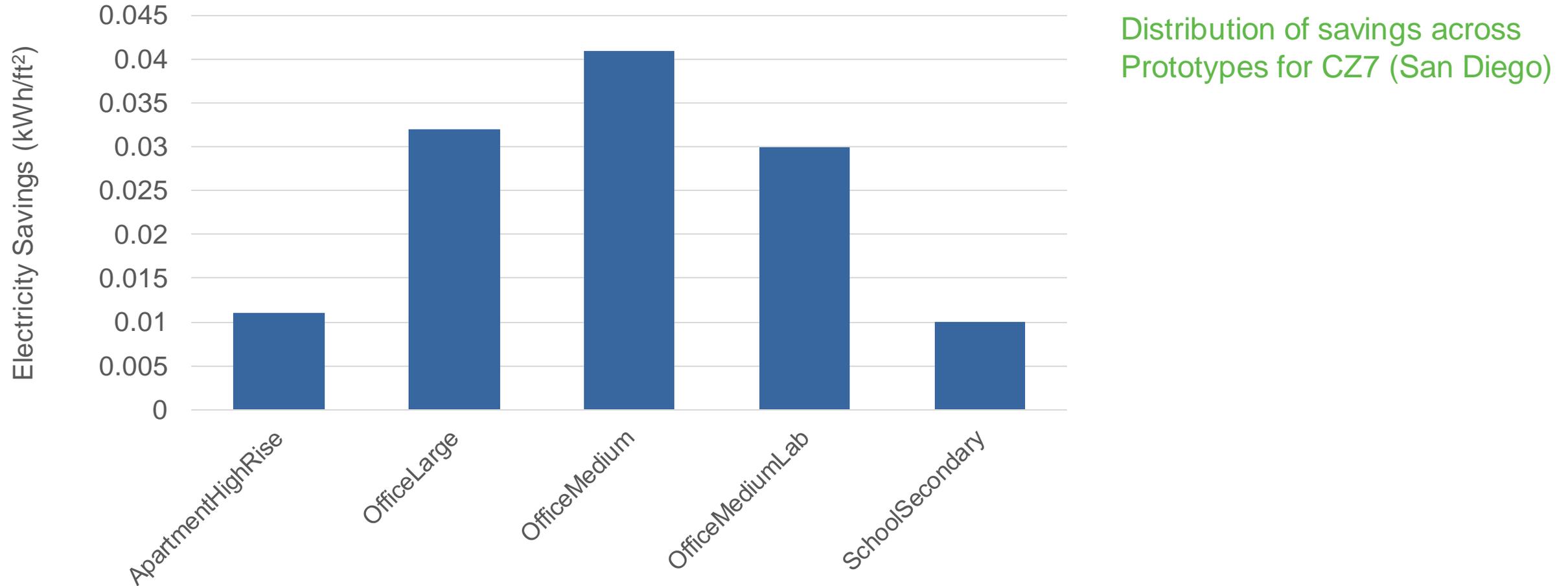
Distribution of savings across prototype models for CZ12 (Sacramento)

Savings are roughly even across impacted prototypes

Energy Savings Results (kWh/ sq-ft):

All Applicable Building Types Climate Zone 7

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 7



2023 Construction Forecast: New Construction (VAV Deadband Airflow)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	10.36	0%	0
Large Office	36.28	100%	36.3
Restaurant	5.44	0%	0
Retail	31.81	0%	0
Grocery Store	8.39	0%	0
Non-refrigerated Warehouse	29.95	0%	0
Refrigerated Warehouse	1.64	0%	0
Schools	12.39	40%	4.96
Colleges	6.50	90%	5.85
Hospitals	9.32	0%	0
Hotel / Motel	10.69	0%	0
Total	162.78	28.9%	47.09

2023 Construction Forecast: Existing Buildings (VAV Deadband Airflow)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	476.52	0%	0
Large Office	1,665.45	5%	86.1
Restaurant	238.92	0%	0
Retail	1,490.53	0%	0
Grocery Store	394.19	0%	0
Non-refrigerated Warehouse	1,402.32	0%	0
Refrigerated Warehouse	75.65	0%	0
Schools	724.95	2%	20.2
Colleges	379.99	5%	8.5
Hospitals	488.66	0%	0
Hotel / Motel	451.77	0%	0
Total	7,788.95	1.50%	114.9

Statewide Energy Savings

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/ yr)	TDV Energy Savings (TDV kBtu/yr)
New Construction	1.1	(1.1)	0.1	62.4
Additions and Alterations	2.7	(2.5)	0.3	147.4
Total	3.9	(3.6)	0.4	209.8

Source: Statewide CASE Team

Energy Saving Estimates

- Savings are significant, shows measure would save 0.08%~0.79% of total building kBTUs with no cost
- Large electrical savings, though slightly projected increased electric peak demand
- **Do these savings seem reasonable?**

Software Updates

- **Current modeling capabilities:**
 - Models 20% of peak primary airflow in the deadband for VAV box minimum airflow
- **Proposed new modeling capabilities:**
 - Apply zone outdoor airflow levels from Section 120.1 in the deadband for VAV box minimum airflow



Submeasure A: Dedicated Outside Air
Systems

Submeasure B: Exhaust Air Heat
Recovery

Submeasure C: VAV Deadband Airflow

**Submeasure D: Expand Economizer
Requirements**

Today's Objectives: Expand Economizer Requirements

The focus of today's meeting includes:

1. **Cover** Measure Summary
2. **Recap** changes since 1st Stakeholder Meeting
3. **Review** Energy Measures and Cost Calculations
4. **Review** Code Language

Expand Economizer Requirements Measure Summary

- This measure consists of **three parts**:
 1. ASHRAE Std 90.1 Code Clean-up Language **[NEW]**: clarifies existing language in the Economizer Trade-Off Table from Title 24, Part 6, Table 140.4-D
 2. Economizing on Smaller Systems: requires economizing on lower capacity units, reducing the threshold from 54,000 Btu/h to 33,000 Btu/h.
 3. Expanded Integrated Economizing: adjusts the minimum displacement requirements from Title 24, Part 6, Table 140.4-F.

Why Expand Integrated Economizing?

- Economizers provide free cooling during mild conditions and if the economizers are integrated they can work in combination with the mechanical cooling to reduce load on the compressor.
- For direct expansion (DX) units, these hours are limited by the minimum compressor displacement to ensure stable compressor operation.
- This proposal will expand the free cooling hours by reducing the minimum compressor displacement.

Adjust Minimum Displacement Requirements

update number
of stages

update
minimum
displacement

	Cooling Capacity	2019 Code Minimum Number of Mechanical Cooling Stages	2019 Code Minimum Compressor Displacement (percent of full load)	Proposed 2022 Minimum Number of Mechanical Cooling Stages	Proposed 2022 Minimum Compressor Displacement (percent of full load)
Add a lower capacity bin	≥ 33,000 Btu/h and < 65,000 Btu/h	N/A	N/A	2 stages	≤ 50%
Divided into two bins	≥ 65,000 Btu/h and < 110,000 Btu/h	3 stages	≤ 35%	3 stages	≤ 35%
	≥ 110,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35%	4 stages	≤ 25%
	≥ 240,000 Btu/h	4 stages	≤ 25%	4 stages	≤ 15%

Methodology for Energy Impacts Analysis

	Economizing on Smaller Systems	Expand Integrated Economizing
Tools Used	CBECC-Com EnergyPlus	CBECC-Com EnergyPlus
Criteria for Prototype Models	Contains DX unit with capacity between 33,000 Btu/h and 54,000 Btu/h	Contains DX unit between: 33,000 – 65,000 Btu/h, 110,00 – 240,00 Btu/h –OR- Greater than 240,00 Btu/h
Building Prototypes Used	Restaurant (FastFood)	Hotel (Small) Office (Medium, Medium Lab) School (Primary) Restaurant (Fastfood) Retail (Large, Mixed Use, Strip Mall)
Climate Zones Modeled	All 16 climate zones	All 16 climate zones

Definition of Baseline and Proposed Conditions (Economizing on Smaller Systems)



Baseline Conditions

- Minimally compliant with 2019 code
- Cutoff cooling capacity with airside economizer: 54,000 Btu/h
- Airside economizer control: Differential Drybulb
- Period of evaluation: 15 years



Proposed Conditions

- Minimally compliant with 2019 code
- Cutoff cooling capacity with airside economizer: 33,000 Btu/h
- Airside economizer control: Differential Drybulb
- Period of evaluation: 15 years

Incremental Per Unit Cost (Economizing on Smaller Systems)

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	~\$1,400	Equipment Replacement	\$0
Installation	\$0	Annual Maintenance	(\$44)
Commissioning	\$0		\$0
Other	\$0		\$0
Total	\$1,400	Total	\$44

Costs for this measure are based on preliminary information from manufacturers and data utilized from previous Code Enhancement efforts.

Incremental Per Unit Cost (Economizing on Smaller Systems)

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	~\$1,400	Equipment Replacement	\$0
Installation	\$0	Annual Maintenance	(\$44)
Commissioning	\$0		\$0
Other	\$0		\$0
Total	\$1,400	Total	\$44

Costs for this measure are based on preliminary information from manufacturers and data utilized from previous Code Enhancement efforts.

