Round 2

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

Nonresidential and Single Family HVAC Proposals (Part 1)

We will begin shortly.

In the meantime, please fill out the polls below.

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

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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.

***Above**: audio conference settings pop-up box*

2022 TITLE 24 CODE CYCLE, PART 6

Second Utility-Sponsored Stakeholder Meeting

Nonresidential and Single Family HVAC Part 1: *Data Centers, Boilers, Air Distribution, Variable Capacity*

Statewide CASE Team

March 12, 2020

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Meeting Guidelines

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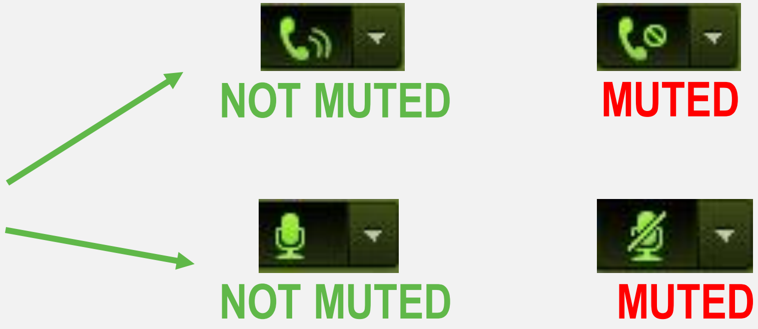


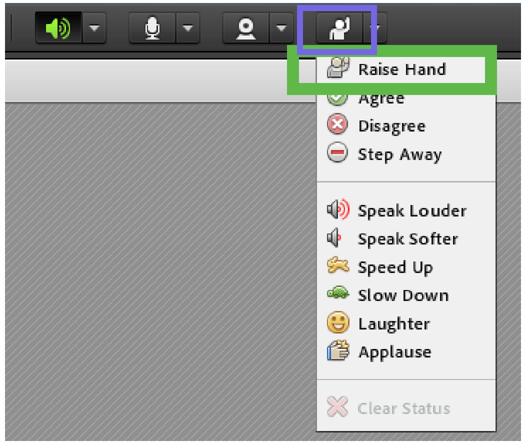
Meeting Guidelines

Part 2 of 3 - Participation

Participation Guidelines:

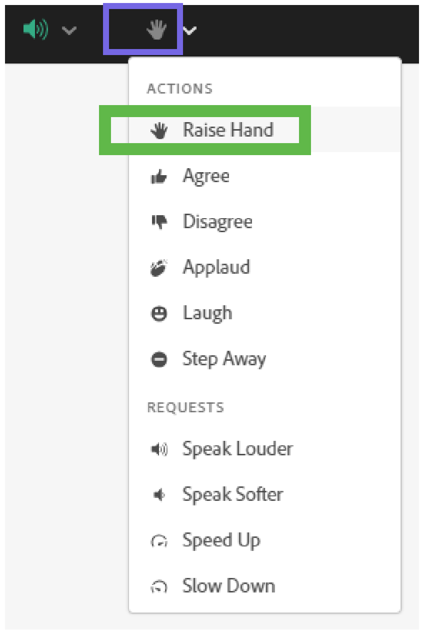
- **Questions & Comments**
  - Click “***Raise Hand***” if you would like to speak. Those with a hand raised will be called on by the speaker.
  - All questions and comments are also welcome via the chat window.

- **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 3 of 3 – Discussion Ground Rules

- **We want to hear your thoughts.**
  - Supporting and opposing viewpoints are welcome.
- **When making comments, please:**
  1. Unmute yourself;
  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**	*8:30 am*
2	**Opening Remarks** from the California Energy Commission	*8:35 am*
3	**Overview & Welcome** from the Statewide Utility Team	*8:40 am*
4	**Presentation I:** Nonresidential Air Distribution	*8:45 am*
5	**Presentation II:** Computer Room Efficiency	*9:45 am*
6	**Presentation III:** Nonresidential High Efficiency Boilers and Service Water Heating	*10:30 am*
7	**Presentation IV:** Single Family Variable Capacity HVAC Compliance Software Revisions	*11:30 am*
8	Wrap Up & Closing	*12:15 pm*

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

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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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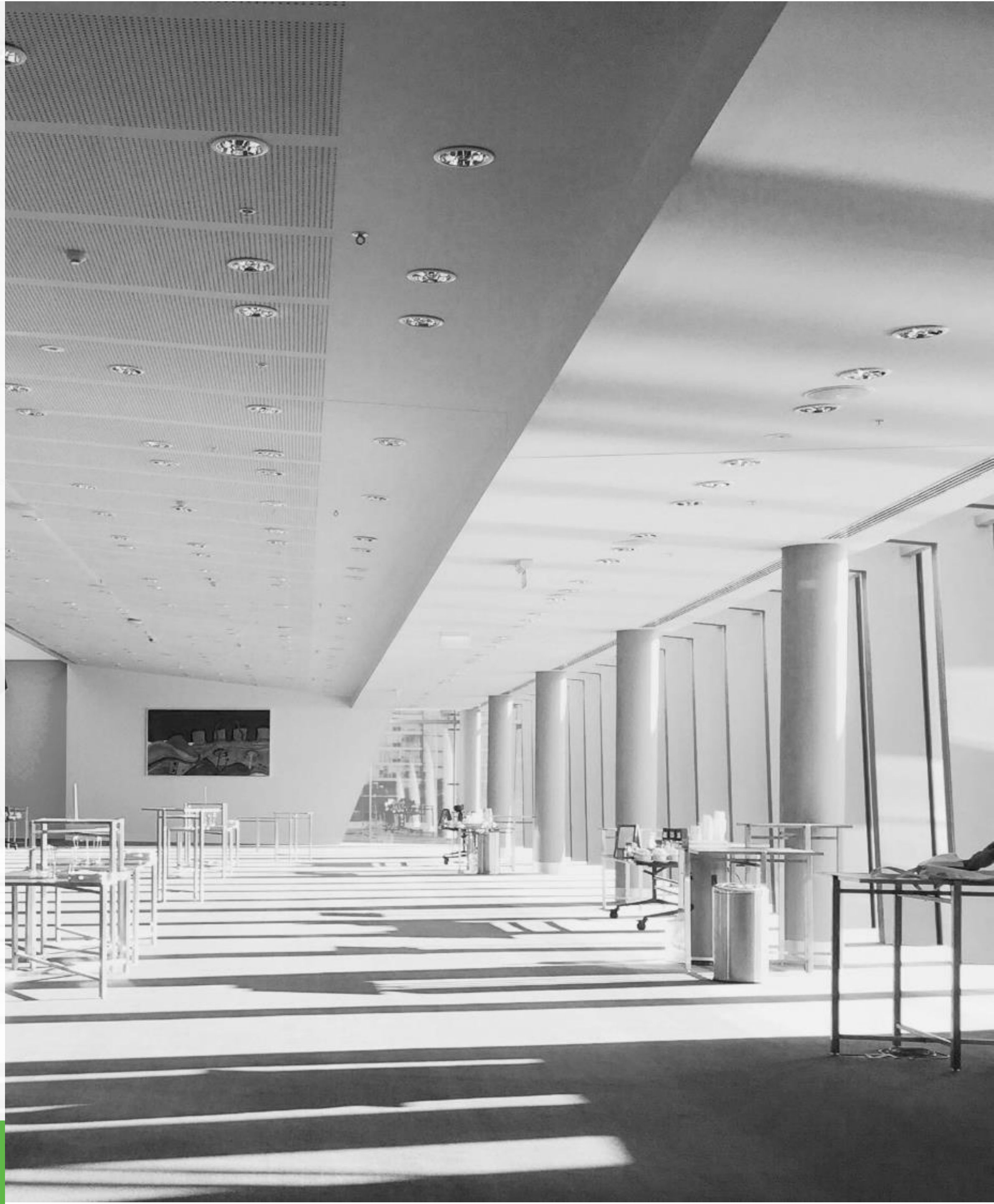
More information on pre-rulemaking for the 2022 Energy Code at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

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

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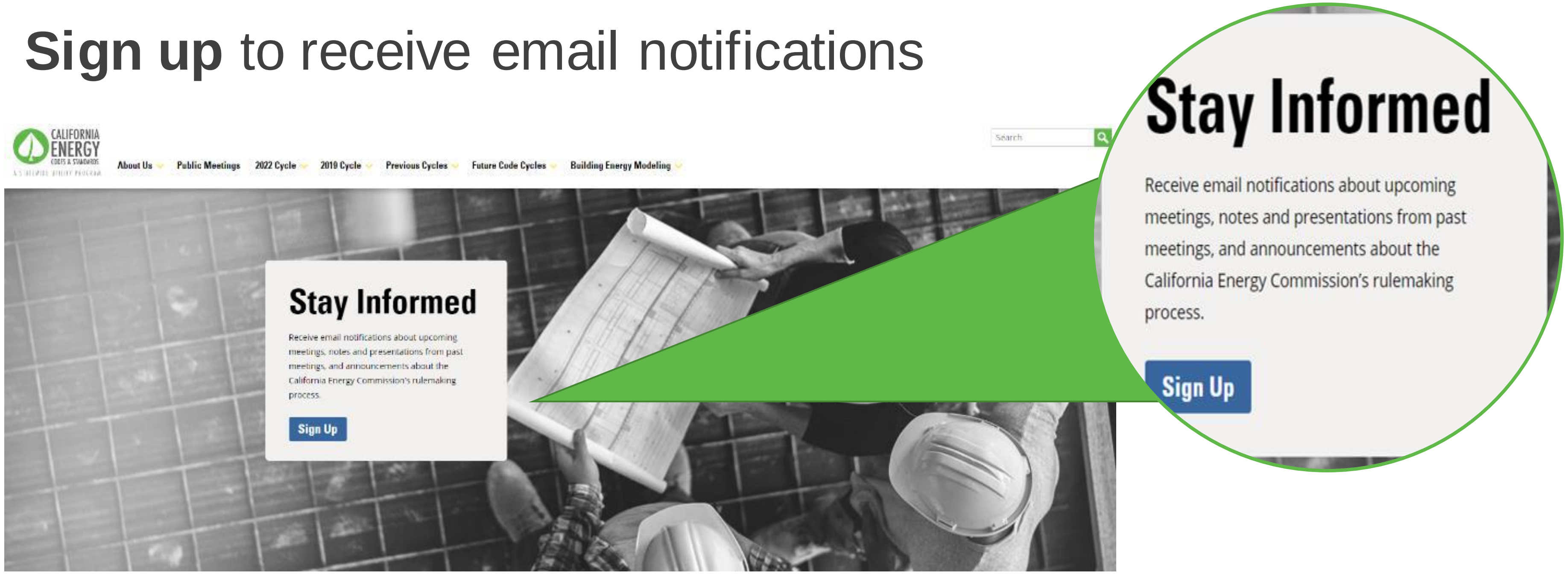
Utility-Sponsored Stakeholder Meetings

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



Second Round Utility-Sponsored Stakeholder Meetings

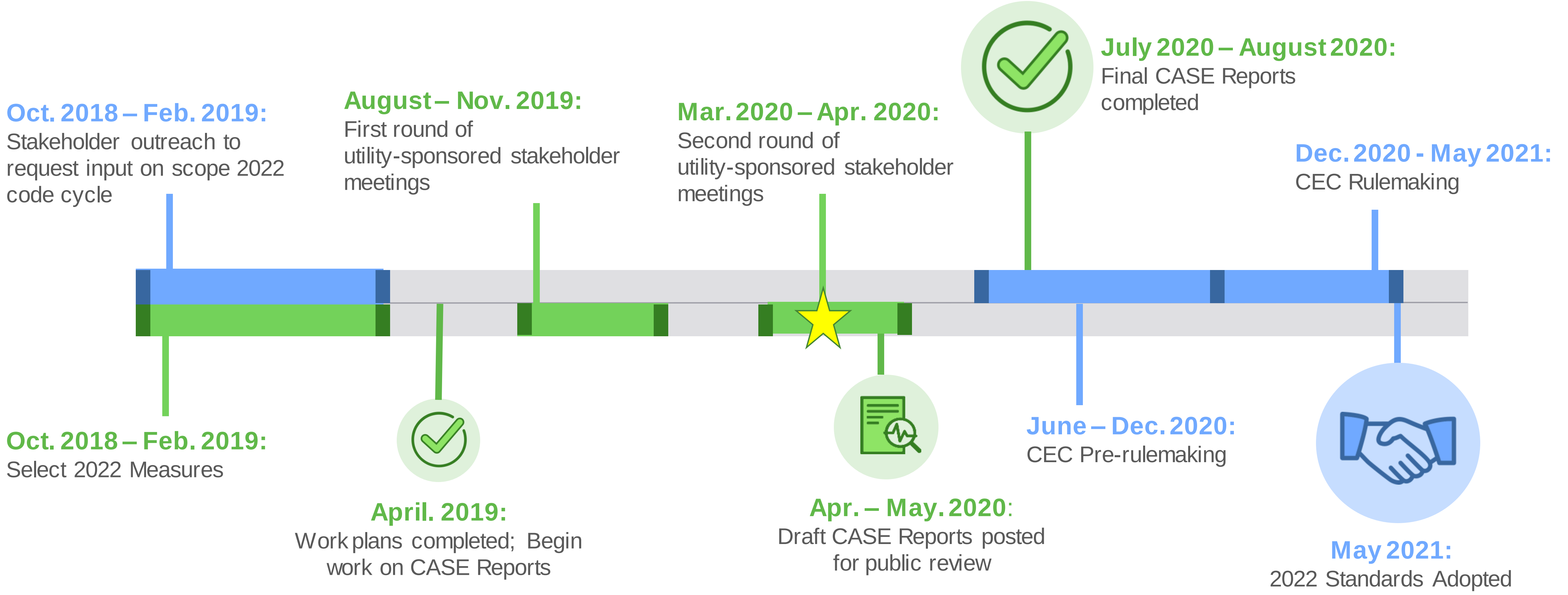
Meeting Topic	Building Type	Date
Lighting	*NR/MF*	*Tuesday, March 3, 2020*
Single Family Whole Building	*SF*	*Thursday, March 5, 2020*
Nonresidential and Single Family HVAC Part 1: Data Centers, Boilers, Air Distribution, Variable Capacity	**NR/SF**	**Thursday, March 12, 2020**
Water Heating and Multifamily All Electric Package	MF	Tuesday, March 17, 2020
Single Family Grid Integration	SF	Thursday, March 19, 2020
~~Multifamily HVAC and Envelope~~	~~MF~~	~~Thursday, March 26, 2020~~ To be rescheduled.
Covered Processes Part 1: Refrigeration System Opportunities	NR	Thursday, April 2, 2020
Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)	NR	Tuesday, April 14, 2020
Covered Processes Part 2: Controlled Environmental Horticulture	NR	Thursday, April 16, 2020
Nonresidential Envelope Part 1: High Performance Envelope	NR	Thursday, April 23, 2020