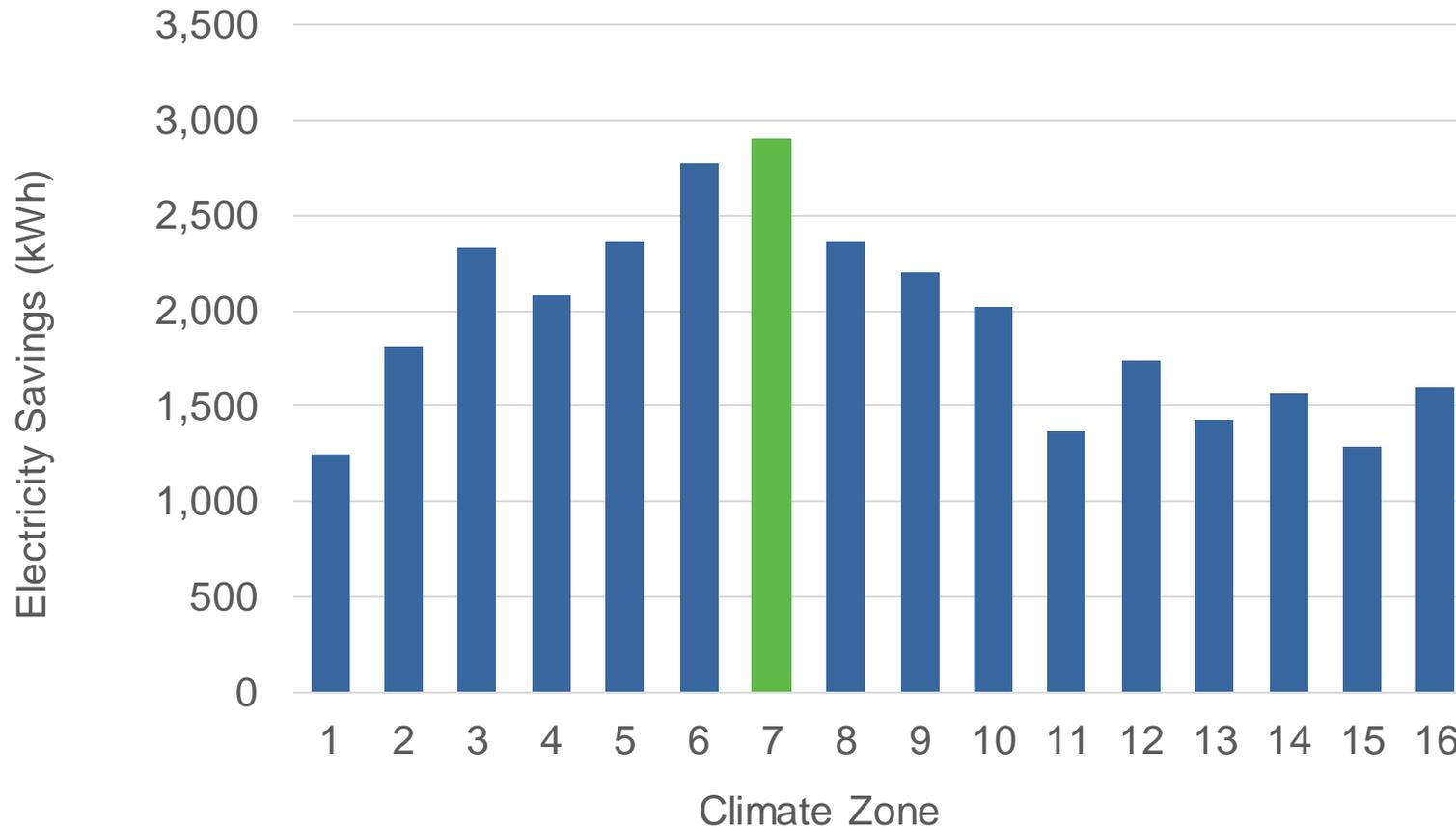
Do these costs seem appropriate to you? If not, can you provide cost data?

We would like to hear from you!

Energy Savings Results (Economizing on Smaller Systems)

RestaurantFastFood Prototype: First year savings by climate zone

First Year Electricity Savings (kWh)



Prototype

RestaurantFastFood

Climate Zone: CZ7 (San Diego)

Building Area: 2501 Sq.Ft.

Number of Units: 2 DX units

Cooling Capacity: 116,412 Btu/h

(Impacted unit: ~39,000 Btu/h)

Airflow Rate: 3,186 CFM

2023 Construction Forecast: New Construction

(Economizing on Smaller Systems)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	10.36	0%	0.0
Large Office	36.28	0%	0.0
Restaurant	5.44	100%	5.4
Retail	31.81	0%	0.0
Grocery Store	8.39	0%	0.0
Non-refrigerated Warehouse	29.95	0%	0.0
Refrigerated Warehouse	1.64	0%	0.0
Schools	12.39	0%	0.0
Colleges	6.50	0%	0.0
Hospitals	9.32	0%	0.0
Hotel / Motel	10.69	0%	0.0
Total	162.78	3.34%	5.4

2023 Construction Forecast: Existing Buildings

(Economizing on Smaller Systems)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	476.52	0%	0.0
Large Office	1,665.45	0%	0.0
Restaurant	238.92	5%	11.9
Retail	1,490.53	0%	0.0
Grocery Store	394.19	0%	0.0
Non-refrigerated Warehouse	1,402.32	0%	0.0
Refrigerated Warehouse	75.65	0%	0.0
Schools	724.95	0%	0.0
Colleges	379.99	0%	0.0
Hospitals	488.66	0%	0.0
Hotel / Motel	451.77	0%	0.0
Total	7,788.95	0.15%	11.9

Statewide Energy Savings (Economizing on Smaller Systems)

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/ yr)	TDV Energy Savings (TDV kBtu/yr)
New Construction	4.7	0.1	-0.1	103.9
Additions and Alterations	10.2	0.1	-0.1	228.1
Total	14.9	0.2	-0.2	332.0

Source: Statewide CASE Team

Energy Saving Estimates

(Economizing on Smaller Systems)

- Savings are significant, shows measure would save **1.49%~4.37% of total building kBTUs**
 - Large electrical savings, though slightly projected increased gas usage.
-
- **Do these savings seem reasonable?**

Questions and Next Steps



Definition of Baseline and Proposed Conditions (Expand Integrated Economizing)



Baseline Conditions

- Applied minimally compressor displacement from Table 140.4-F in 2019 Code
- Period of evaluation: 15 years



Proposed Conditions

- Change minimum compressor displacement:
- Cooling capacity $\geq 33,000$ and $< 65,000$ Btu/h, Minimum compressor displacement $\leq 50\%$ full load
 - Cooling capacity $\geq 110,000$ and $< 240,000$ Btu/h, Minimum compressor displacement $\leq 25\%$ full load
 - Cooling capacity $\geq 240,000$ Btu/h, Minimum compressor displacement $\leq 15\%$ full load
 - Period of evaluation: 15 years

Incremental Per Unit Cost (Expand Integrated Economizing)

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	~\$800	Equipment Replacement	\$0
Installation	\$0	Annual Maintenance	(\$0)
Commissioning	\$0		\$0
Other	\$0		\$0
Total	~\$800	Total	\$0

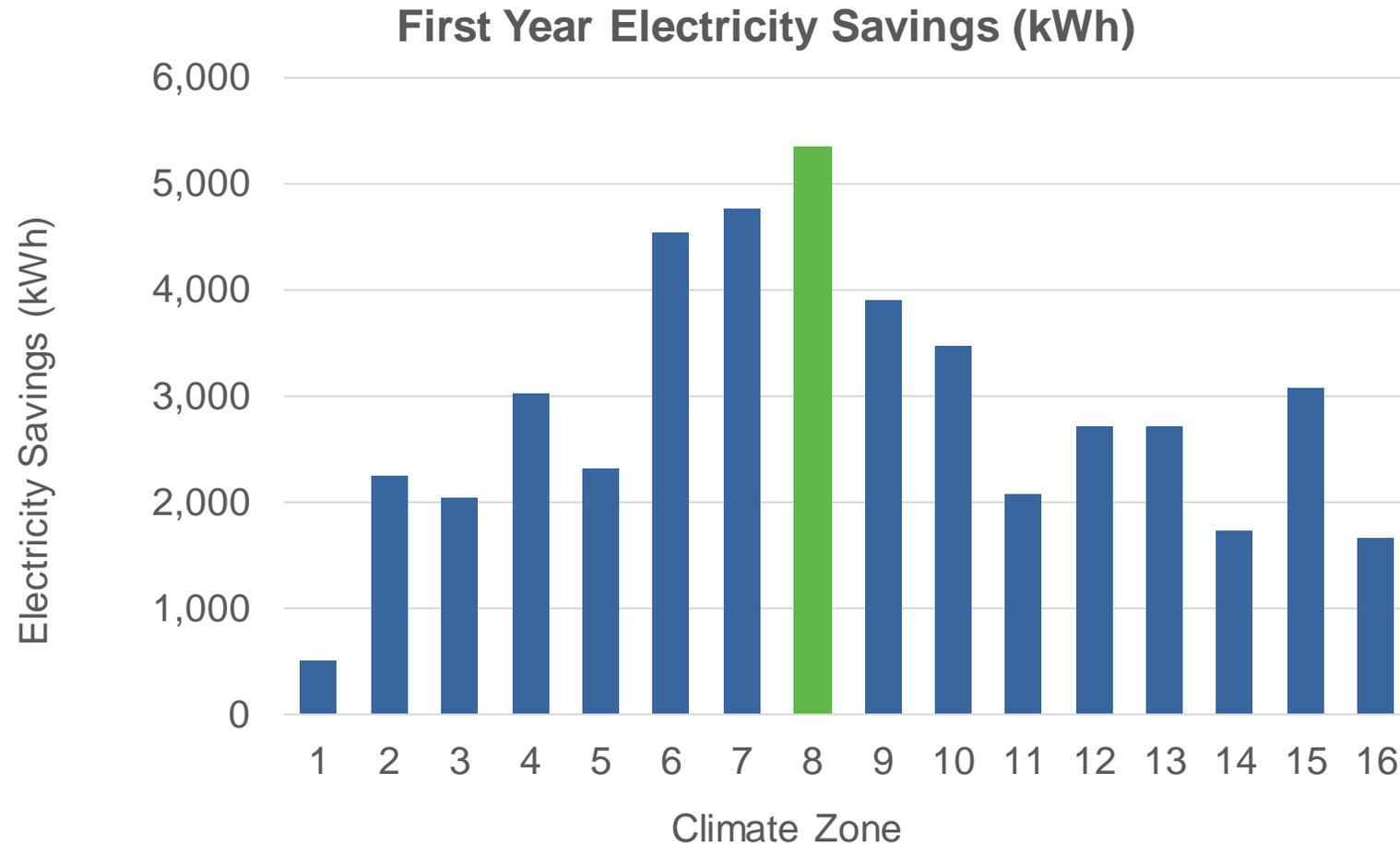
Do these costs seem appropriate to you?

If not, can you provide cost data?

Costs for this measure are based on information from manufacturers. We are still seeking additional cost data and would like to hear from you.

Energy Savings Results (Expand Integrated Economizing)

SchoolPrimary Prototype: First year savings by climate zone



Prototype: SchoolPrimary

Climate Zone: CZ 8

Building Area: 24,413 Sq.Ft.

Number of Units: 11 DX units

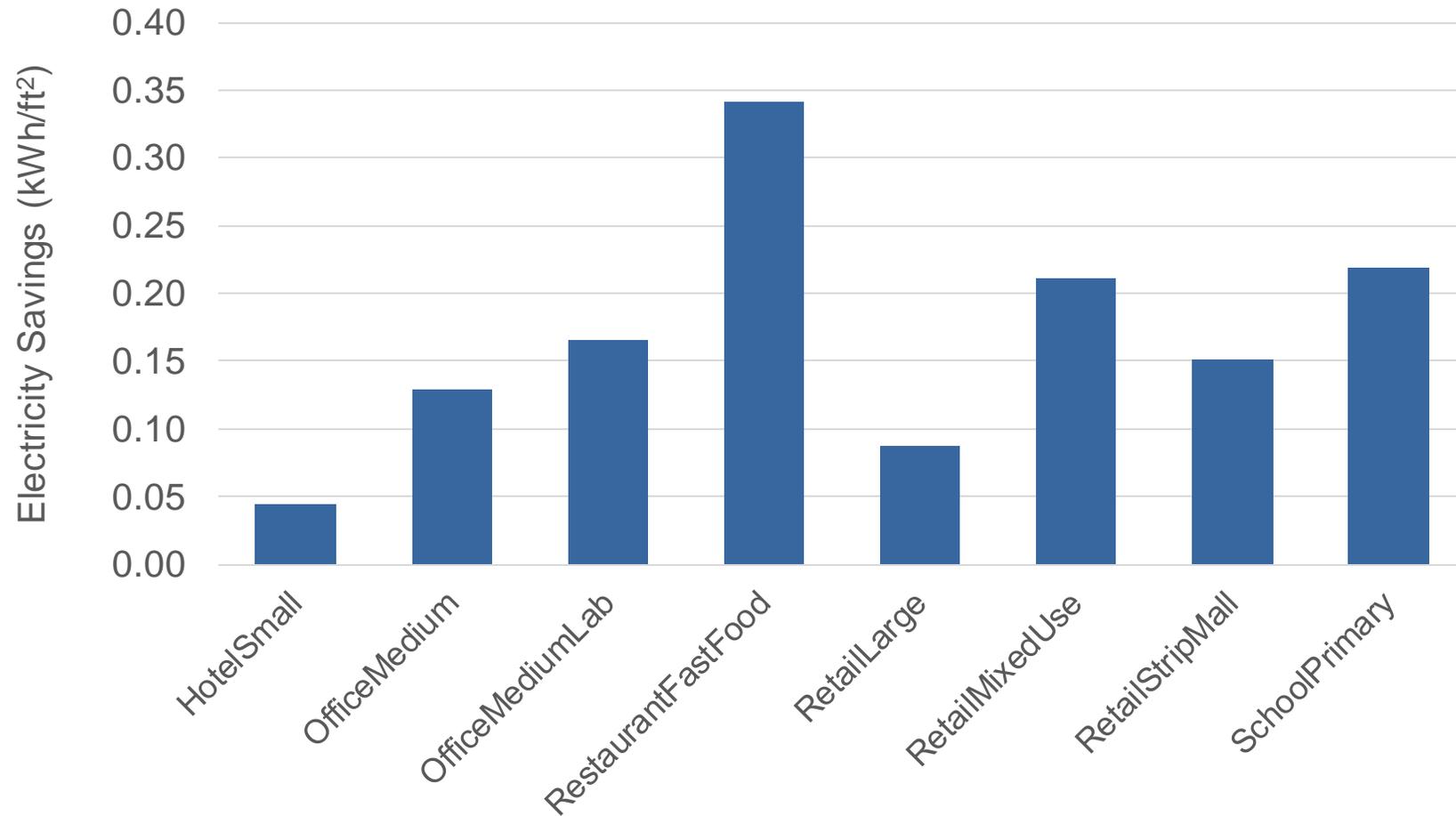
Cooling Capacity: 674,870 Btu/h

Airflow Rate: 22,662 CFM

Energy Savings Results (kWh/ sq-ft) (Expand Integrated Economizing)

All Building Types, Climate Zone 8

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 8

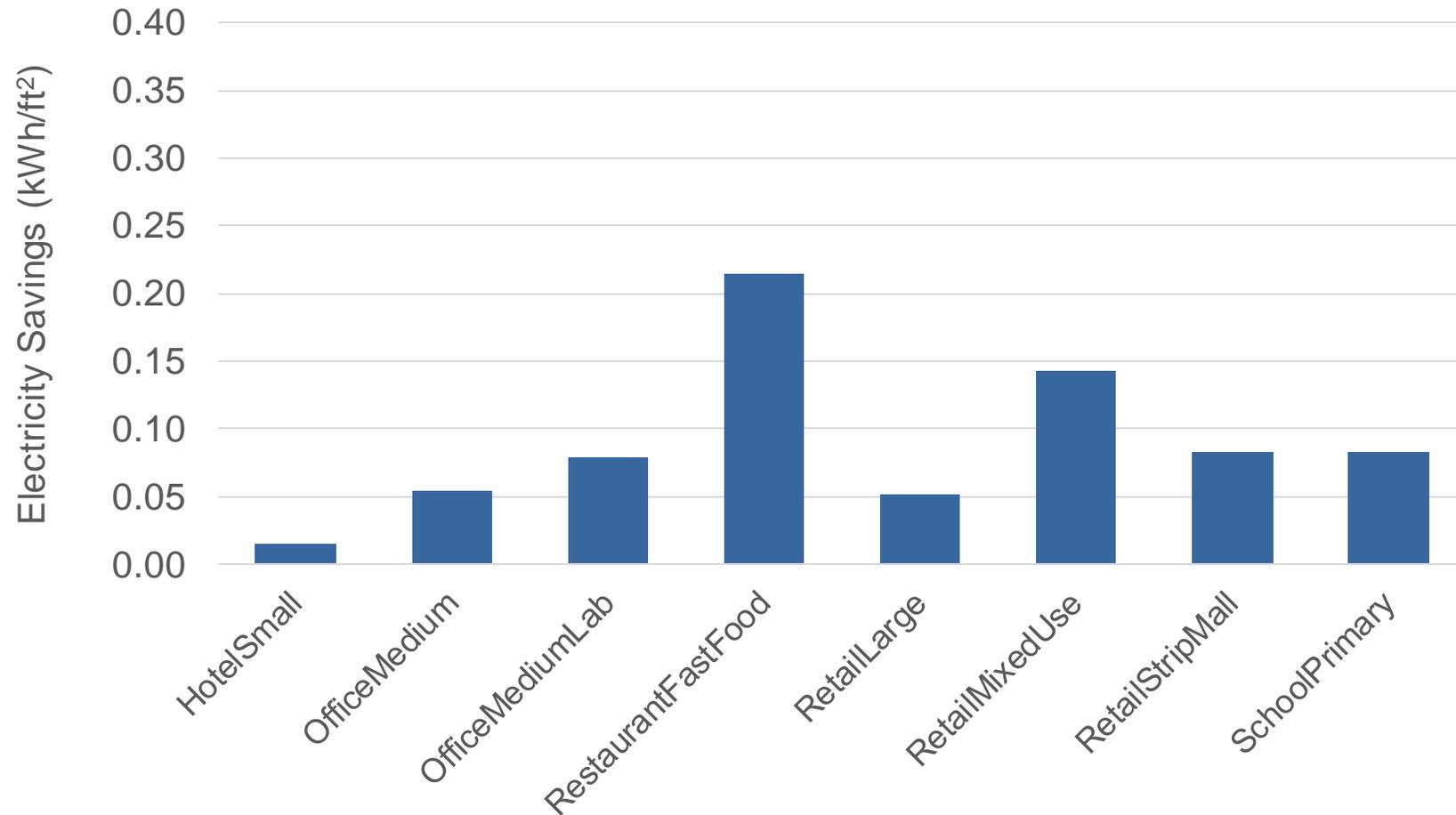


Distribution of savings across
prototype models for CZ08
(Fullerton)

Energy Savings Results (kWh/ sq-ft) (Expand Integrated Economizing)

All Building Types, Climate Zone 3

First Year Electricity Savings for All Analyzed Prototypical Buildings in Climate Zone 3



Distribution of savings across prototype models for CZ03 (Oakland)

Savings are significantly lower around the board due to more mild weather.

2023 Construction Forecast: New Construction

(Expand Integrated Economizing)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	10.36	0%	0.0
Large Office	36.28	50%	1.0
Restaurant	5.44	100%	5.4
Retail	31.81	90%	28.6
Grocery Store	8.39	0%	0.0
Non-refrigerated Warehouse	29.95	0%	0.0
Refrigerated Warehouse	1.64	0%	0
Schools	12.39	60%	7.4
Colleges	6.50	35%	1.3
Hospitals	9.32	0%	0.0
Hotel / Motel	10.69	100%	10.7
Total	162.78	33.47%	54.48

2023 Construction Forecast: Existing Buildings

(Expand Integrated Economizing)

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Statewide Existing Building Impacted by Proposal	Statewide Existing Building Impacted by Proposal in 2023 (million square feet)
Small Office	476.52	0%	0
Large Office	1,665.45	3%	44.5
Restaurant	238.92	5%	11.9
Retail	1,490.53	5%	67.1
Grocery Store	394.19	0%	0
Non-refrigerated Warehouse	1,402.32	0%	0
Refrigerated Warehouse	75.65	0%	0
Schools	724.95	3%	21.7
Colleges	379.99	2%	3.8
Hospitals	488.66	0%	0
Hotel / Motel	451.77	5%	22.6
Total	7,788.95	2.20%	171.6

Statewide Energy Savings (Expand Integrated Economizing)

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/ yr)	TDV Energy Savings (TDV kBtu/yr)
New Construction	5.5	0.6	0	149.6
Additions and Alterations	17.1	1.4	0	466.1
Total	22.6	2.0	0	615.7

Energy Saving Estimates (Expand Integrated Economizing)

- Savings are significant, shows measure would **save 0.03%~2.8% of total building kBTUs**
- Large electrical savings, no change for gas usage

- **Do these savings sound realistic?**

Software Updates

- **Current modeling capabilities:**

- Models packaged DX unit compressor turndown to 35% for 240,000 Btu/h cooling capacity and less
- Models packaged DX unit compressor turndown to 25% for 240,000 Btu/h cooling capacity and less

- **Proposed new modeling capabilities:**

- Models packaged DX unit compressor turndown to 50% for cooling capacity between 33,000 Btu/h and less than 65,000 Btu/h
- Models packaged DX unit compressor turndown to 35% for cooling capacity between 65,000 Btu/h and less than 110,000 Btu/h
- Models packaged DX unit compressor turndown to 25% for cooling capacity between 110,000 Btu/h and less than 240,000 Btu/h
- Models packaged DX unit compressor turndown to 15% for cooling capacity of 240,000 Btu/h and larger

Draft Code Change Language (revised)

- **Updated** draft code language for this submeasure is available in the **resources tab**.
- Code language has gone through significant changes. In these four ways:
 - Dropped Submeasure on Power Modulated Exhaust Fans
 - Dropped Submeasure on Minimum Separation Distance from Intake and Exhaust
 - Adjusted Integrated Economizer values, added additional bins
 - Added in ASHRAE Standard 90.1 Clean-up language for Table 140.4-D
- We recognize there may be need for exceptions for these requirements and encourage your feedback on this measure.