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

2022 Code Cycle – Key Milestones

CEC Milestone

Utility Team Milestone



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Tools ♠ Training ♠ Resources

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

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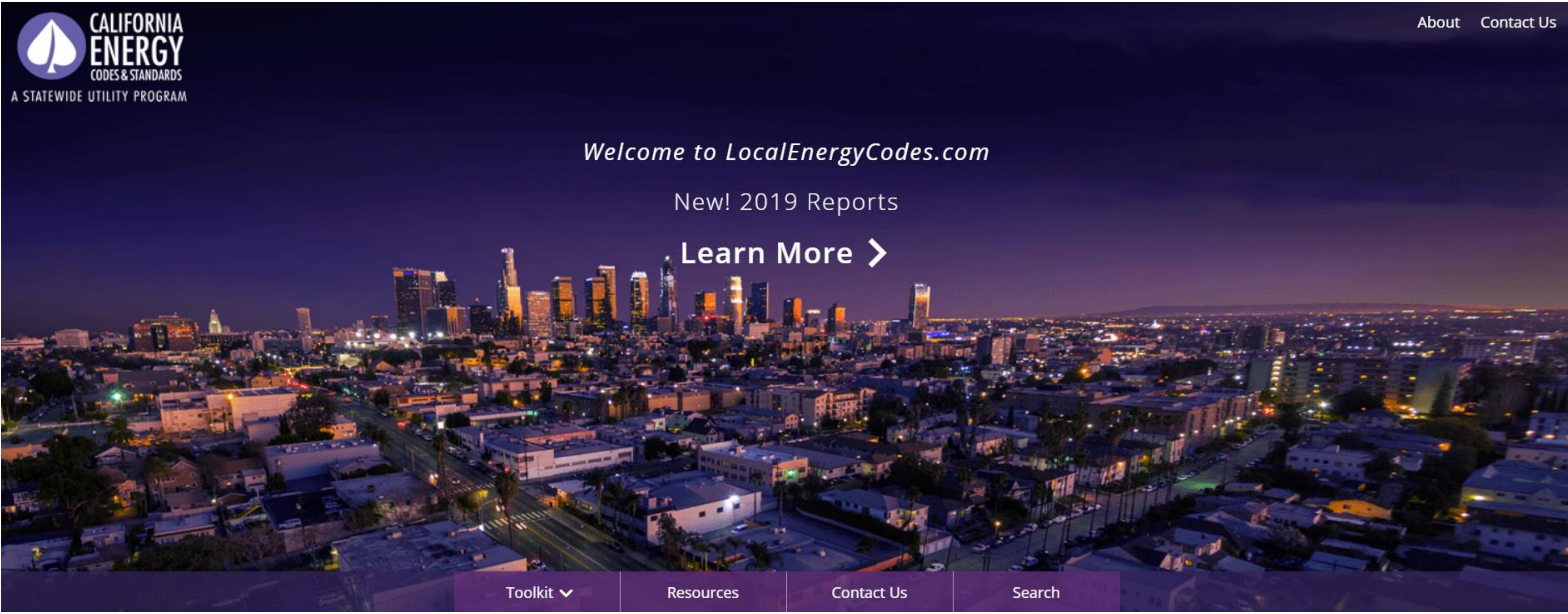
This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities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



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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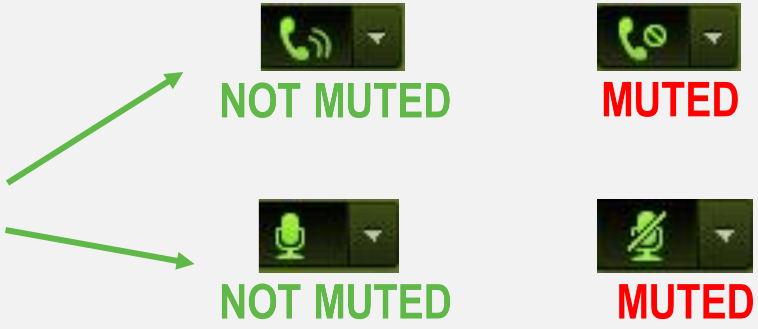

Meeting Guidelines Reminder

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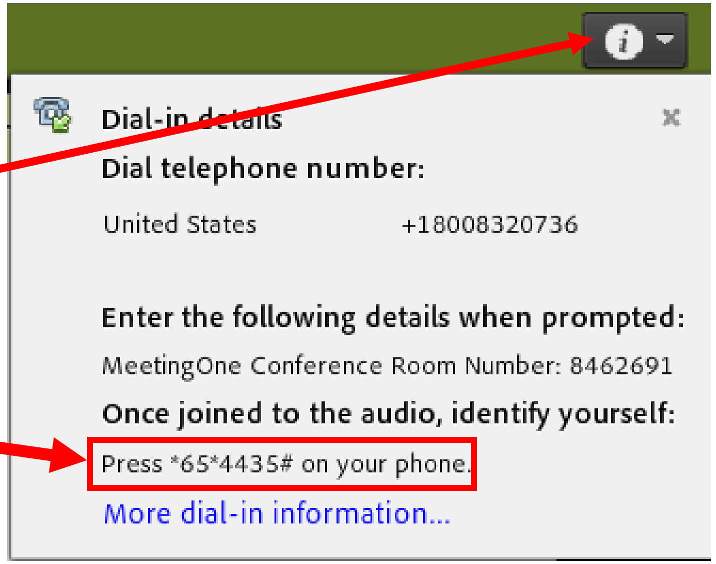
If you dialed in to join the audio, please **pair your line**.

- Please keep yourself **MUTED**.
- Navigate to the (i) button in the top right of your screen.
- Click the pull-down menu and ***identify your line*** *by entering your unique user ID on your phone.*

Steps to Pair Line:

1. **Select (i) button** pull-down on the top right of Adobe Connect window;
2. Identify your line using your unique code.



2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Air Distribution

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Air Distribution

Chad Worth & Benny Zank, *Energy Solutions*

March 12, 2020

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1 Today’s Objectives

2 Proposal Background

3 Cost and Energy Calculations

5 Questions and Next Steps

Code Change Proposal Summary

Submeasures	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Fan Power Budget	Prescriptive	Y	140.4(c)	NRCC-MCH-E
Fan Energy Index	Mandatory (New Construction Only)	N	120.10	NRCC-MCH-E
Duct Leakage	Mandatory	N	120.4	NRCC-MCH-E

Today's Objectives

The focus of today's meeting includes the following, across 3 measures:

1. **Review** Energy and Cost Calculations
2. **Revisit** Technical Feasibility
3. **Revisit** Code Language

Proposal Background

Why focus on air distribution?

Why are we proposing these measures?

- Fans for air circulation and ventilation account for 28% of HVAC energy consumption
- Commercial building ventilation represents ~1.5% of total national primary energy consumption!
- Significant opportunity for cost-effective savings.

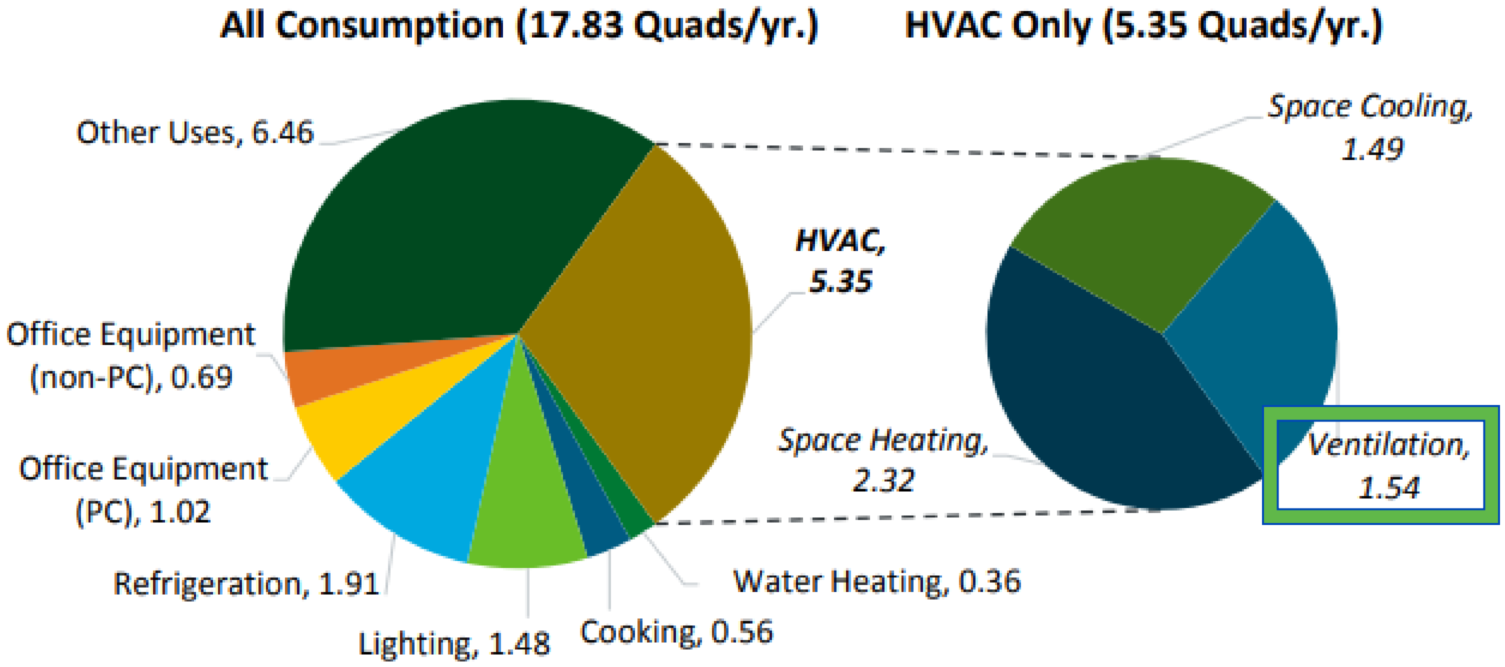


Figure 4: Commercial primary energy consumption by end use, Quads/yr. (2017)

Source: EIA AEO (2017)[11]

Source: https://www.energy.gov/sites/prod/files/2017/12/f46/bto-DOE-Comm-HVAC-Report-12-21-17.pdf

Energy Savings in Building Air Distribution Systems

Low pressure ductwork, efficient fans, motors and transmissions and tight ducts reduce fan energy consumption, fan heat gain, and supply air temperature rise.

Reduce flow through **Duct Leakage (3)**

Reduce pressure through the **Fan Power Budget (1)**

$$Fan\ electrical\ input\ power = \frac{Flow \cdot Pressure}{6343 \cdot \eta_{fan} \cdot \eta_{tran} \cdot \eta_{motor}}$$

Increase fan efficiency through the **Fan Energy Index (2)**

Increase transmission and motor efficiency through the **Fan Power Budget (1)**

Source: Statewide CASE Team

Proposal Overview

1. Fan Power Budget

- Replaces the 2019 fan power limits
- Budget is achieved by either lower pressure (e.g., better ducts), improve fan/motor/transmission efficiency, or both
- Applies to all fan systems with an input power ≥ 1 kW

2. Fan Energy Index (FEI)

- Individual fan efficiency metric for certain fan selections (mostly stand-alone fans, not packaged equipment)
- Encourages more efficient fan selections

3. Duct Leakage

- No longer considering duct leakage testing beyond existing California Mechanical Code (CMC) requirements
- Proposing testing specifications for the CMC requirements in Title 24, Part 6
- Requiring Seal Class A duct-sealing on all ductwork and VAV box leakage certification or field testing

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**

Resources on

Presentation slides and **Submeasure summary** documents available that cover the following:

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

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

Energy and Cost Impacts

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

Submeasure A: Fan Power Budget

Submeasure B: Fan Energy Index

Submeasure C: Duct Leakage

Proposal Overview: Fan Power Budget

Replace existing 2019 *Fan Power Limitations* with *Fan Power Budget:*

- Clearly defines fan systems
- Separates supply and return / exhaust fan systems
- Applies to all fan systems with an input power ≥ 1 kW
- Each “fan system” is allocated a power budget (kW) as a function of airflow (cfm), system type, with additional allowances for various components.
- *Flexibility* in how to achieve fan power budget:
  - More efficient fans
  - More efficient motors (e.g., more than DOE minimum eff.)
  - More efficient transmissions (e.g., direct drive)
  - *Lower pressure* (e.g., better duct design)
- Aligns with draft proposal in ASHRAE 90.1 for 2022

Baseline and Proposed Conditions

Fan Power **Limits**

2019 Title 24, Part 6

- Trigger based on **motor and brake-horsepower**
- **No transmission** or motor efficiency losses
- Supply-side and exhaust/ return-side treated as ***one* fan system**
- **Applies** to *each* fan system with a nameplate HP ≥ 5 HP
- **Applies *only*** to fan systems which supply air from the heating/ cooling source and return it
- **Overly simplified**, generous for small buildings