Adjust Minimum Displacement Requirements

update number
of stages

update
minimum
displacement

	Cooling Capacity	2019 Code Minimum Number of Mechanical Cooling Stages	2019 Code Minimum Compressor Displacement (percent of full load)	Proposed 2022 Minimum Number of Mechanical Cooling Stages	Proposed 2022 Minimum Compressor Displacement (percent of full load)
Add a lower capacity bin	≥ 33,000 Btu/h and < 65,000 Btu/h	N/A	N/A	2 stages	≤ 50%
Divided into two bins	≥ 65,000 Btu/h and < 110,000 Btu/h	3 stages	≤ 35%	3 stages	≤ 35%
	≥ 110,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35%	4 stages	≤ 25%
	≥ 240,000 Btu/h	4 stages	≤ 25%	4 stages	≤ 15%

ASHRAE Standard 90.1 Code Clean-up

TABLE 140.4-D ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement ^a
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%
13	30%
14	30%
15	30%
16	70%

^a If a unit is rated with an annualized or part-load metric IPLV, IEER or SEER, then to eliminate the required ~~air or water~~ economizer, only the applicable annualized or part-load minimum cooling efficiency of the ~~HVAC~~ unit must be increased by the percentage shown. If the ~~HVAC~~ unit is only rated with a full load metric, ~~such as~~ like EER or COP cooling, then that metric must be increased by the percentage shown. To determine the efficiency required to eliminate economizer, when the unit equipment efficiency is rated with an energy-input divided by work-output metric, the metric shall first be converted to COP prior to multiplying by the efficiency improvement percentage and then converted back to the rated metric.

This change generalizes compliance for part-load and annualized metrics.

Language is currently identical to what is being discussed under ASHRAE Standard 90.1 subcommittee and our CASE Team will track any changes closely

Thank You

Questions?

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2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Reduced Infiltration

Codes and Standards Enhancement (CASE) Proposal
Nonresidential | Reduced Infiltration

Benny Zank & Alamelu Brooks, *Energy Solutions*
April 14, 2020

Agenda

1 Today's Objectives

2 Proposal Background

3 Cost and Energy Calculations

4 Questions and Next Steps

Today's Objectives

The focus of today's meeting includes the following, across **three** submeasures:

- 1. Review** Expansion of Air Barrier Requirements to All Climate Zones and Alterations
- 2. Review** Testing and Failure Protocols
- 3. Review** Energy and Cost Methodology and Calculations
- 4. Revisit** Code Language



Proposal Background

Why Address Air Leakage?

- Tighter buildings:
 - Require less energy to heat and cool
 - Have fewer moisture issues
 - Have improved odor and sound control
- Testing is necessary to evaluate leakage
- Whole building leakage testing will:
 - Identify leaks to seal
 - Confirm performance is achieved
 - Provide contractors/building owners with feedback, opportunity for continuous improvement



Code Change Proposal Summary

Submeasures	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Expand continuous air barrier requirement to all climate zones	Prescriptive		Section 140.3 (a) 9	
Require whole building leakage testing <ul style="list-style-type: none"> • <i>Reduce minimum leakage rates</i> • <i>With alternative for air barrier verification (discuss today)</i> 	Prescriptive	Y	Section 140.3(a) 9 and Section 141.0(b) 2	NRCC-ENV-E
Update default leakage rates in compliance modeling	Performance	Y	N/A	
Vestibules	No longer proposing for 2022	--	--	--

Code Change Proposal Summary

1. Expand Continuous Barrier Requirements

Current

- Continuous air barrier:
 - Required in climate zones 10 – 16
 - Not required for in hotel/motel guest rooms
 - No air barrier requirements for alterations in any climate zone

Proposed

- Continuous air barrier required in all climate zones and all building types in new construction
- Air barrier requirements for major alterations
 - Exceptions from IECC/ASHRAE 90.1:
 - Storm windows over existing fenestration, surface-applied window film
 - Envelope cavities exposed during construction, if filled with insulation
 - Roof recover or replacement where the rest of the envelop is not renovated or repaired

Are there specific alterations that should be included?

Code Change Proposal Summary

2. Require Leakage Testing to Confirm Workmanship of Air Barrier

Current

Continuous air barriers must either:

1. Use materials that meet leakage criteria; OR
2. Use assemblies that meet leakage criteria; OR

Exception: construction types that naturally meet air barrier requirements

3. Achieve whole building leakage of 0.4 cfm/ft² when tested in accordance with E779

Proposed

Continuous air barriers must:

1. Use materials or assemblies that meet leakage criteria; **AND**
2. Conduct whole building leakage test in accordance with ASTM E3158 and complete following mitigations:
 1. Tested leakage \leq 0.3 cfm/ft²: no mitigation
 2. Tested leakage $>$ 0.3 cfm/ft² \leq 0.6 cfm/ft²: mitigate as directed (see slides 11-12)
 3. Tested leakage $>$ 0.6 cfm/ft²: retest after mitigation

Exception: continuous air barrier is verified (see ASHRAE example on slide 15)

Comparison of Current Code Requirements

2018 Washington State Energy Code (Mandatory)	ASHRAE 90.1 – 2019 (Mandatory)
<p>C402.5.1 Air Barriers Continuous air barrier required.</p> <p>C402.5.1.1 Air Barrier Construction Technical specifications for construction of air barrier.</p> <p>C402.5.1.2 Building test. The air leakage rate of the <i>building envelope</i> shall not exceed 0.25 cfm/ft² at 0.3 in. wc.</p> <p>If the tested rate exceeds that defined here by up to 0.15 cfm/ft², a visual inspection of the air barrier shall be conducted and any leaks noted shall be sealed to the extent practicable.</p>	<p>5.4.3.1 Continuous Air Barrier Continuous air barrier is mandatory. Exceptions: semiheated spaces in CZ 0-6, single wythe concrete masonry buildings in CZ2B</p> <p>5.4.3.1.1 Whole-Building Air Leakage The measured air leakage rate of the building envelope shall not exceed 0.40 cfm/ft² at 0.3 in. wc.</p> <p>Where the measured air leakage rate exceeds 0.40 cfm/ft² but does not exceed 0.60 cfm/ft², a diagnostic evaluation shall be conducted and any leaks noted shall be sealed to the extent practicable.</p>

- ASHRAE 90.1 requires whole building air leakage testing in addition to requirements for materials or assemblies.
- Voted in as an IECC 2021 mandatory requirement. Exception to Buildings or portions of buildings of other than group R and group I occupancy: Buildings in Climate Zones 2B, 3B, 3C, and 5C.

Code Change Proposal Summary

2. Require Leakage Testing to Confirm Workmanship of Air Barrier

ASTM E3158 builds on **ASTM E779** by providing:

1. Additional protocols for testing large or multizone buildings by co-pressurization
2. Larger test pressure range
3. Detailed building preparation instructions for testing
4. Additional data quality requirements

Costs do not change.

Code Change Proposal Summary

2. Require Leakage Testing to Confirm Workmanship of Air Barrier

Mitigation if tested leakage exceeds 0.3 cfm/ft²

**Tested leakage rate
is between 0.30 cfm/ft² and 0.60 cfm/ft²**

1. Complete diagnostic evaluation
2. Seal leaks
3. Submit comprehensive report on testing and corrective actions

**Tested leakage rate
is greater than 0.60 cfm/ft²**

1. Complete diagnostic evaluation
2. Seal leaks
3. Retest to confirm leakage < 0.6 cfm/ft²
4. Submit report on testing and corrective actions.

Additional appendix section to clarify what would be required for diagnostic evaluation.

Code Change Proposal Summary

2. Require Leakage Testing to Confirm Workmanship of Air Barrier

FAQ

1. When?

- Several weeks before the certificate of occupancy, when the envelope is fully installed.

2. What happens if not passed?

- The testing agency performs diagnosis (smoke tracer and infrared imaging) during pressurization test.
- Identify leakage points and prepare a report for the contractor and building owner with mitigation.
- The contractor submits an additional report detailing mitigation steps taken to the building owner and code official.
- See next slides for diagnostic details.

Code Change Proposal Summary

2. Require Leakage Testing to Confirm Workmanship of Air Barrier

What happens if measured air leakage is greater than allowable limit?

Verification of temporary seals and mandatory seals of the air barrier (Section 110.7).

Use a smoke tracer to identify leaks according to ASTM E1186-17. Typical locations:

- Perimeter of windows and doors
- Operable window and door hardware
- Penetrations through the roof, wall, and floor assemblies along the plane of the intended air-barrier
- Electrical outlets located on exterior-facing walls
- Lighting and other electrical penetrations through the roof level ceiling
- Above- and below-grade vestibules
- Stairs leading to unconditioned space

Poll

What should happen if a building retests and has an infiltration rate above 0.60 cfm/ft²?

- A. Repeated diagnostics testing and sealing, and retest
- B. Repeated diagnostics testing and sealing, no retest
- C. Document why 0.60 cfm/ft² could not be met and seek approval of variance from code official
- D. Other (please elaborate)

ASHRAE 90.1 Alternative

2. Alternative for Continuous Air Barrier Design and Installation Verification

- ASHRAE 90.1-2019 alternative allows for continuous air barrier verification instead of leakage testing (Exception 3 to Section 5.4.3.1.1)
- Requirements of Continuous Air Barrier Design and Installation Verification (Section 5.9.1.2)
 1. Complete a third party design review to verify compliance with air barrier requirements
 2. Complete periodic third party field inspections during constructions while continuous air barrier is still accessible for inspection
 3. Repair to verify compliance
 4. Document results in “field performance test” documents

Field Inspection Procedures

2. Alternative for Continuous Air Barrier Design and Installation Verification

1. Initial assemblies of all air barrier systems, with additional periodic reviews of progress installation (defined as once per week of construction or every 1000 ft² of envelope area installed if construction is not continuous).
2. Transitions to adjacent air barrier systems (including but not limited to: Roof parapet transitions, glazed framing systems to adjacent framed wall assemblies transitions , plaza waterproofing to podium transitions, vertical wall to soffit transitions)
3. Detailing of penetrations through air barrier systems.
4. Building assemblies used as ducts or plenums
5. Contractor internal quality control/quality assurance procedures

Red text is additionally proposed by the Statewide CASE Team

Poll

Should Title 24, Part 6 offer a continuous air barrier verification alternative? Please explain.

- A. Yes
- B. No
- C. It depends
- D. Not sure

Sampling Procedure Options

ASHRAE 90.1 Sampling

For buildings over 50,000 ft² conditioned floor area, the following portions of the building must be tested:

- a. The entire floor area of all stories that have any spaces directly under a roof.
- b. The entire floor area of all stories that have a building entrance or loading dock.
- c. Additional representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space.

PNNL formula for ASHRAE 90.1 sampling procedure

Building Size	Percent of floor space tested (PNNL formula for tested floor area)
Below 50,000 sq. ft.	Full area is tested
50,000 – 150,000 sq. ft	50,000 sq. ft plus 75% of area above 50,000 sq. ft
Above 150,000 sq. ft.	50,000 sq. ft 75% of area between 50,000 and 150,000 sq. ft 50% of area above 150,000 sq. ft

Sampling Procedure Options

PNNL Sampling Example

Building Size (square feet)	Baseline Sample Size (square feet) A	50,000 – 150,000 Square Feet Sample Size (square feet) B	Greater Than 150,000 Square Feet Sample Size (square feet) C	Total Sample Size (square feet) A + B + C
25,000	25,000	--	--	25,000
50,000	50,000	--	--	50,000
100,000	50,000	$75\% \times (100,000 - 50,000)$ 37,500	--	87,500
150,000	50,000	$75\% \times (150,000 - 50,000)$ 75,000	--	125,000
200,000	50,000	$75\% \times (150,000 - 50,000)$ 75,000	$50\% \times (200,000 - 150,000)$ 25,000	150,000
300,000	50,000	$75\% \times (150,000 - 50,000)$ 75,000	$75\% \times (300,000 - 150,000)$ 75,000	200,000

Poll

Should sampling be allowed for whole building air leakage testing?

- A. Yes, follow ASHRAE 90.1
- B. Yes, other sampling procedure (please elaborate)
- C. No
- D. Not sure

Code Change Proposal Summary

3. Update default leakage rates in compliance modeling

Current

CBECC-Com default value:

- Standard Design: leakage of 0.4 cfm/ft² for all climate zones regardless of whether a prescriptive requirement for a continuous air barrier exists and how the barrier is verified

ASHRAE 90.1 default value (for reference):

- Baseline Building: leakage rate of 1.8 cfm/ft² from ASHRAE 90.1-2009 without an air barrier
- Prototype Building: *continuous air barrier is mandatory*
 - Air leakage test completed: 0.4 cfm/ft²
 - Continuous air barrier verification default value: 0.6 cfm/ft²

Proposed

CBECC-Com default value:

- Standard Design: 0.3 cfm/ft²
 - Assumes continuous air barrier in all climate zones
 - Assumes continuous air barrier is verified with a leakage test
- Proposed design options:
 - No continuous air barrier: TBD – use an appropriate leakage rate if builder trades off continuous air barrier
 - Continuous air barrier with air leakage test completed: 0.3 cfm/ft²
 - Continuous air barrier with continuous air barrier verification: 0.6 cfm/ft²

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
 - Incremental costs
 - Maintenance costs
 - Energy cost savings
- Cost-effectiveness



Methodology for Energy Impacts Analysis

Calculated reduction in HVAC energy usage as a result of reduced infiltration.

Tools Used	Spreadsheet analysis, CBECC simulation
Building Prototypes Used	Hotel Small, Office Small, Office Large, Office Medium Lab, Office Medium, Retail Large, Retail Mixed-use, Retail Standalone, Retail Strip-mall, School Secondary, School Primary, Warehouse
Climate Zones Modeled	All 16 climate zones

Definition of Baseline and Proposed Conditions



Baseline Conditions

Infiltration rate of 0.80 cfm/ft² at 0.3 iwc in all climate zones



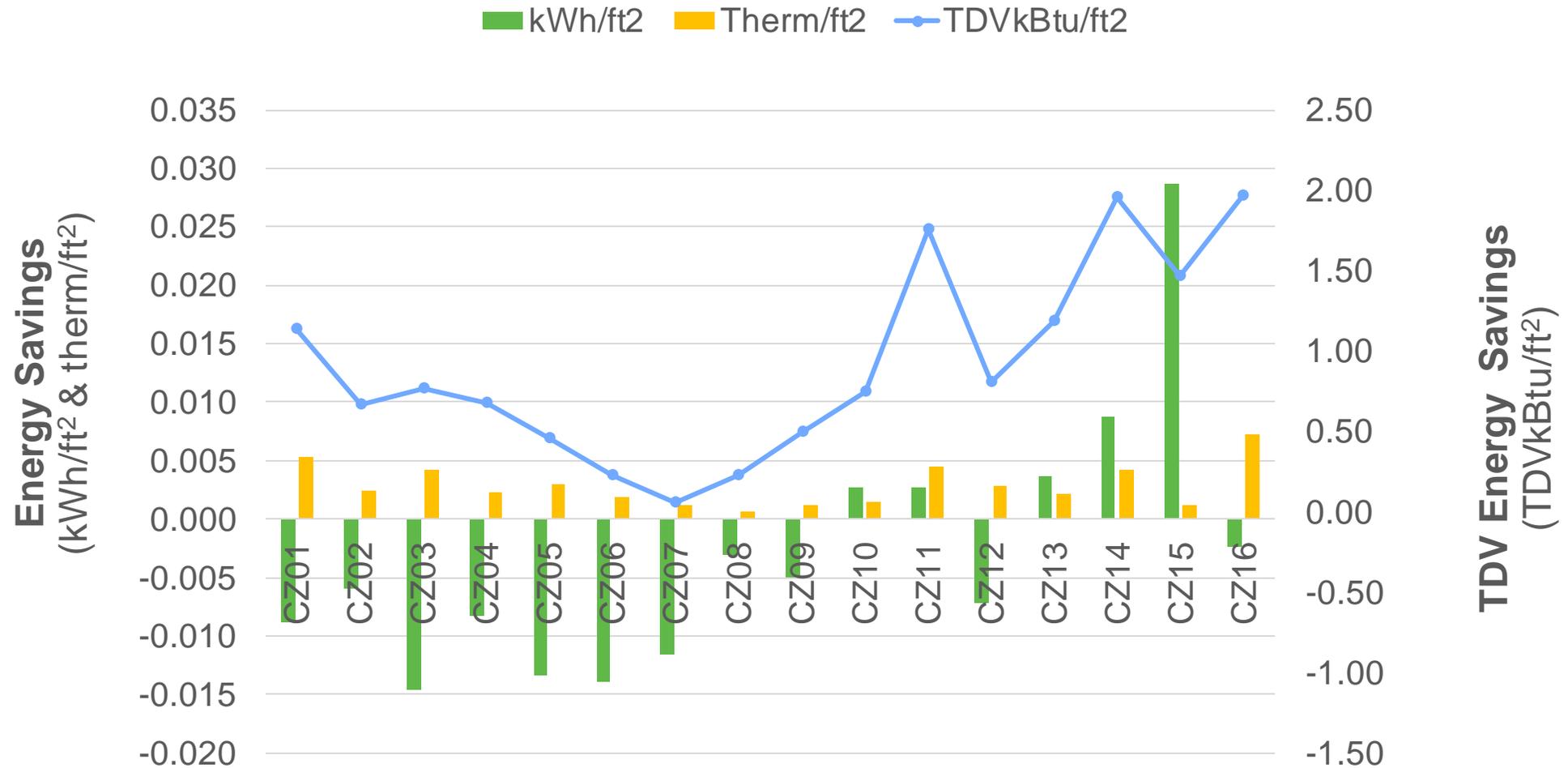
Proposed Conditions

Infiltration rate of 0.30 cfm/ft² at 0.3 iwc

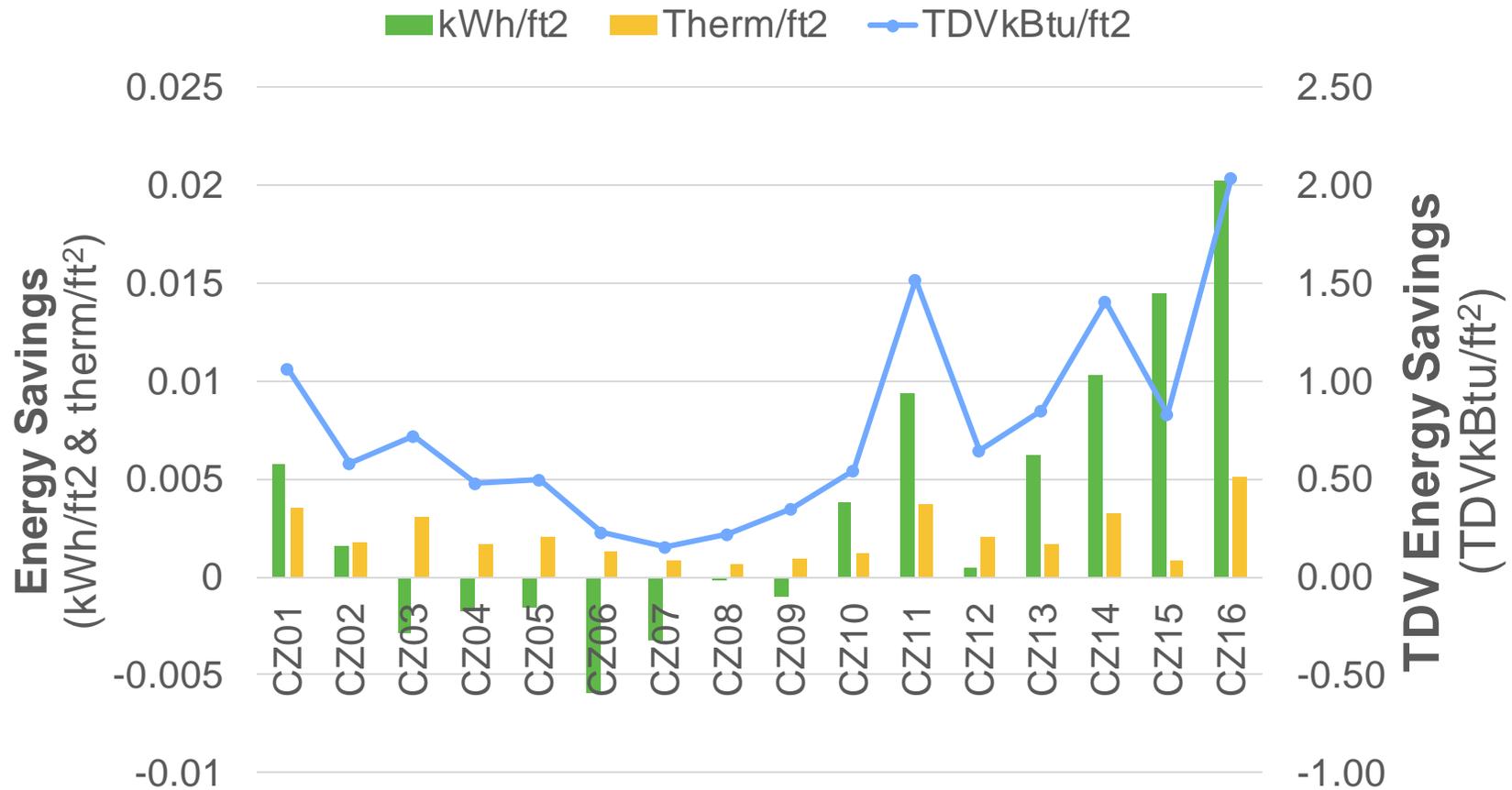
Notes:

- Baseline compliant with 2019 Energy Code
- Evaluated over 30-year period of analysis

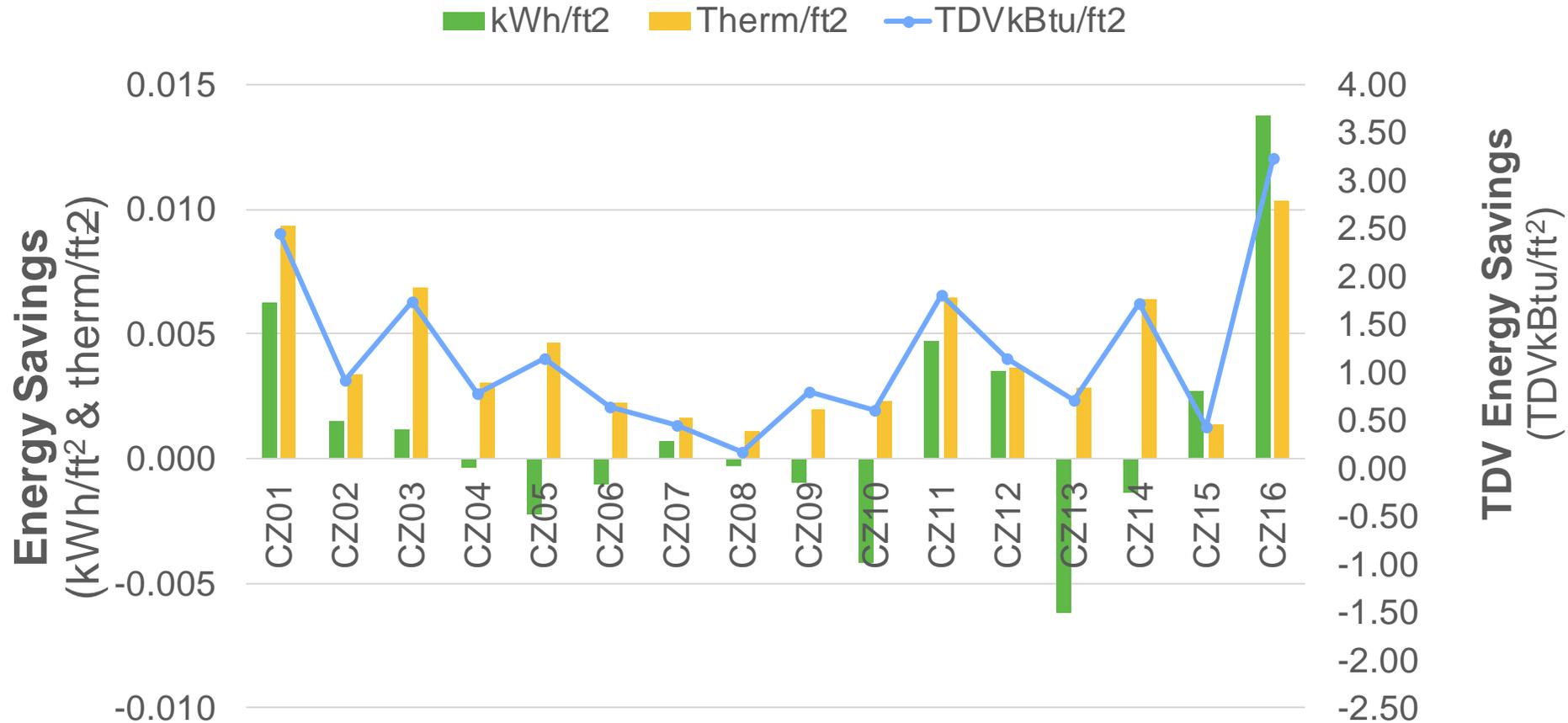
Energy Savings Per Square Foot – Office Medium



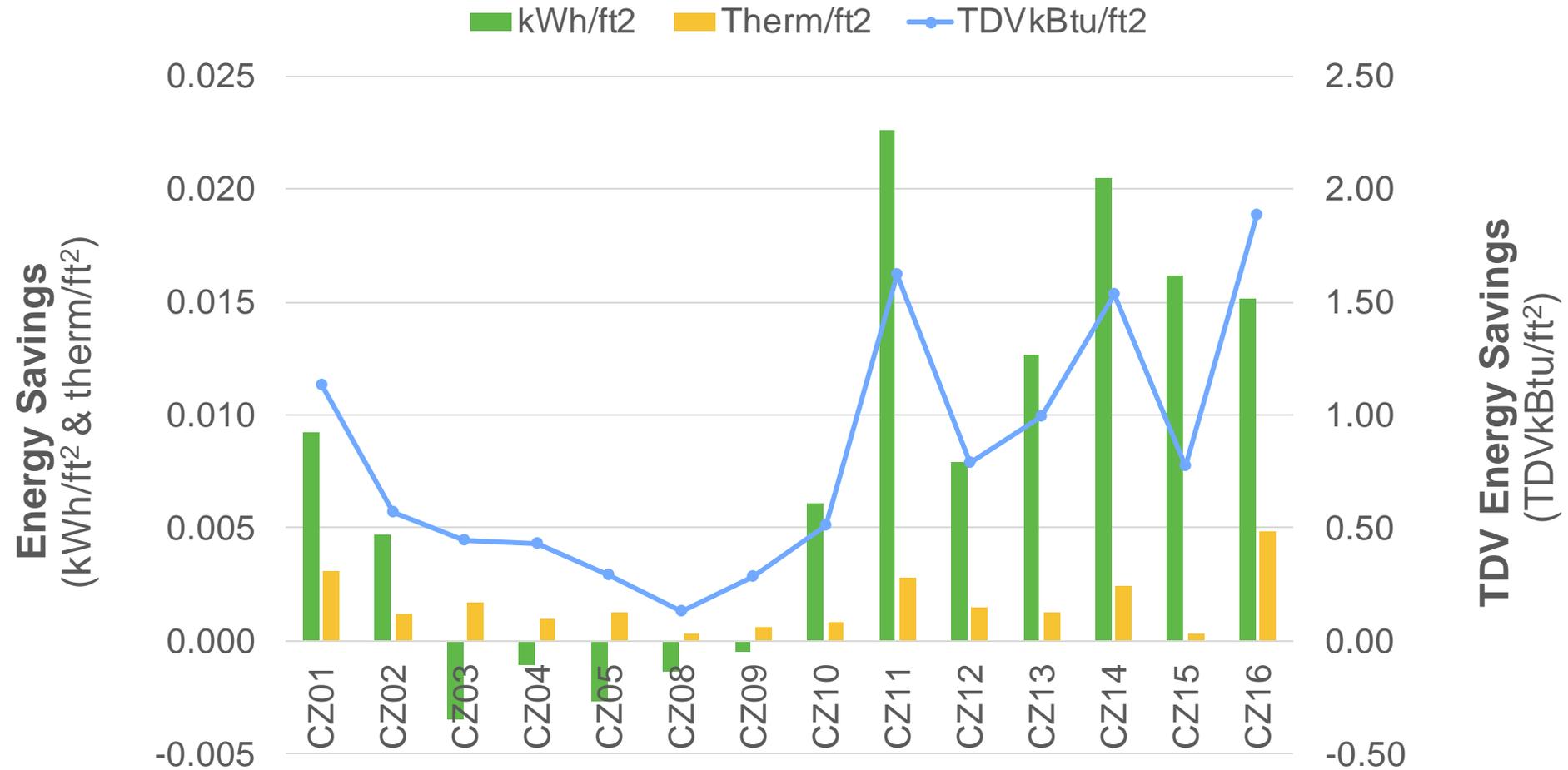
Energy Savings Per Square Foot – Secondary School