Fan Power **Budget**

2022 Title 24, Part 6

- Trigger based on **electrical input power (kW)**
- **Includes transmission** and motor efficiency losses
- Supply-side and exhaust/ return-side treated as ***separate* fan systems**
- **Applies** to *each* fan system with an input power ≥ 1 kW
- **Applies to *all*** fan-systems which move air whether to/ from heating/ cooling source or not
- **More robust** and accurate calculation for all buildings

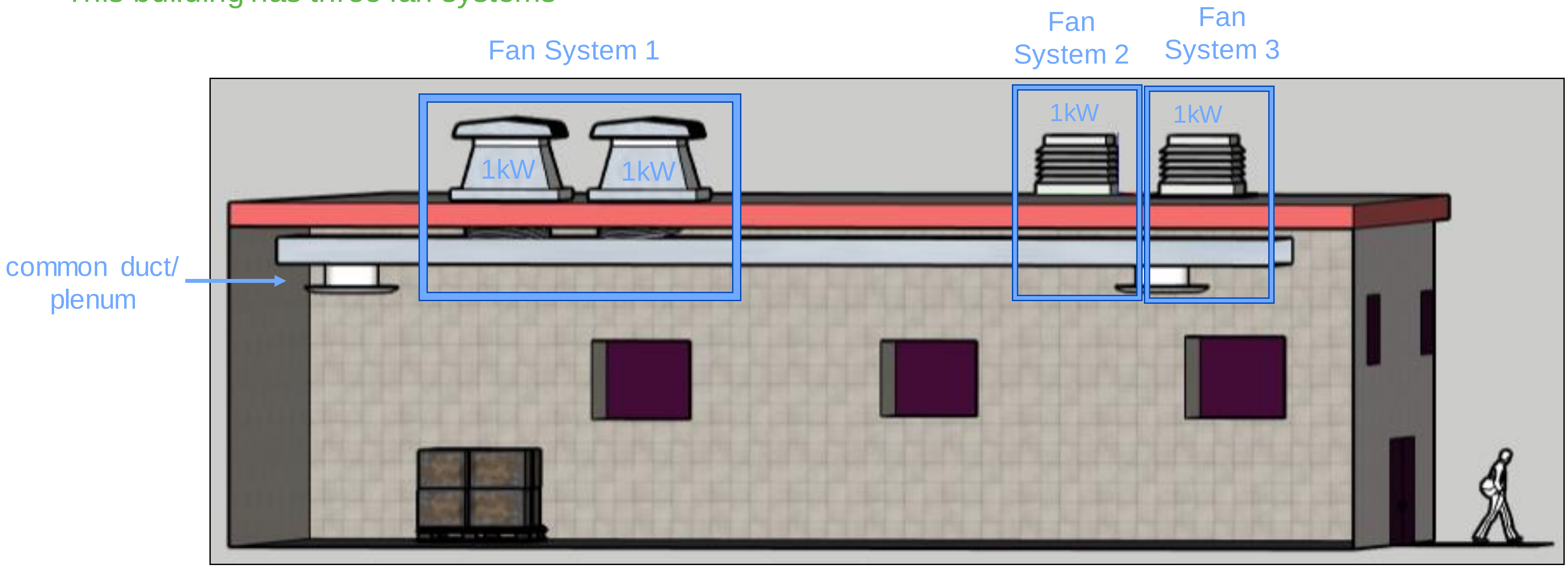
What is a fan system?

- **2019 definition (by reference):** “*All fans in the system that are required to operate at design conditions in order to supply air from the heating or cooling source to the conditioned space, and to return it back to the source or to exhaust it to the outdoors.*”
- 2022 Proposed definition of *Fan system: All the fans that contribute to the movement of air through a point of a common duct, plenum, or cabinet.*

What is a fan system?

Example: Warehouse (un-conditioned air) with common duct/ plenum

This building has three fan systems



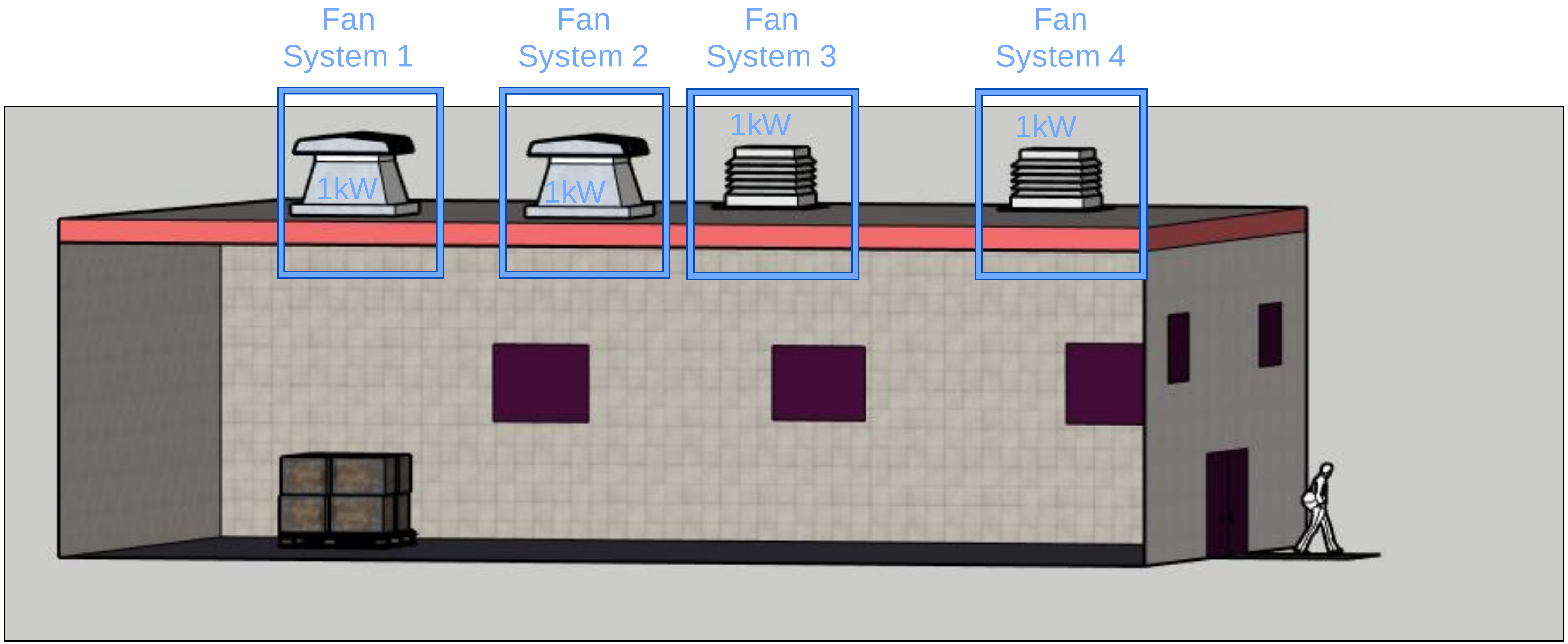
Source: Statewide CASE Team

What is a fan system?

Example: Warehouse (un-conditioned air) with no common plenum/ ducting

This building has four fan systems

No common duct/ plenum



Source: Statewide CASE Team

How Does Fan Power Budget Work?

Two approaches to determine fan power budget (kW):

Approach 1: For more common fan systems with standard components

- Use look-up table to determine allowable input kW (design conditions) based on system type and airflow
- Assumptions include standard pressure allowances for a ductwork, heating coil, cooling coil, MERV-13 filter, belt-drive fans and DOE minimally compliant motors

Approach 2: For more complex systems

- Calculate fan power budget using equations and pressure tables in Reference Appendices
- Advantage when using direct-drive transmissions, high efficiency motors, or for fan systems with unique components (e.g. HEPA filters, heat recovery, etc.) that need additional pressure allowances

Determining Fan System Input Power (kW)

Fan system input power is the sum of the fan input power for each fan, or fan array, included in the system with fan input power > 1kW.

3 methods to determine fan input power:

1. Provided by fan / equipment manufacturer at design conditions *(most likely).*
2. Calculated according to methods in Section 5.3 of ANSI/AMCA 208 at design conditions *(less likely).*
3. Use default values in Table 140.4-E *(likely).*

Proposed Table 140.4-E: Default Values for Fan Input Power Based on Motor Nameplate Horsepower *(Excerpt)*

Motor Nameplate Horsepower	Default Fan Input Power (kW)
1	0.99
1.5	1.49
2	1.86
3	2.80
5	4.66

Example One

Using Approach 1 (Look-up Table)

System Information
Single Fan System, Supply & Return • 0’ altitude • 16,000 cfm • Motor nameplate 10 HP

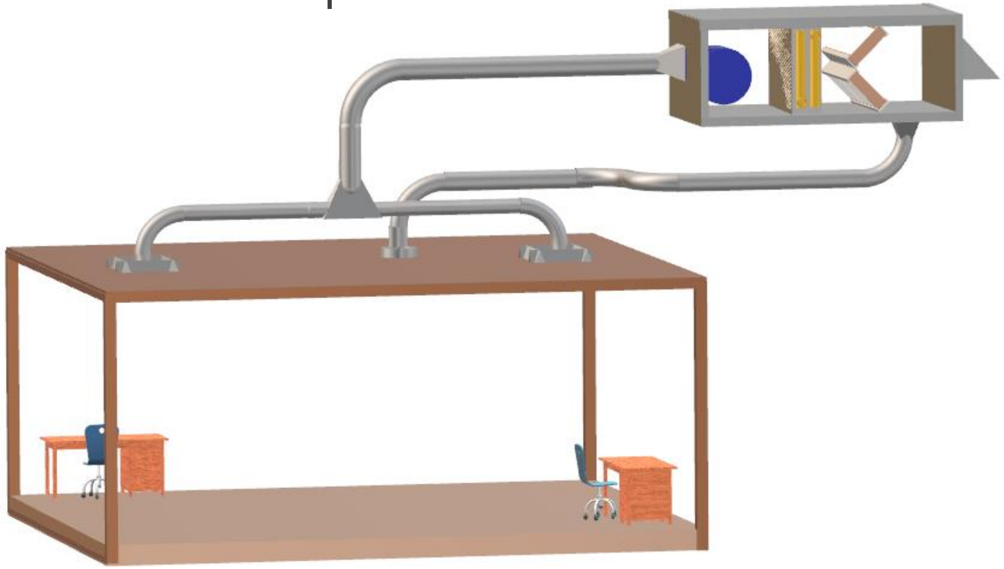


Image Source: Statewide CASE Team

Example One

Using Approach 1 (Look-up Table)

System Information

Single Fan System, Supply & Return

- 0' altitude
- 16,000 cfm
- Motor nameplate 10 HP

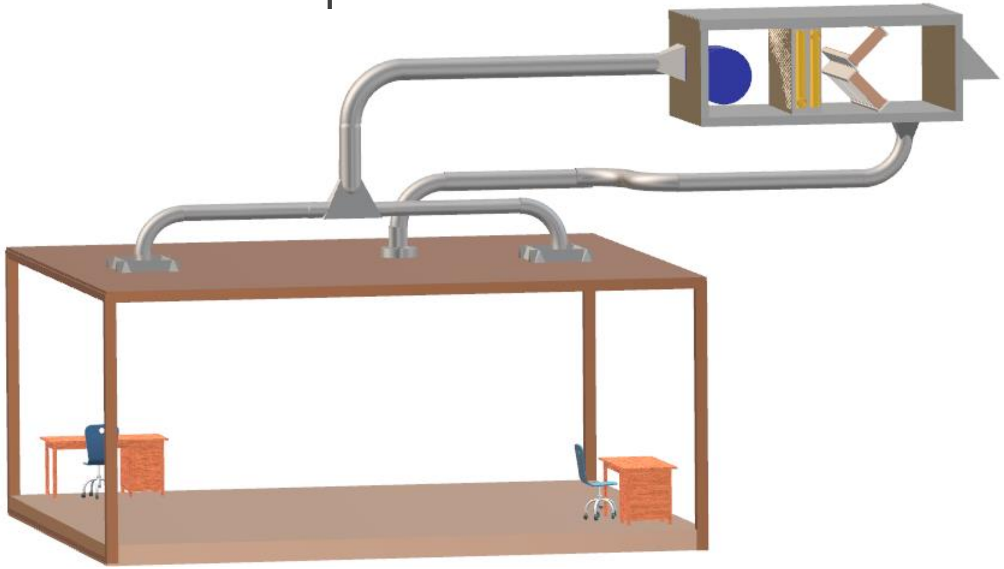


Image Source: Statewide CASE Team

Proposed Table 140.4-A (excerpt)

Airflow	CV/SZ-VAV pressure (Both Supply & Return or Exhaust) (kW)
10000	5.35
12000	6.88
14000	7.96
16000	9.04
18000	10.12
20000	11.20

Fan Power Budget

9.04 kW

Supply **Fan Power Budget**

Default **fan input power**

Example One

Using Approach 1 (Look-up Table)

System Information

Single Fan System, Supply & Return

- 0' altitude
- 16,000 cfm
- Motor nameplate 10 HP

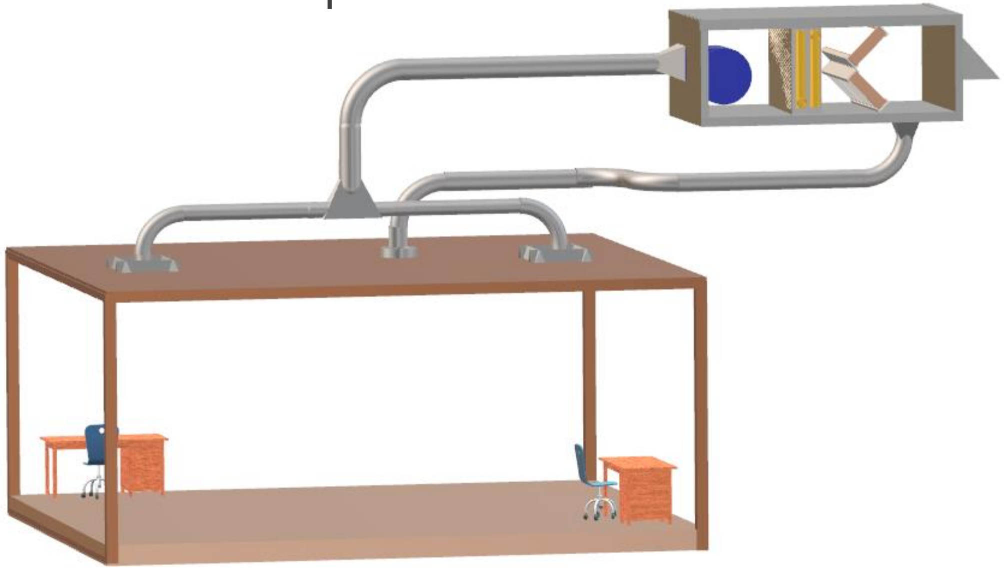


Image Source: Statewide CASE Team

Proposed Table 140.4-A (excerpt)

Fan Power Budget

Airflow	CV/SZ-VAV pressure (Both Supply & Return or Exhaust) (kW)
10000	5.35
12000	6.88
14000	7.96
16000	9.04
18000	10.12
20000	11.20

9.04 kW

Supply **Fan Power Budget**

Complies!