Energy Savings Per Square Foot – Warehouse



Energy Savings Per Square Foot – Dormitory

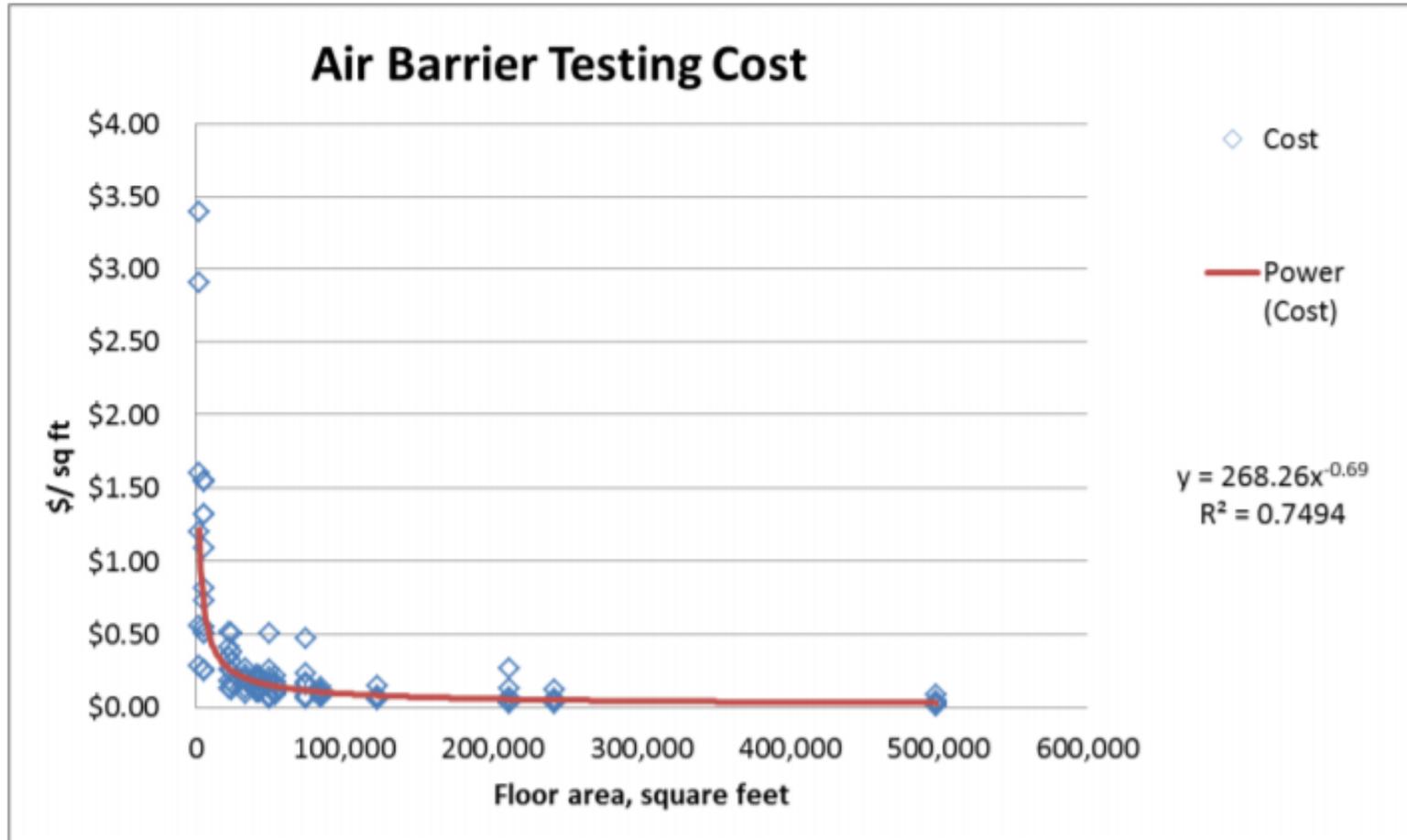


Incremental Cost Information

- Costs were collected through interviews with testing professionals inside and outside of California and literature reviews.
- Incremental first costs include:
 - Preparation and coordination of test
 - Fan rentals
 - Labor hours to execute the test
 - Labor hours for data analysis

Is anything missing from the included costs? The Statewide CASE Team is investigating the costs for air barrier materials in CZ 1-9.

Incremental Cost Information



What are your reactions to these costs?

The Statewide CASE Team is collecting and revising costs.

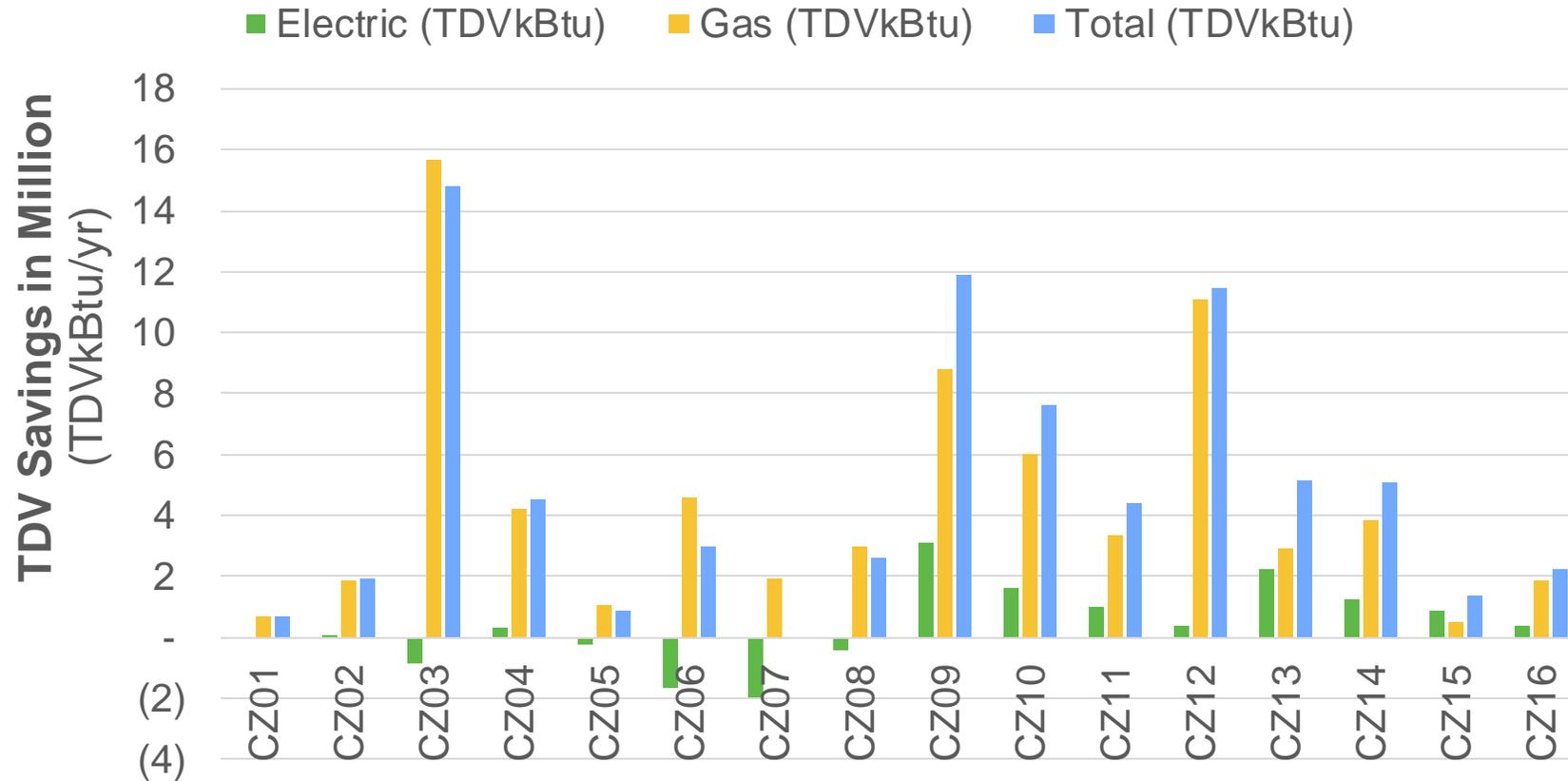
Costs incorporate PNNL's formula for the ASHRAE 90.1 sampling procedure

First Year Statewide Savings

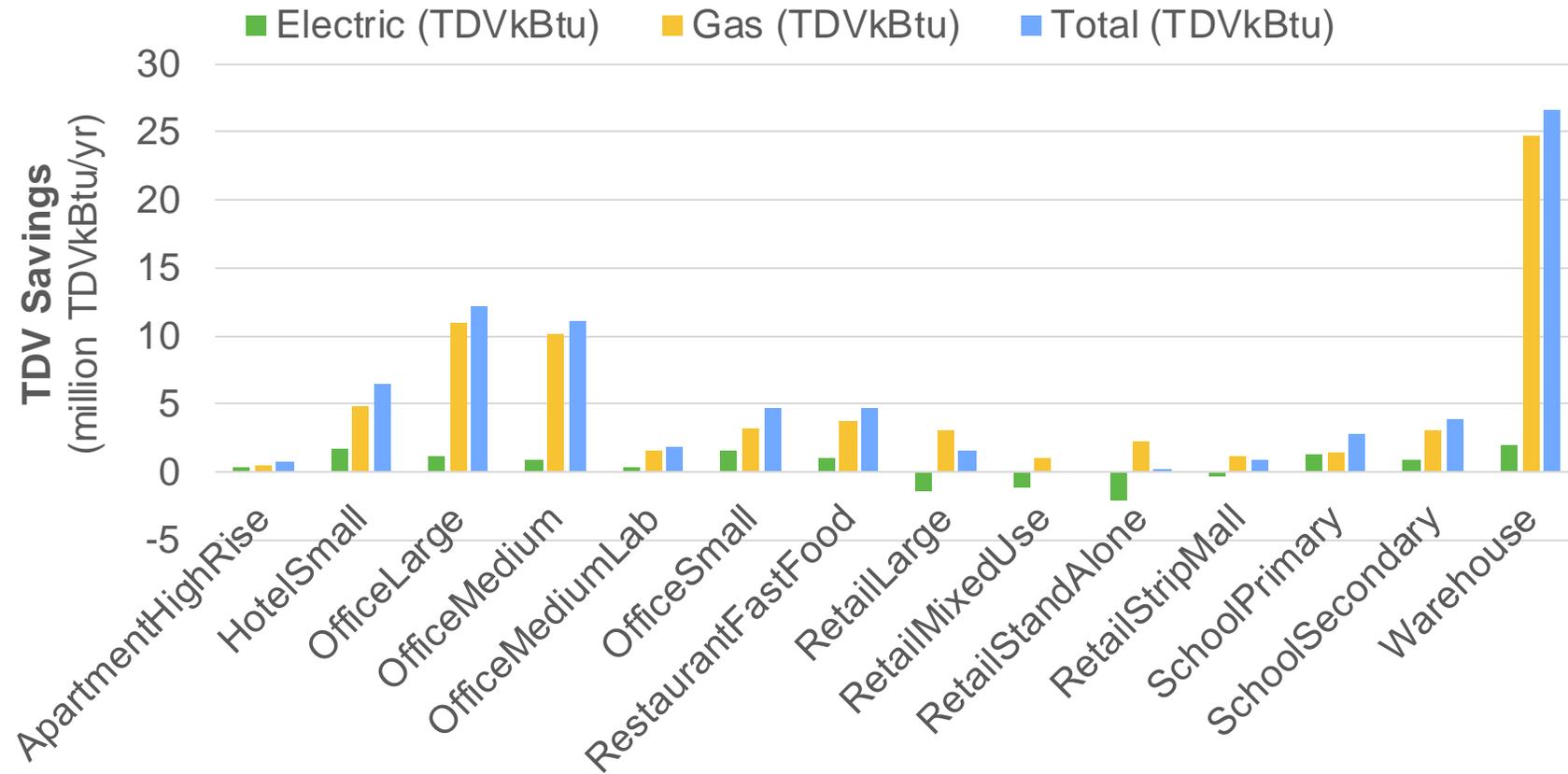
	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/yr)	TDV Energy Savings (TDV kBTU/yr)
New Construction	1.5	7.6	2.4	790.5
Alterations	2.1	10.7	3.4	1,111.0
Total	3.5	18.3	5.8	1,901.5

Note: There are negative electric savings for some climate zones and building types. Gas and TDV savings are positive in every climate zone.