Fan input power (8.13 kW) < fan power budget (9.04 kW)

Proposed Table 140.4-E (excerpt)

Fan Input Power

Motor Nameplate Horsepower	Default Fan Input Power (kW)
1	0.99
1.5	1.49
2	1.86
3	2.80
5	4.66
7.5	6.15
10	8.13

8.13 kW

Default **fan input power**

Comparison to 2019 Fan Power Limits

Fan System	Fan Power Limits (2019) kW	Fan Power Limits (2019) kW (if transmission losses were included)	Fan Power Budget (2022) kW
Supply System	12.14	12.77	9.04

-26%

-29%

- Savings on a kW basis are significant.
- Especially when accounting for transmission efficiency (e.g., belt losses) on top of existing 2019 code.

Source: Statewide CASE Team

Example Two

Using Approach 1 (Look-up Table)

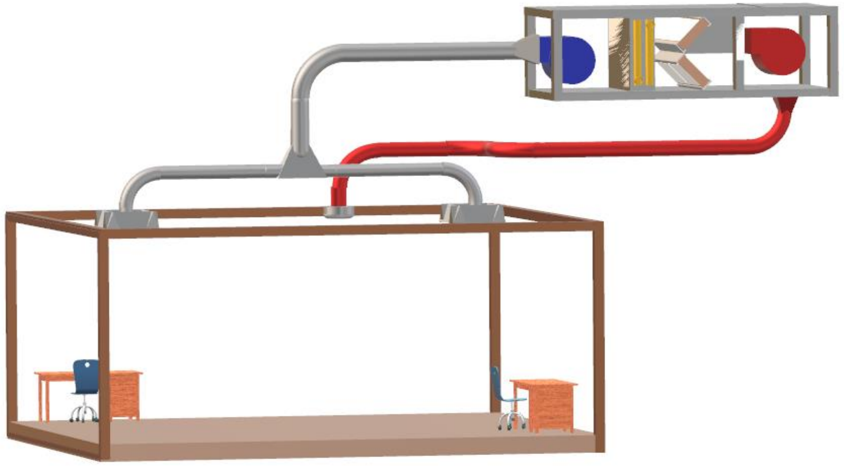
System Information
Two Fan System, Supply & Return • 0’ altitude • **Supply:** 16,000 cfm, Motor nameplate 10 HP • **Return:**14,000 cfm, Motor nameplate 3 HP 

Image Source: Statewide CASE Team

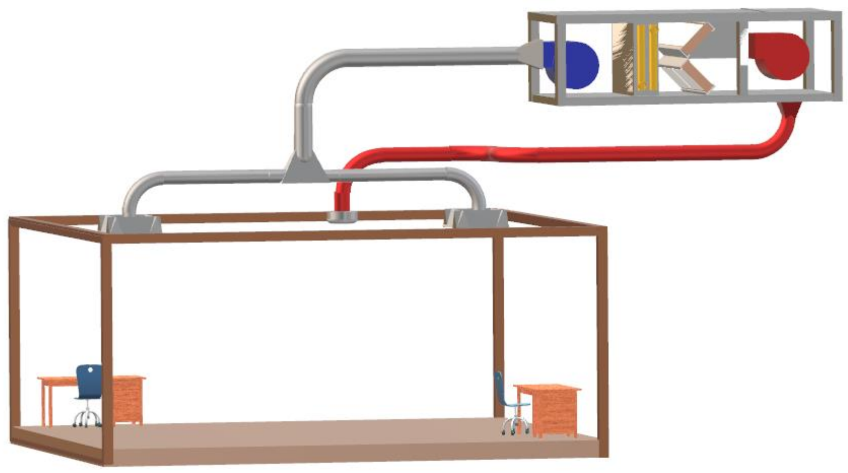
Example Two

Using Approach 1 (Look-up Table)

System Information

Two Fan System, Supply & Return

- 0' altitude
- **Supply:** 16,000 cfm, Motor nameplate 10 HP
- **Return:**14,000 cfm, Motor nameplate 3 HP



Proposed Table 140.4-A (excerpt)

Fan Power Budget

Airflow	CV/SZ-VAV pressure (Supply-Only) (kW)	CV/SZ-VAV pressure (Exhaust/ Return/ Relief) (kW)
10000	4.47	1.41
12000	5.82	1.66
14000	6.74	1.91
16000	7.65	2.16
18000	8.56	2.40
20000	9.47	2.65

Return Fan Power Budget

Supply Fan Power Budget

Image Source: Statewide CASE Team

Example Two

Using Approach 1 (Look-up Table)

System Information

Two Fan System, Supply & Return

- 0’ altitude
- **Supply:** 16,000 cfm, Motor nameplate 10 HP
- **Return:**14,000 cfm, Motor nameplate 3 HP

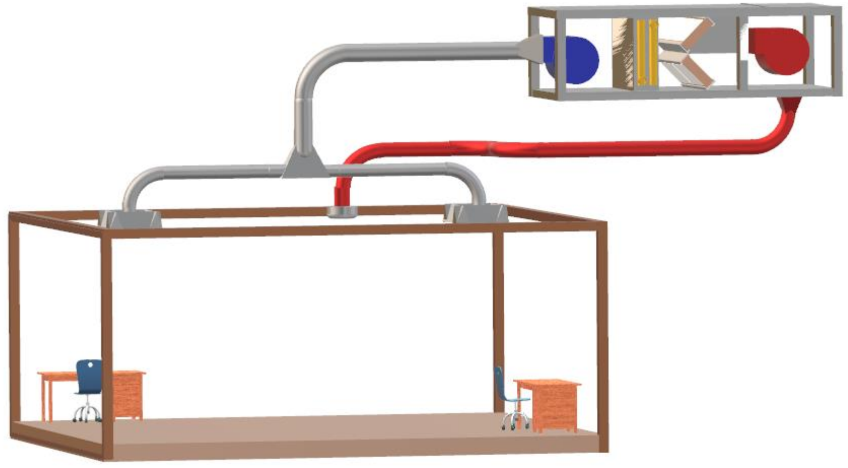


Image Source: Statewide CASE Team

Proposed Table 140.4-A (excerpt)

Fan Power Budget

Airflow	CV/SZ-VAV pressure (Supply-Only) (kW)	CV/SZ-VAV pressure (Exhaust/ Return/ Relief) (kW)
10000	4.47	1.41
12000	5.82	1.66
14000	6.74	1.91
16000	7.65	2.16
18000	8.56	2.40
20000	9.47	2.65

Return **Fan Power Budget**

Supply **Fan Power Budget**

Relief Fan Fails, Supply Fan Complies!

Proposed Table 140.4-E (excerpt)

Fan Input Power

Motor Nameplate Horsepower	Default Fan Input Power (kW)
1	0.99
1.5	1.49
2	1.86
3	2.80
5	4.66
7.5	6.15
10	8.13

Default fan input power

> 1.91 kW **Return** Fails

< 7.65 kW **Supply** Passes

Note: Return fan may comply w/ Approach # 2, where lower-than-reference actual pressure rise, and better-than-default fan/trans/motor efficiency are credited.

Comparison to 2019 Fan Power Limits

Fan System	Fan Power Limits (2019) kW	Fan Power Limits (2019) kW (if transmission losses were included)	Fan Power Budget (2022) kW
Supply System	12.14	12.77	7.65
Return System			1.91
Total	12.14	12.77	9.56

- Savings on a kW basis are significant.
- Especially when accounting for transmission efficiency (e.g., belt losses) on top of existing 2019 code.

-21%

-26%

Source: Statewide CASE Team

Using Fan Power Budget Calculation (Approach 2)

- Step 1: Determine the airflow
- **Step 2:** Calculate the reference fan brake horsepower (BHP_{ref})
- Step 3: Calculate reference belt-drive transmission efficiency
- Step 4: Calculate the reference transmission HP input
- Step 5: Calculate the motor efficiency
- **Step 6:** Calculate the maximum fan system electrical input power (kW_{max})

$$bhp_{ref} = \frac{(Q_i + Q_o)(P_{ref} + P_o)C_A}{6343 \cdot 0.66 \cdot EF}$$

Where:

bhp_{ref} = Reference Fan system brake horsepower (hp)

Q_i = Actual airflow at fan system design conditions
Q_o = 250 acfm
P_{ref} = The sum of the pressure losses from Table 140.4-C
P_o = 0.2 in. H_2O
C_A = Altitude density correction from Table 140.4-B
EF = 1.15 efficiency factor

Equations not shown, see **Submeasure Summary**

Source: Statewide CASE Team

Methodology for Energy Impacts Analysis

- Applied new fan power budget to all fan systems in prototype buildings.
- Compared fan input power from baseline and proposed prototypes.

Tools Used	Spreadsheet analysis CBECC-Com
Building Prototypes Used	Apartment High Rise, Hotel 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

Energy Impact Analysis: Baseline and Proposed Systems

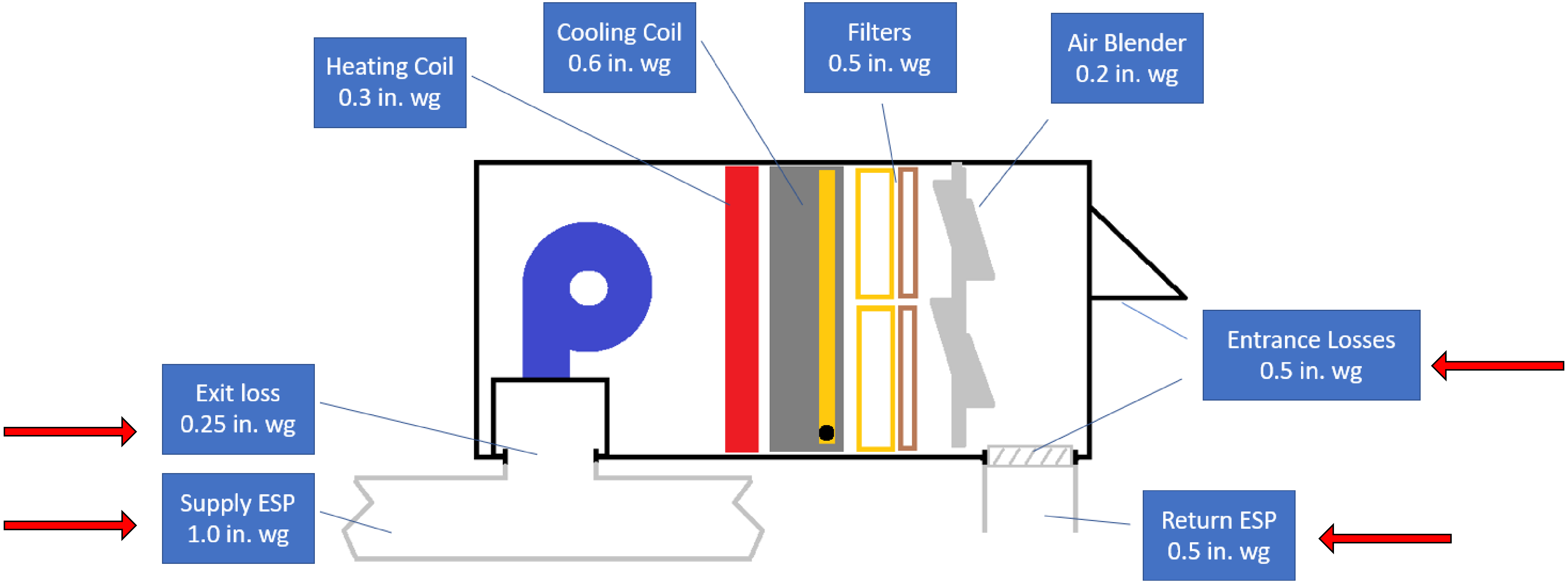
Baseline: 2019 minimally compliant building with Fan Power Limits

- Adjusted to account for belt-driven fans
- Total system pressure at 5.35 in w.g. for VAV systems, 3.85 in w.g. for CV, matching existing fan power limits
- Applies to all fan systems > 5 HP (nameplate)

Proposed: 2022 minimally compliant building with Fan Power Budget

- Assumes belt-driven fans
- System pressure calculated separately for each prototype based on components
- Applies to all fan systems > 1 kW

2019 Baseline Fan System Pressure Basis
Constant Volume

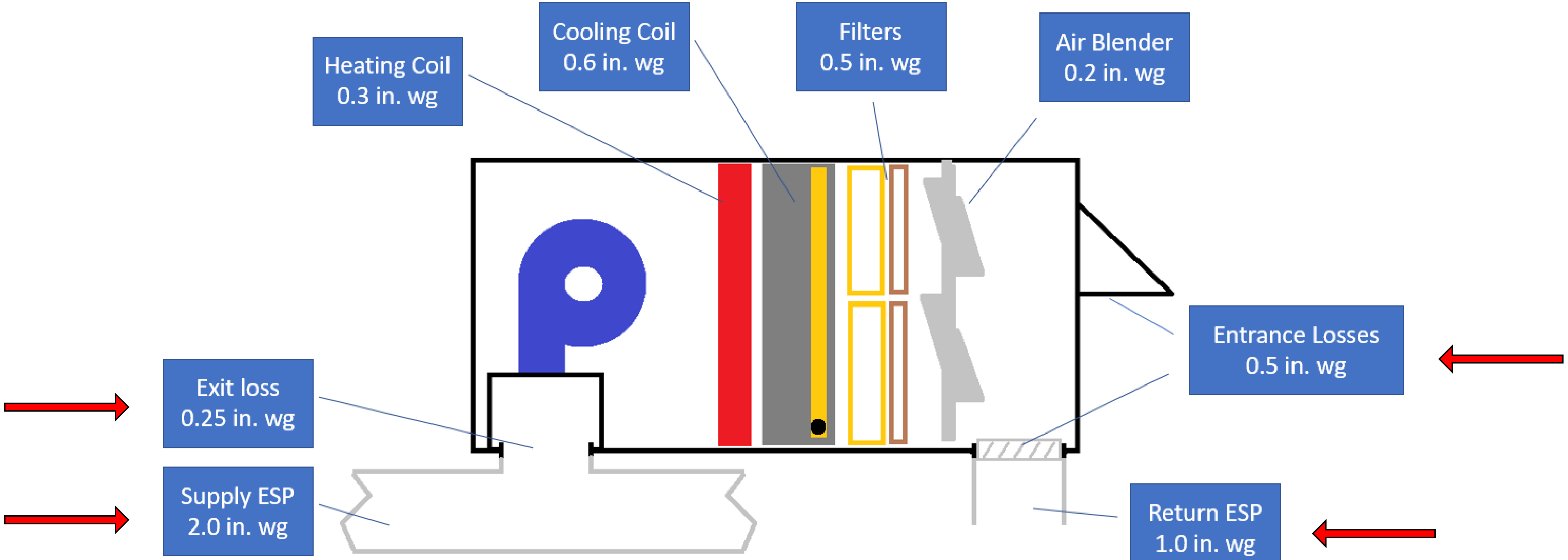


2019 Title 24 Pressure Assumption for Constant Volume Systems

Total Pressure: 3.85 in w.g.

External Static Pressure: **2.25 in w.g**.

2019 Baseline Fan System Pressure Basis
Variable Air Volume



2019 Title 24 Pressure Assumption for Variable-Air Volume System

Total Pressure: 5.35 in w.g.

External Static Pressure: **3.75 in w.g.**

2022 Proposed Reference Pressures (Supply)

Proposed reference pressure allowances a function of 1) *system type*, 2) *airflow* and 3) *components.*

Table 140.4-C Reference Pressure Fan System Pressure Losses for Calculating P_{ref} (Excerpt)

Reference Pressure Loss Components - Supply Systems	Multi-Zone VAV System[1]	Constant Volume/Single-zone VAV >10,000 cfm	Constant Volume/Single-zone VAV >5,000 cfm and ≤10,000 cfm	Constant Volume/Single-zone VAV ≤5,000 cfm
System Type and Design Airflow				
Supply fan system duct and outlet losses	2.00	1.25	1	0.80
100% Outside air system meeting the requirements of Note 2.	N/A	0.5	0.5	0.3
Particle filtration (select only 1)[3]				
MERV 13 to MERV 16 Filter	0.60	0.60	0.60	0.40
MERV 13 to MERV 16 Filter located downstream of thermal conditioning equipment.	1.00	1.00	0.90	0.60
HEPA Filter	1.50	1.50	1.00	1.00
Gas-phase filtration (select only 1)				
General odor control	0.50	0.50	0.50	0.30
Gas phase filtration required by code or accredited standard	Pressure loss at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less			
Heating				
Hydronic heating coil	0.30	0.30	0.20	0.20
Electric heat	0.20	0.20	0.20	0.20
Gas heat	0.20	0.20	0.20	0.20

2022 Proposed Reference Pressures (Return/ Exhaust/ Relief)

Table 140.4-C Reference Pressure Fan System Pressure Losses for Calculating P_{ref} (Excerpt)

Budget Pressure Loss Components - Return/Exhaust/Relief Systems	Multi-Zone VAV System[1]	Other Systems >10,000 cfm	Other Systems >5,000 cfm and ≤10,000 cfm	Other Systems ≤5,000 cfm
Select one of the following:				
Exhaust system duct, plenum, inlet, and outlet	1	0.75	0.75	0.50
Particle filtration				
Filter - any MERV value	0.20	0.20	0.20	0.20
Energy recovery (select only 1) where required by code				
Enthalpy recovery	2 X Enthalpy Recovery Ratio - 0.60			
Sensible only	0.50	0.50	0.50	0.30
Special exhaust and return system requirements				
Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.50	0.50	0.50	0.50

Comparison of Fan System Reference Pressure

Title 24- 2019

Variable-Air Volume	Constant-Air Volume
5.35	3.85

Title 24- 2022 *(Supply + Exhaust)*

Multi-Zone VAV System[1]	Constant Volume / Single-zone VAV >10,000 cfm	Constant Volume / Single-zone VAV >5,000 cfm and ≤10,000 cfm	Constant Volume / Single-zone VAV ≤5,000 cfm
4.5	3.4	3.15	2.5

Note: These are reference values, not actual pressure limits. There are many ways to reach the fan power limits/ budget with higher pressure systems (e.g., better motors, fans transmissions).

Additionally, This table is for general comparison purposes only, does not account for all 2019 additional allowances, or all 2022 potential additional reference pressures.

Source: Statewide CASE Team

Energy Savings Examples

Prototype Building	Prototype Fan	Airflow (CFM) / System Type	2019 Fan Power Limits (kW)*	2022 Fan Power Budget (kW)	Power Reduction %	Equivalent Pressure Reduction (in.w.g.) *(if all savings came from ductwork)*
Large Office	BASESYS6 FAN-3	167,925 (VAV)	176.36	133.05	24.6%	0.95
Retail Large	BASESYS7 FAN-5	62,505 (CV)	47.93	38.66	19.3%	0.74
Hotel Small	BASESYS5 FAN	7,058 (VAV)	7.86	6.15	21.7%	0.84
School Primary	BASESYS7 FAN-2	3,296 (CV)	2.76	1.84	33.5%	1.29

* With added losses due to belt-drives

Source: Statewide CASE Team

Incremental Cost Approach

Assumed all incremental cost (and energy savings) come from lower pressure duct work via better duct design, fittings selection, duct size, etc:

- Conservative approach, to achieve all savings from ductwork design changes (or external static pressure (ESP)
  - Acknowledge that other low cost/ easier options exist such as better air handler design, more efficient fans, motors, transmissions, etc.
- Developed two duct designs and associated costing to compare baseline and proposed layout for Large office (100% outside air/ CV) and (Mixed-air/ VAV)
  - Large office prototype represents the CBECC-Com model with the most ductwork

Incremental Cost Approach

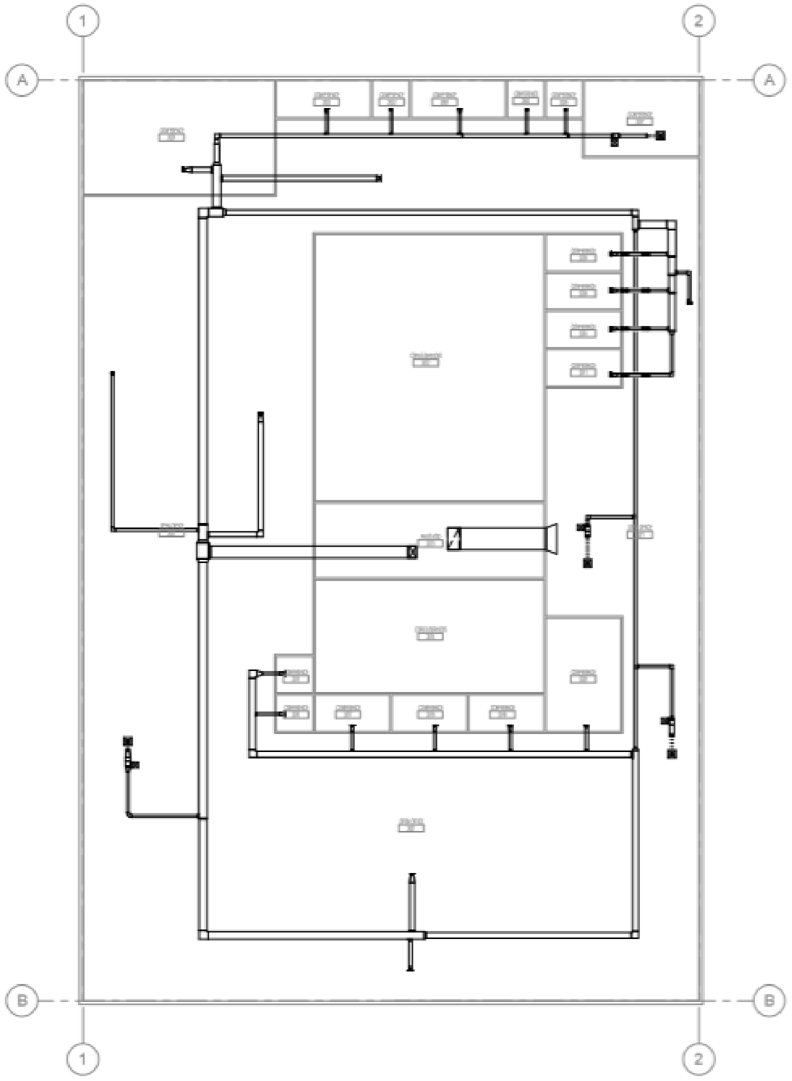
- Modeled ductwork cost for both CV 100% outside air and VAV mixed-air large office.
- Building Details:
  - Climate Zone 9 – Los Angeles Weather
  - Usable area – 31,200 ft^2
  - 16% Conference Rooms, 84% Open Office
- Airflow modeled on typical office occupancy.
- Design Exercise Goal: Get all energy savings from ductwork with same equipment.

HVAC Type	System Type	Calculated Airflow (CFM)	2019 Target ESP	2022 Target ESP	2022 Design Layout ESP
Mixed-Air Design	VAV Supply	18,375	2.25	1.78	1.76
	VAV Return	18,375	1.50	1.21	0.46
100% Outside Air Design	CV Supply	7,765	1.25	0.73	1.20
	CV Return	7,765	1.00	0.84	0.45

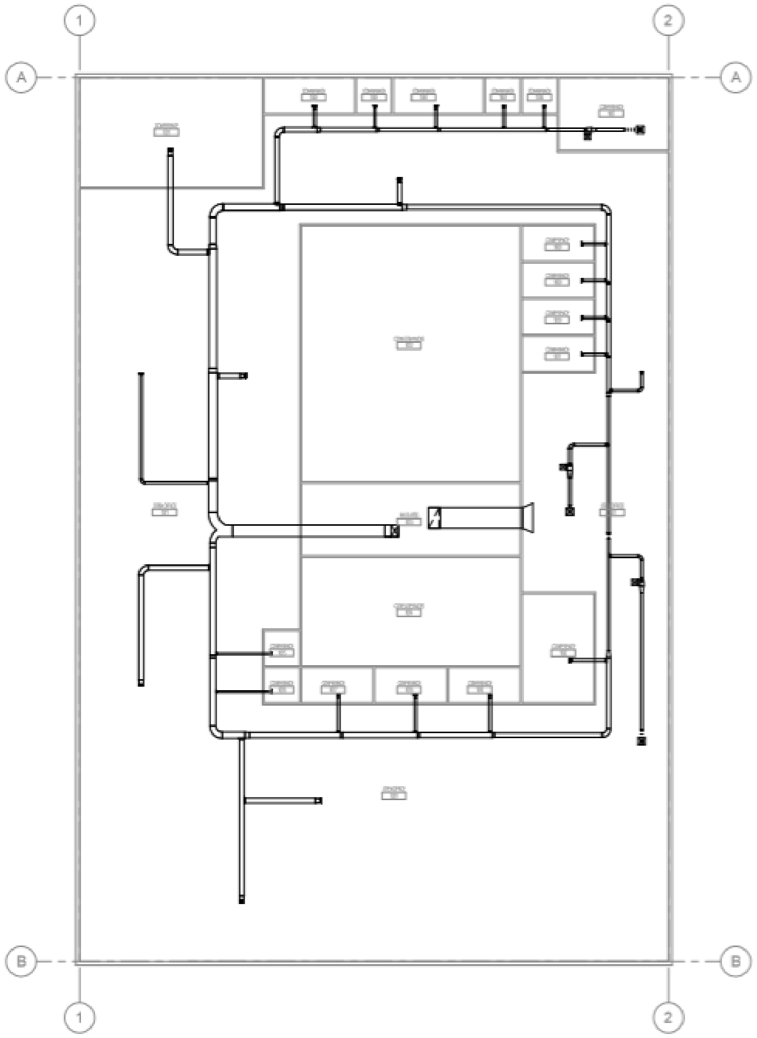
Source: Statewide CASE Team

Incremental Duct Costing- Layouts (CV Example)