Statewide First-Year TDV Savings – New Construction



Statewide First-Year TDV Savings – New Construction



2023 Construction Forecast: New Construction

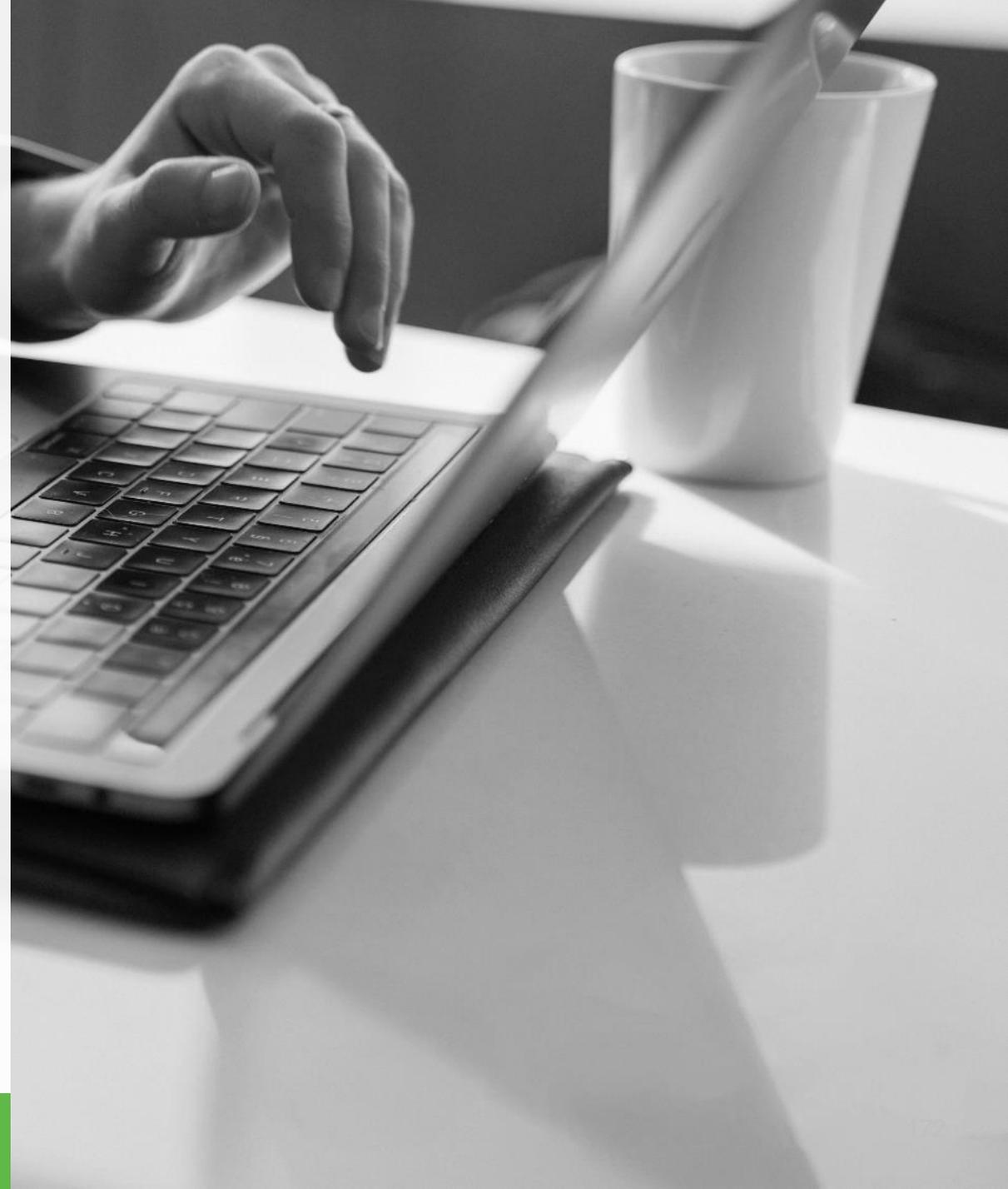
Building Type	Total Statewide New Construction Permitted (million square feet)	Percent Impacted
Small Office	10	100%
Large Office	36	100%
Restaurant	5	100%
Retail	32	100%
Non-Refrigerated Warehouse	30	100%
Schools	12	100%
Colleges	7	100%
Hotel/Motels	11	100%
Total	143	100%

2023 Construction Forecast: Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of area Impacted by Proposal	Statewide Impacted by Proposal in 2023 (million square feet)
Small Office	477	3%	14
Large Office	1,665	3%	50
Restaurant	239	3%	7
Retail	1,491	3%	45
Non-refrigerated Warehouse	1,402	3%	42
Schools	725	3%	22
Colleges	380	3%	11
Hotel / Motel	452	3%	14
Total	6,830	3%	205

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

- **Updated** draft code language for this submeasure is available in the **resources tab**.
- Whole building air leakage will be a **prescriptive requirement** for all climate zones
- The **maximum infiltration** rate shall be 0.30 cfm/ft² at 0.3 iwc.
- If the tested rate exceeds 0.30 cfm/ft² but does not exceed 0.60 cfm/ft², a diagnostic evaluation shall be conducted and any leaks noted shall be sealed. If the tested rate exceeds 0.60 cfm/ft² the building shall be sealed and retested.
 - Exception for periodic field inspections for an attributed infiltration rate of 0.60 cfm/ft²
 - Code official determines compliance when infiltration exceeds 0.30 cfm/ft² at 0.3 iwc.
- Alterations will be included:
 - Significant envelope replacement or improvement requires meeting the new construction requirements.
 - Other alterations to the envelope or HVAC duct system replacements are not required to retest if they cannot meet 0.60 cfm/ft² but must make improvements where practical.

Software Updates

- **Adjustment to the default** leakage rate.
- **Functionality** needs to be added to input:
 - If using whole building air leakage testing or air barrier verification exception
 - Possibility for project teams to input a lower infiltration rate in the performance path if it is verified

Code Change Proposal: Additional Resources

First-Utility Sponsored Meeting

The Statewide CASE Team held its first utility-sponsored stakeholder meeting for this topic on **November 5, 2019 (Reduced Infiltration)**



Resources on [Title24stakeholders.com](https://www.title24stakeholders.com)

Presentation slides and **Submeasure summary** documents available that cover the following ([link](#)):

- ✓ Measure Background
- ✓ Market Overview & Analysis
- ✓ Technical Feasibility
- ✓ Cost and Energy Methodology
- ✓ Compliance & Enforcement
- ✓ Proposed Code Changes

Also available in the **resources tab** in today's presentation.

**Thank
You**

Questions?

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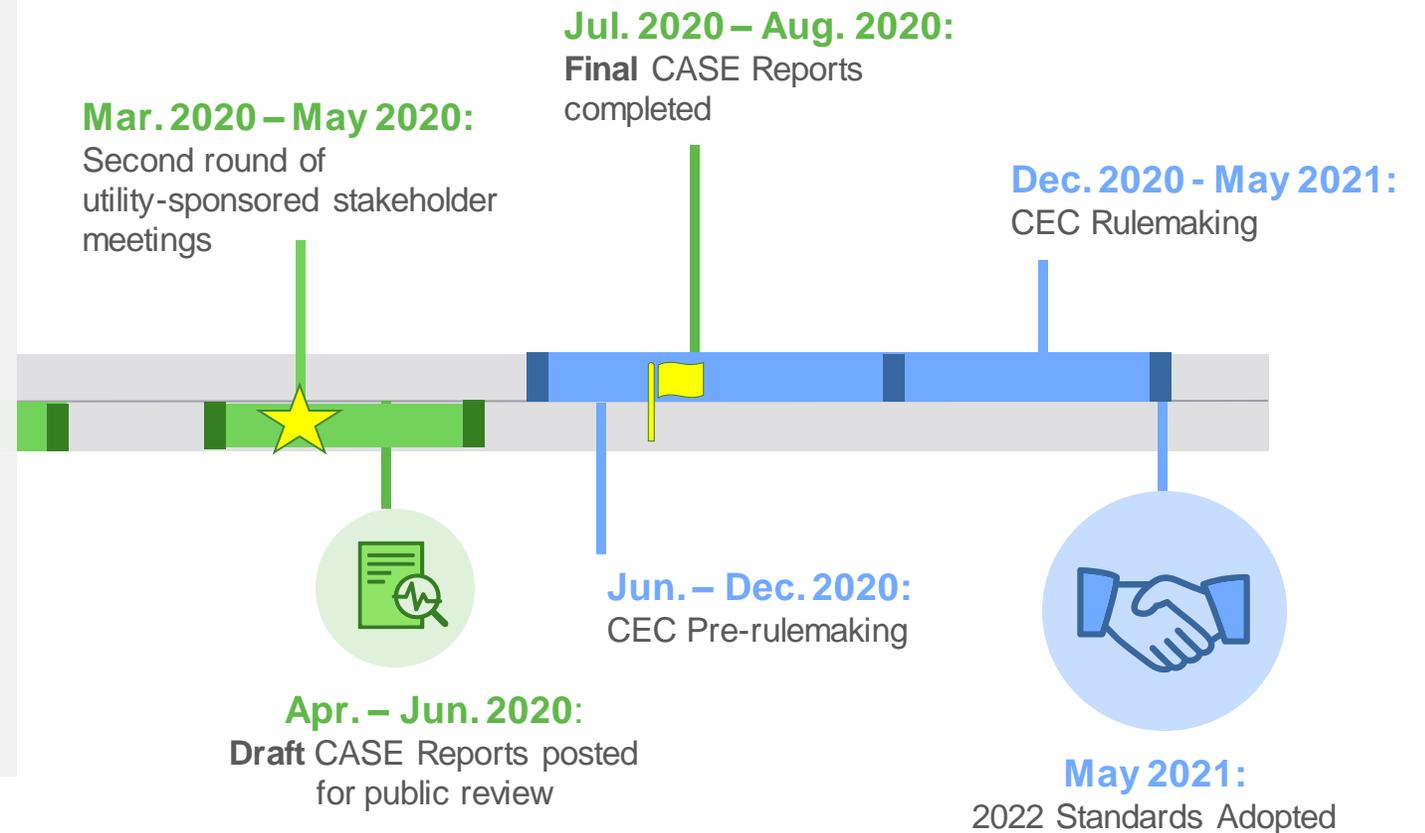
We want to hear from you!

- + Stakeholder meeting feedback informs utility-sponsored CASE Reports.
- + Draft CASE Reports for today's topics will be published in **June 2020**.

*Comments will be considered as they are received. Stakeholders are invited to submit feedback on [today's presentation](#), and the [Draft CASE Report](#) to help shape the **Final** CASE Report submitted to the Energy Commission.*



info@title24stakeholders.com



Upcoming Meetings

Meeting Topic	Building Type	Date
Covered Processes Part 2: Controlled Environmental Horticulture	NR	Thursday, April 16, 2020
Nonresidential Envelope Part 1: High Performance Envelope	NR	Thursday, April 23, 2020
Multifamily Restructuring	MF	Thursday, May 7, 2020

Thank you for your participation today

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Please complete the closing polls below