High Pressure/ Baseline Design



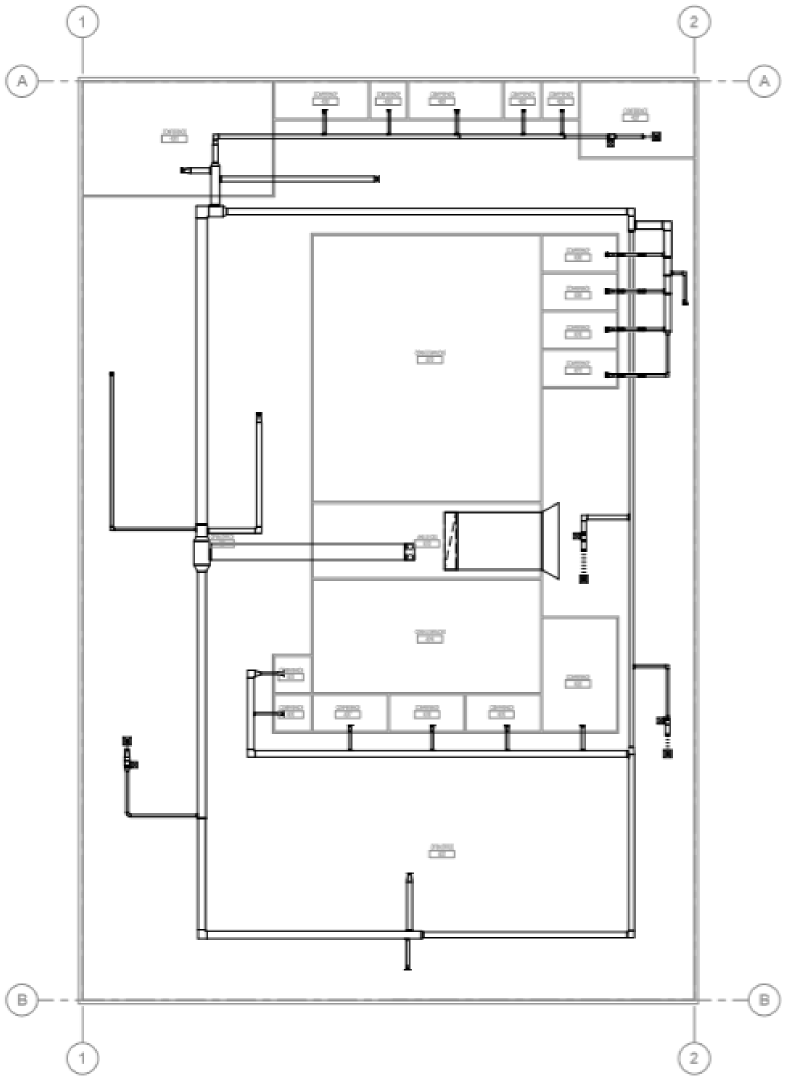
Low Pressure/ Proposed Design



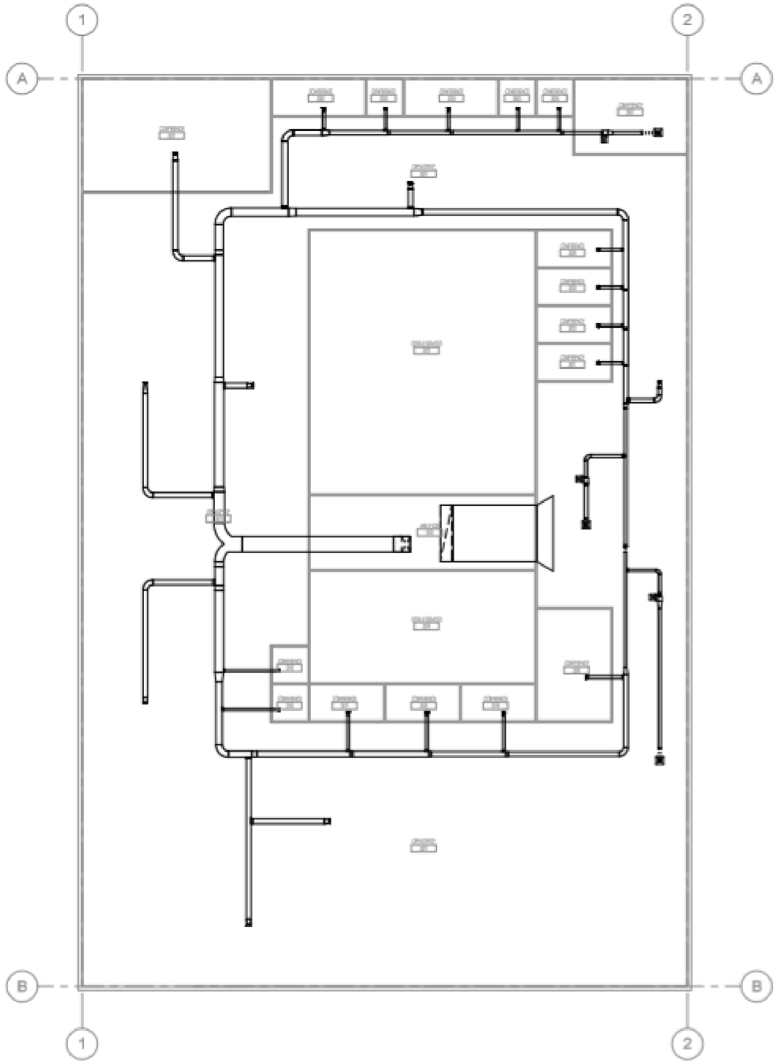
Source: Statewide CASE Team

Incremental Duct Costing- Layouts (VAV Example)

High Pressure/ Baseline Design



Low Pressure/ Proposed Design



Source: Statewide CASE Team

Incremental Cost Approach- Duct Design

Practice	2019 Standard Design Duct Practices	2022 Proposed Design Duct Practices
Duct Shape/ Selection/ Size	• Duct widths selected to be much higher than duct heights • No use of round ductwork	• Use round duct where possible • Keep as close to square as possible, when rectangular duct is used • Larger sizes (+2") in long runs
Elbows	• All elbows mitered, without turning vanes	• Use radiused elbows for turns, @1.5 D • Use of turning vanes
Transitions	• All transitions at 60-degree angles	• All transitions at 15-degree angles
Takeoffs	• Grouped to maximize percentage of main flow pulled	• Designed to pull no more than 30% of main flow

Source: Statewide CASE Team/ ARUP

Incremental Per Unit Cost

Over 15 Year Period of Analysis

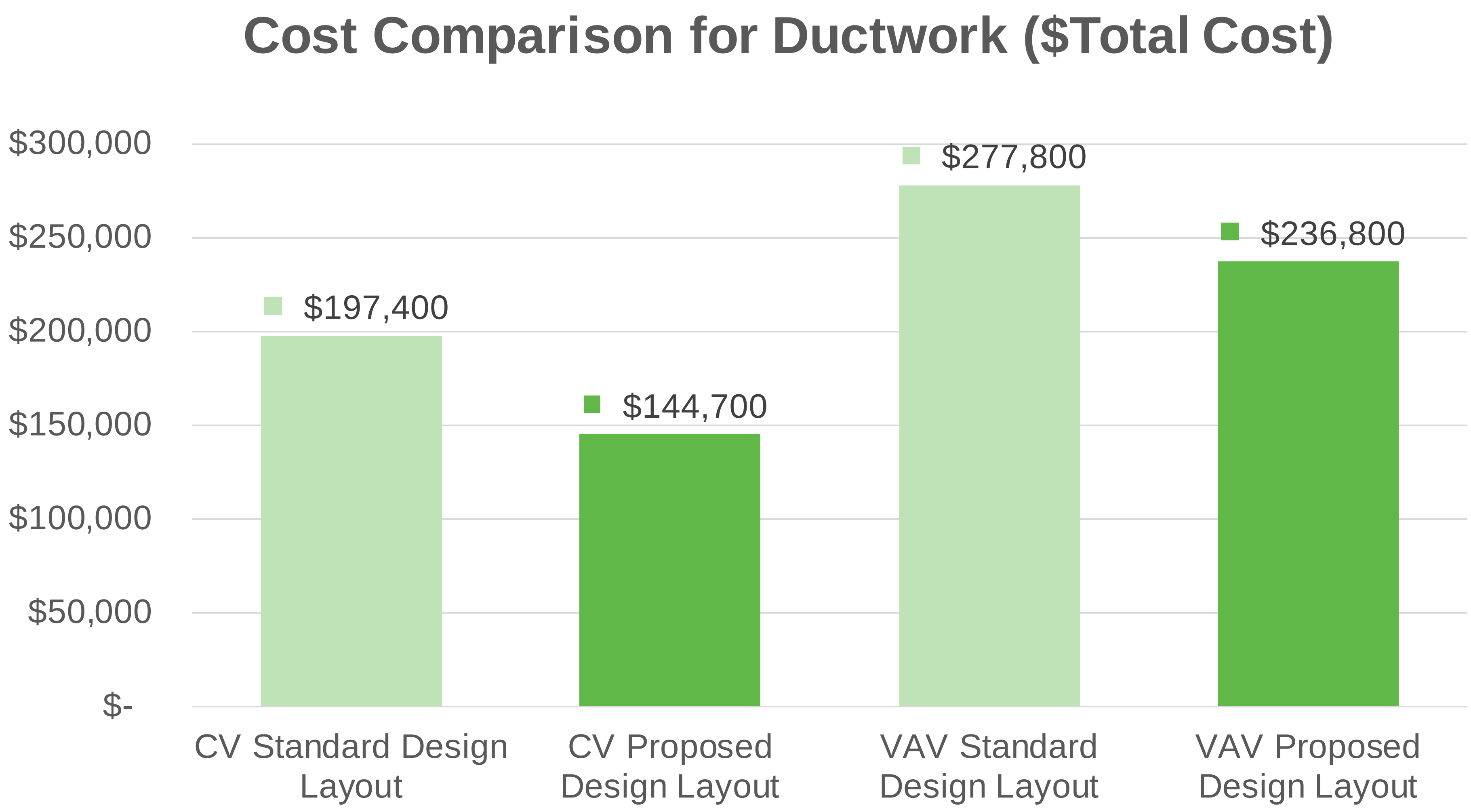
- Analysis found *negative* incremental cost primarily due to better duct design, leading to fewer large fittings, greater use of round-duct work and overall shorter length of duct work.
- Collectively, these changes combined led to lower sheet-metal costs.
- However, Statewide CASE team is proposing *zero* incremental cost

Incremental First Cost		Incremental Maintenance Cost	
Equipment	$0.00	Equipment Replacement	N/A
Installation	$0.00	Annual Maintenance	$0.00
Commissioning	$0.00		$0.00
Other	$0.00		$0.00
Total	**$0.00**	**Total**	**$0.00**

Source: Statewide CASE Team

Feedback on using no incremental cost?

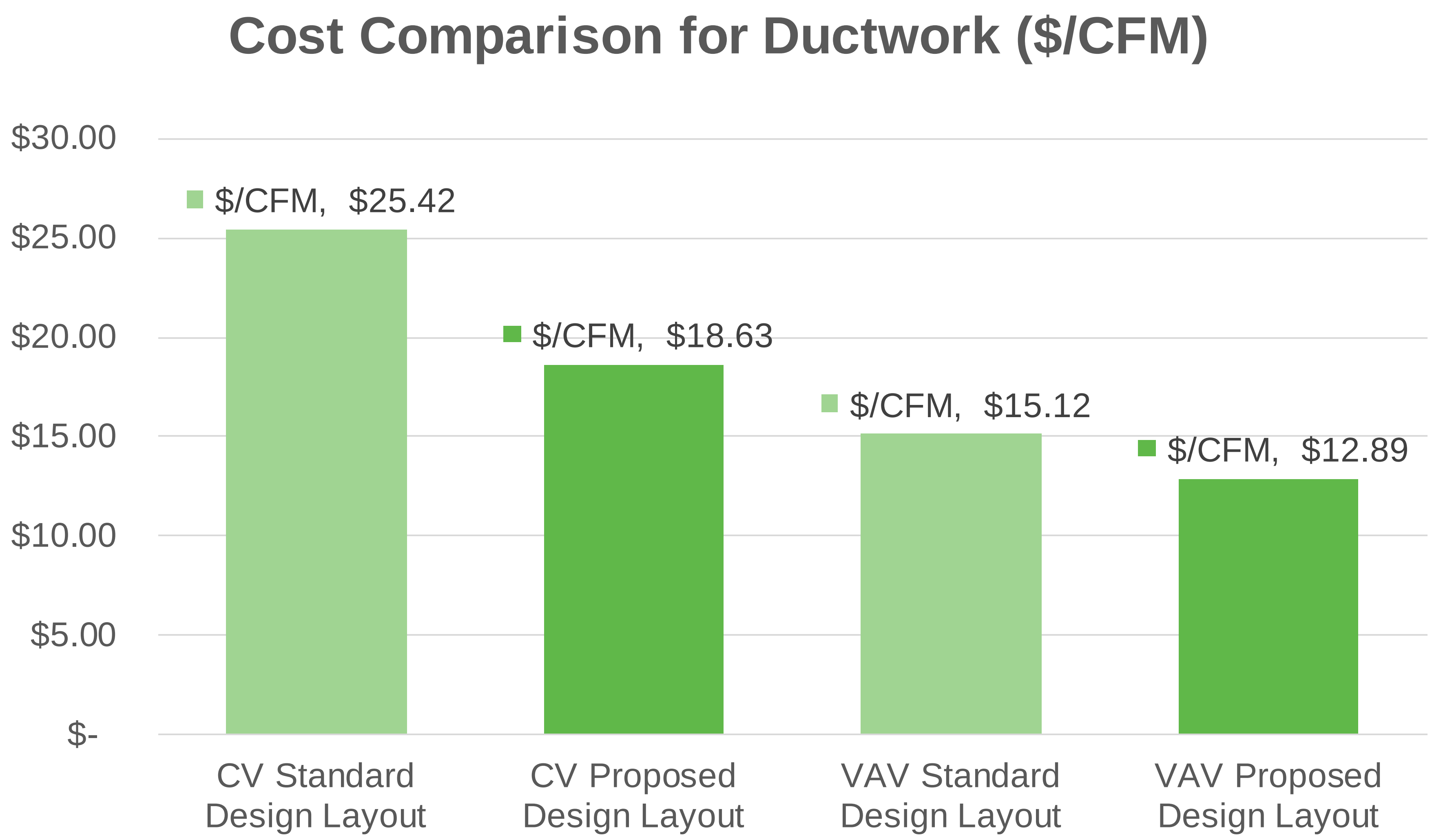
Incremental Cost Results: Large Office Duct Design



Proposed Design is less expensive than Standard Design for both CV and VAV Layouts

Source: Statewide CASE Team

Incremental Cost Results: Large Office Duct Design



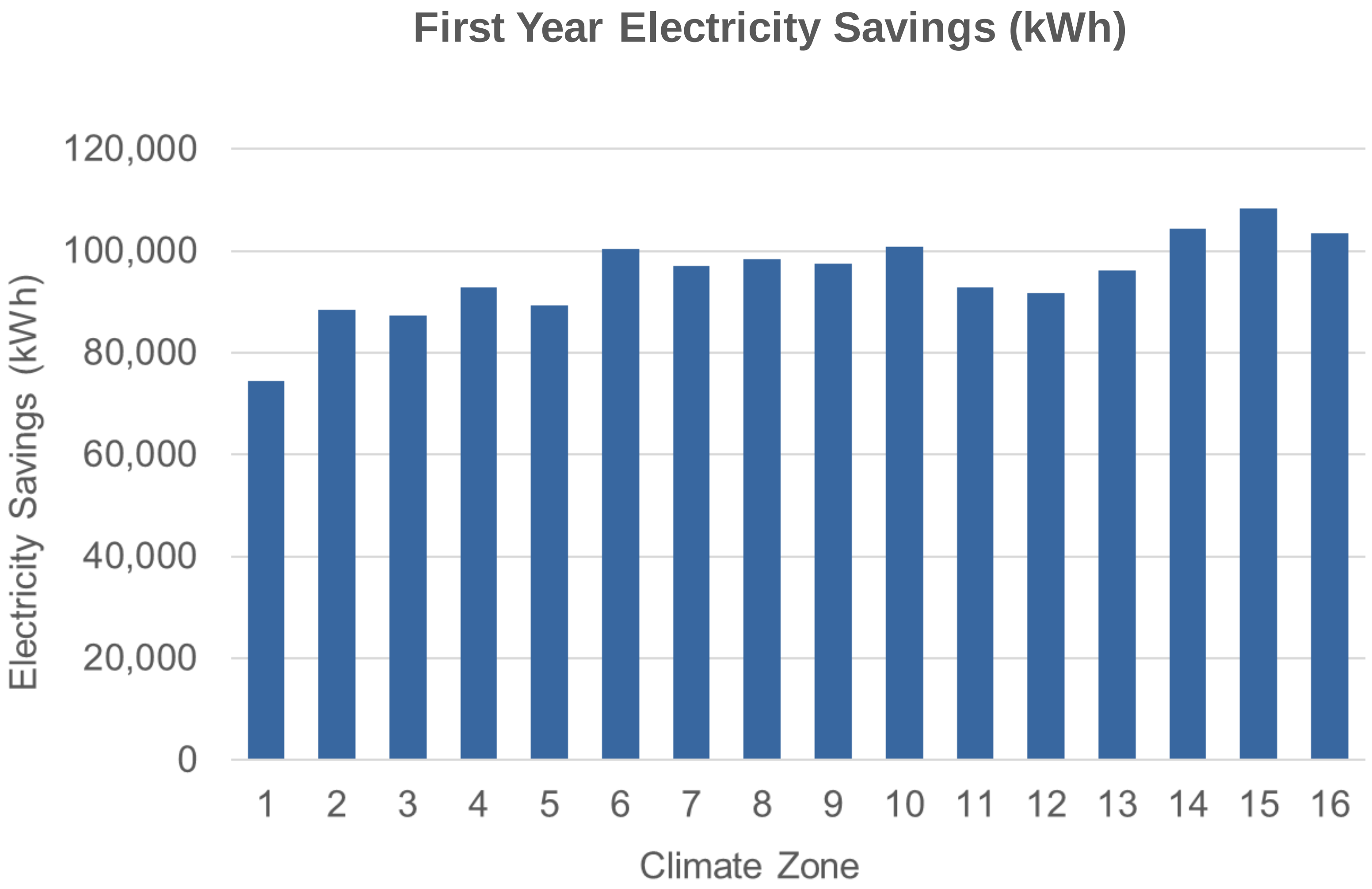
Source: Statewide CASE Team

Takeaways from Duct Costing Exercise

- ✓ The external static pressure assumptions underpinning the existing 2019 fan **power limits are generous**.
- ✓ If the pressure reductions can be achieved in the Large Office prototype, they **can be achieved in other building types**.
- ✓ Using duct design best practices, pressure can be reduced significantly **without new or expensive technology**, at negative or negligible costs.

Energy Savings Results

Office Large in all Climate Zones

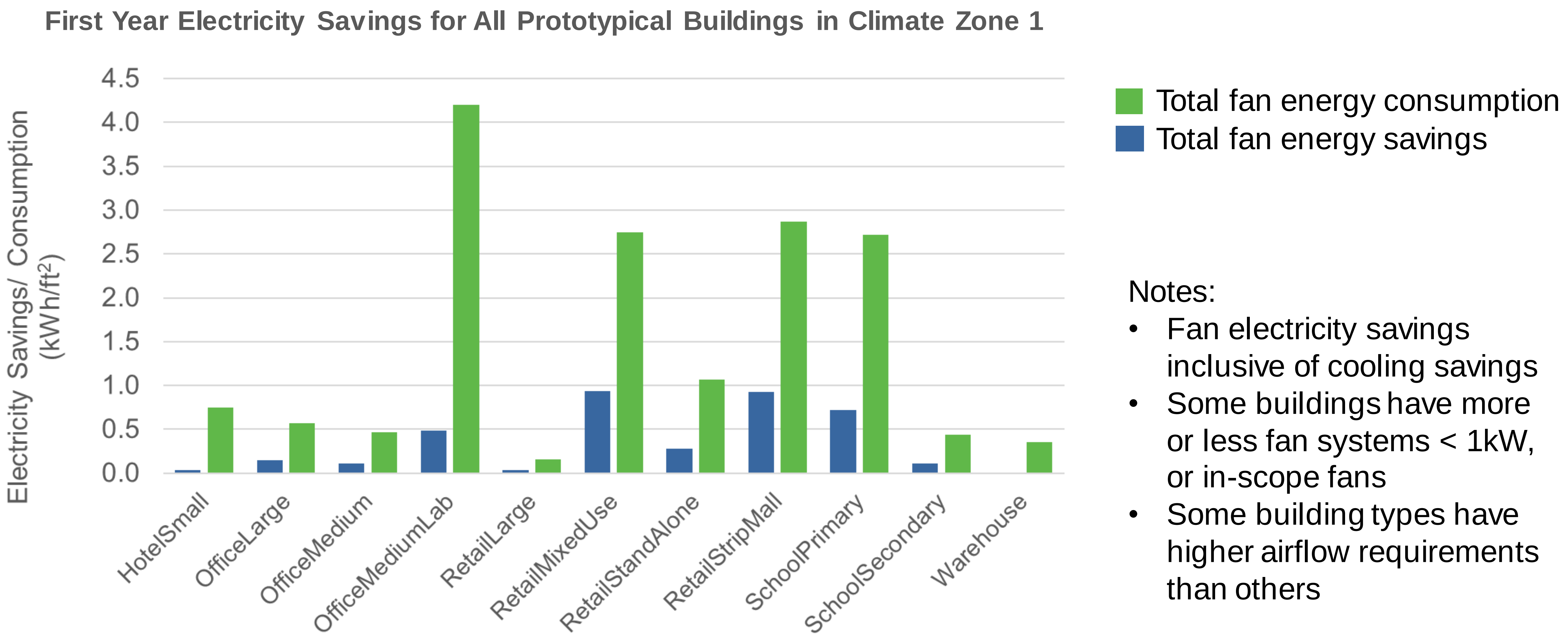


Fan electricity savings is a function of heating and cooling loads, which vary by climate zone.

Source: Statewide CASE Team

Energy Savings Results (kWh/ sq-ft)

All Building Types, Climate Zone 1



Notes:

- Fan electricity savings inclusive of cooling savings
- Some buildings have more or less fan systems < 1kW, or in-scope fans
- Some building types have higher airflow requirements than others

Source: Statewide CASE Team

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023 (million square feet)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million square feet)
Nonresidential	162	85%	146

Source: Statewide CASE Team

2023 Construction Forecast: Existing Buildings

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%	0.00
Large Office	1,665.45	5%	83.27
Restaurant	238.92	5%	11.95
Retail	1,490.53	5%	74.53
Grocery Store	394.19	0%	0.00
Non-refrigerated Warehouse	1,402.32	5%	70.12
Refrigerated Warehouse	75.65	0%	0.00
Schools	724.95	5%	36.25
Colleges	379.99	5%	19.00
Hospitals	488.66	0%	0.00
Hotel / Motel	451.77	5%	22.59
Total	**7,788.95**	**4.1%**	**317.70**

Source: Energy Commission and Statewide CASE Team

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	25	10.41	-0.17	103.6
Additions and Alterations	64	25.93	-0.43	262.3
Total	**89**	**36.35**	**-0.59**	**365.8**

Source: Statewide CASE Team

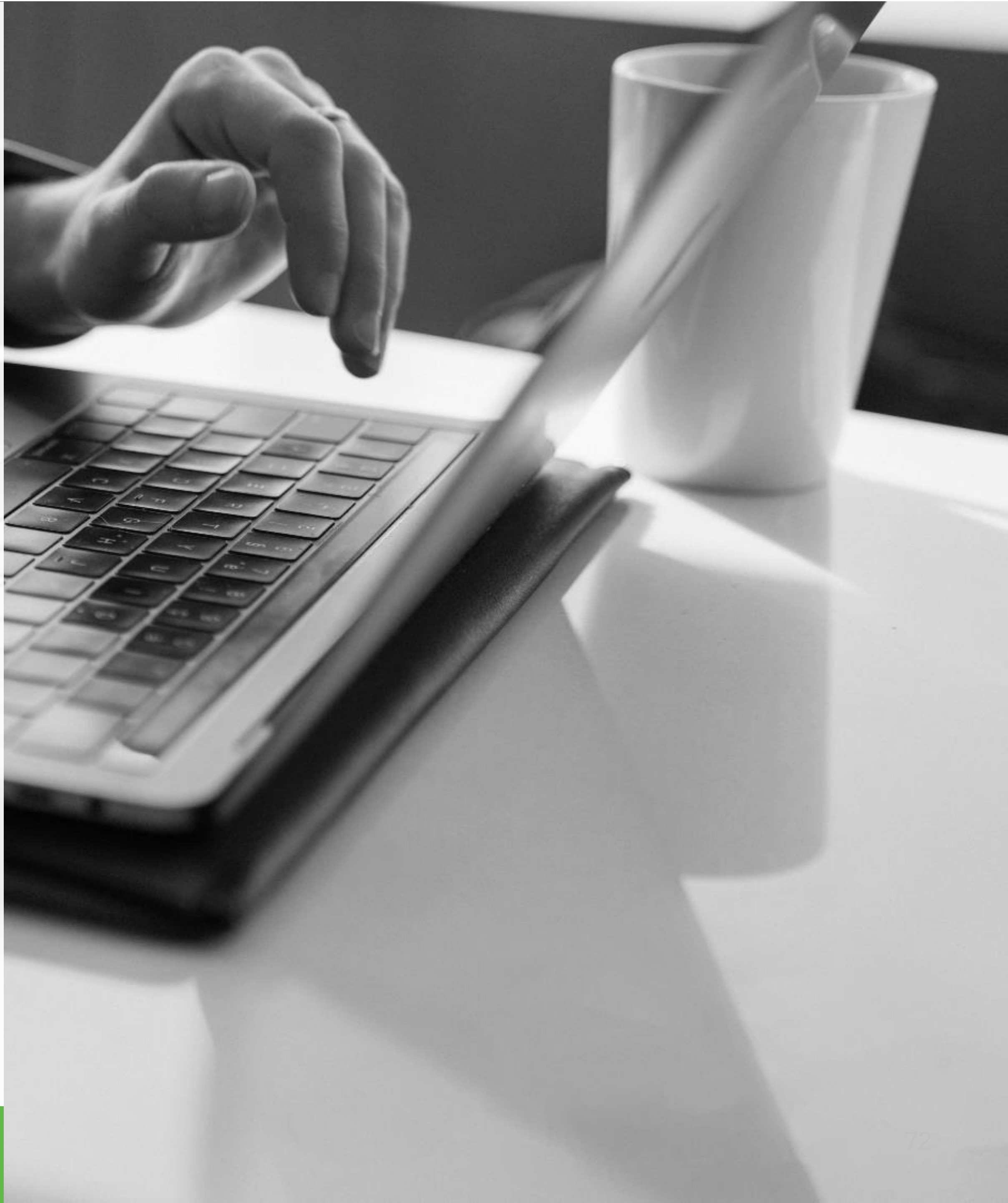
Energy Saving Estimates

- Savings are significant, shows measure would save ~2% of total building kBTUs
- Large electrical savings, though slightly projected increased gas usage due to less fan power heat
- Savings are roughly equal in their impact to CV and VAV systems, across various system sizes

- **Do these savings sound realistic?**

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.**
- **Key Changes from November 2019 Workshop / Code Language:**
  - Addition of an “approach 1” maximum input kW at design conditions with simple look-up table based on system type and airflow
  - Significant updates to reference pressure tables, new components
  - Creation of motor nameplate look-up table option to determine input kW
  - Clarifies additional pressure budget allowance 0.6 in w.g. for supply 0.3 in w.g. for exhaust/ return budget pressure for all alterations and additions

Are the reference pressure reasonable?

Are there components that are not included that should be granted allowance?

Does “approach 1” and motor nameplate to kW method ease concern of calculation complexity?

Software Updates

- **Current modeling capabilities:**
  - Models 5.35 in w.g. (VAV) and 3.85 in w.g. (CV) for fan systems over 5 nameplate HP
- **Proposed new modeling capabilities:**
  - New fan power budget methodology will modify the base case design for fan systems over 1 kW
  - Default pressures will be created for each prototype dependent on air flow, system type and likely system components
  - Switch motor efficiency from look-up table to be calculated via AMCA 208
  - **User inputs will mostly be un-changed, except to be able to select transmission type: belt-driven, direct-drive or synchronous belt**
    - Transmission efficiency to be calculated via AMCA 207

Questions and Next Steps

Submeasure A: Fan Power Budget

Submeasure B: Fan Energy Index

Submeasure C: Duct Leakage

Proposal Overview: Fan Energy Index (FEI)

Add new Fan Energy Index (FEI) metric as a mandatory requirement for certain fans:

- FEI is a wire-to-air metric that encourages more efficient fan selections
- FEI is the ratio of Fan Electrical Power (FEP) of an actual fan compared to power of a reference fan at the same duty point.
- The higher the FEI the more energy efficient

$$\text{FEI} = \frac{\text{Baseline Fan Electrical Input Power}}{\text{Fan Electrical Input Power}}$$

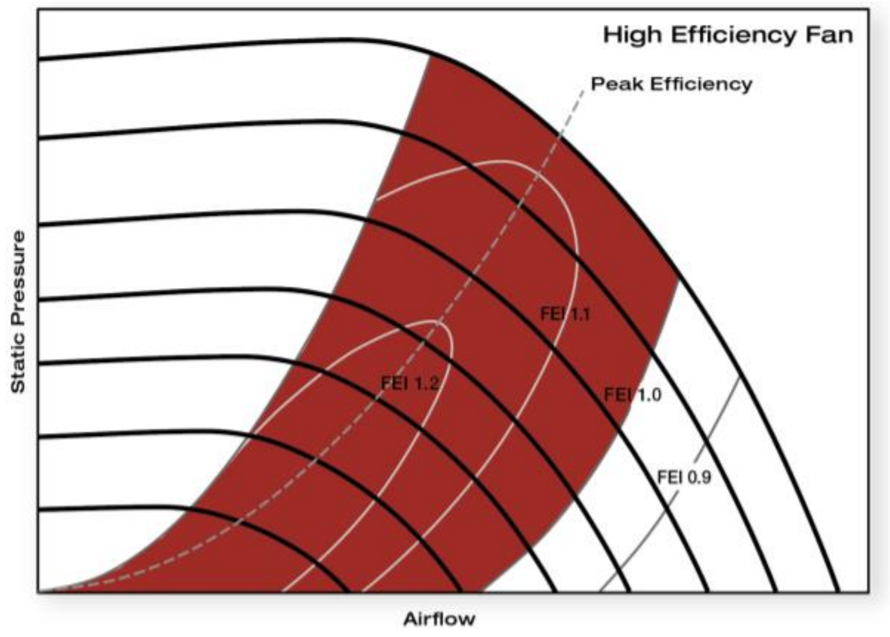
Relevant background information:

- FEI recently adopted into ASHRAE 90.1-2019, IECC
- California Title 20 is currently in pre-rulemaking phase for FEI equipment standard
- AMCA Certified Ratings Program is currently certifying catalogs and software selection tools to accurately display FEI

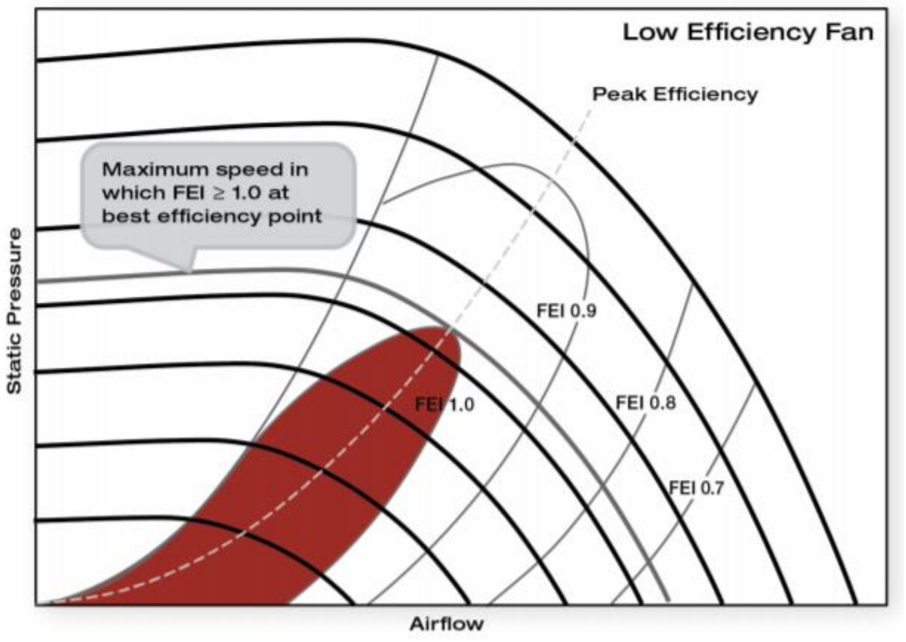
Image Source: https://www.amca.org/assets/resources/public/documents/Introducing%20the%20Fan%20Energy%20Index%20Metric.pdf

More About FEI

- Wire-to-air metric, inclusive of motor, transmission and controls
- More efficient fans have a larger array of compliant/ efficient duty points



EFFICIENT FAN



INEFFICIENT FAN

Image Source: https://www.amca.org/assets/resources/public/documents/Introducing%20the%20Fan%20Energy%20Index%20Metric.pdf

Methodology for Energy Impacts Analysis

- Current 2019 prototype buildings have default fan efficiency and total pressure inputs that lead to all FEI values > 1.0
- Therefore, prototype building fan systems will be modified where FEI metric is most likely to have an impact

Tools Used	CBECC-Com
Building Prototypes Used	TBD
Climate Zones Modeled	All 16 climate zones

Source: Statewide CASE Team

Large Office Supply Fan (VAV) FEI Example

Input	1. CEC Prototype (CBECC-Com Assumptions	2. Plausible Scenario (20% less eff fan, 20% less pressure) w/o FEI requirement	3. Plausible Scenario (20% less pressure) w/ FEI requirement
Airflow (CFM)	31,349	31,349	31,349
Total Pressure (in w.g.)	*5.35*	*4.28*	*4.28*
Fan Efficiency	*65%*	*52%*	*60%*
Total kW	**33.75**	**33.75**	**29.25**
Meets *2019* fan power limits?	Yes, exactly	Yes, exactly	Yes, below
Fan FEI	**1.06**	**0.87**	**1.0**
kW Savings	N/A	N/A	**4.5 kW**

Applying an FEI >= 1.0 mandatory requirement, to scenario 2, a user would have to select a more efficient fan (52% to 60%) to meet an FEI = 1.0, saving 4.5 kW.

Assumptions for Energy Impacts Analysis

- **Background and Context**
  - In overall Air Distribution proposal FEI designed to serve “backstop” to Fan Power Budget and also a “floor” to ensure efficient fan selections regardless of pressure in fan systems.
  - Pursuing FEI compared to 2019 fan power limit baseline
- **Why pursue *FEI?***
  - Metric itself will be valuable to designers/ builders, encourage specification of higher FEI fans
  - Serves as a backstop in cases where there is little to no duct work, namely exhaust fans
  - FEI is in ASRHAE 90.1-2019, IECC-2021, thus significant momentum nationally to move to FEI

Assumptions for Energy Impacts Analysis

- **Baseline: 2019 compliant building, modified fan efficiency**
  - Modified various fan efficiencies / pressures at commonly selected duty points where FEI < 1.0, but where fan power limits are in compliance.
- **Proposed: 2022 minimally compliant building**
  - Energy savings are achieved through raising FEI to 1.0
  - Energy savings are calculated based on incremental savings over 2019 fan power limits, or where 2019 fan power limits do not apply (e.g., < 5HP)

Image Source: https://www.greenheck.com/products/air-movement/fans/centrifugal-downblast-exhaust-fans

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Fan sizes are minimally compliant with 2019 code, specifically the existing Fan Power Limit requirement
- Only in-scope fans with input power ≥1 kW included

Proposed Conditions

- Minimally compliant with 2019 code, specifically the existing Fan Power Limits
- Fans ≥ 1kW will meet the FEI = 1.0 at the design point, not exceed it

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023 (million square feet)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million square feet)
Nonresidential	162	85%	146

Source: Statewide CASE Team

Energy Saving Estimate Status

- Expect draft energy savings in draft CASE report
- Savings will likely be modest due to types of fans assumed in prototype buildings
- Additional real-world energy savings likely as higher FEI values start being specified, industry adapts

Incremental Per Unit Cost

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	$147.16	Equipment Replacement	$0.00
Installation	$0.00	Annual Maintenance	$0.00
Commissioning	$0.00		$0.00
Other	$0.00		$0.00
Total	**$147.16**	**Total**	**$0.00**

$ 147.16

Total incremental cost per fan

Incremental equipment cost represents the average national incremental cost to achieve an FEI of 1.0, based on the 2016 DOE NODA III analysis for a shipment weighted average of all fans analyzed in the DOE scope.

Source: Statewide CASE Team IOU comments Sept 28. 2019, Docket 17-AAER-06: https://efiling.energy.ca.gov/GetDocument.aspx?tn=224826&DocumentContentId=55408

Draft Code Language

SECTION 120.10 (new) – MANDATORY REQUIREMENTS FOR FANS

Each fan or fan array with a combined motor nameplate horsepower greater than 1.0 hp or with a combined fan nameplate electrical input power greater than 0.89 kW shall have a fan energy index (FEI) of 1.00 or higher at fan system design conditions. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C.

Where:

- All FEI values shall be provided by a manufacturer or third party.

Note: The language is slightly different than ASHRAE.

Draft FEI Exemptions

EXCEPTION 1 to Section 120.10. Fans that are part of equipment listed under Section 110.2 (Mandatory Requirements for Space Conditioning Equipment)

EXCEPTION 2 to Section 120.10. Embedded fans and fan arrays with a combined motor nameplate horsepower of 5 hp or less or with a fan system electrical input power of 4.1 kW or less.

EXCEPTION 3 to Section 120.10. Ceiling fans.

EXCEPTION 4 to Section 120.10.. Fans that are intended to only operate during emergency conditions.

EXCEPTION 5 to Section 120.10. Does not apply to additions or alterations.

Changes from ASHRAE Language

Each fan and *fan array at fan system design conditions* shall have a *fan energy index (FEI)* of 1.00 or higher. ~~Each fan and *fan array* used for a *variable-air-volume system* shall have an *FEI* of 0.95 or higher~~ *at fan system design conditions*. The *FEI* for *fan arrays* shall be calculated in accordance with AMCA 208 Annex C.

Exemptions:

1. Fans that are not embedded fans with a motor nameplate horsepower of less than 1.0 hp or with a fan nameplate electrical input power of less than 0.89 kW.
2. Embedded fans and fan arrays with a combined motor nameplate horsepower of 5 hp or less or with a fan system electrical input power of 4.1 kW or less.
3. Embedded fans that are part of equipment listed under Section 110.2 (Mandatory Requirements for Space Conditioning Equipment)
4. ~~Embedded fans included in equipment bearing a third-party-certified seal for air or energy performance of the equipment package.~~
5. Ceiling fans, i.e., nonportable devices suspended from a ceiling or overhead structure for circulating air via the rotation of fan blades.
6. ~~Fans used for moving gases at temperatures above 482°F.~~
7. ~~Fans used for operation in explosive atmospheres.~~
8. ~~Reversible fans used for tunnel ventilation.~~
9. ~~Fans outside the scope of AMCA 208.~~
10. Fans that are intended to only operate during emergency conditions.

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Submeasure A: Fan Power Budget

Submeasure B: Fan Energy Index

Submeasure C: Duct Leakage

Proposal Background

Motivation for Tighter Air Distribution Systems

- Testing and sealing is needed across all ductwork, not just high pressure
- Accessories such as VAV boxes add to leakage
- Fans for air circulation and ventilation account for 28% of HVAC energy consumption
- Fan energy use increases non-linearly with leakage, even in semi-conditioned spaces
- There are numerous technologies and methodologies to create tighter air distribution systems

Image Source: Statewide CASE Team

Code Change Proposal Summary – Duct Leakage Testing

Topic	Construction	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Duct Leakage Acceptance Test	New construction only	--	--	120.4, NA 2.1	NRCC-MCH-E
Seal Class A	New construction only	Mandatory	N	120.4	NRCC-MCH-E
VAV box certification	New construction, alterations and additions	Mandatory	N	120.4	New Documentation

Description of Changes

- Add acceptance test and compliance forms to Title 24, Part 6 for the duct leakage testing requirements in the California Mechanical Code (CMC - 2019)
- Require Seal Class A for all ductwork
- Add certification or field testing of leakage of variable air volume (VAV) boxes

Evolution of Duct Leakage Testing Proposal

- The Statewide CASE Team is no longer pursuing 100 percent system leakage testing:
  - No field studies to assess accuracy and precision of either ASHRAE 215 or the SMACNA SALT Manual and no comparison of the results from the two approaches
  - Insufficient data to support the need for 100 percent testing
  - *Interested in researching full system leakage testing and potentially consider for a future code cycle*
- Pursuing common sense alternative proposals to address air leakage
  - Ductwork:
    - Supplement duct leakage testing requirements in Title 24, Part 4 with clearer testing procedures and forms for Acceptance Test Technicians (ATTs)
    - Require Seal Class A
  - Components: VAV box leakage certification or field test

Existing Duct Leakage Requirements Title 24, Part 6 (not changing)

Section 140.4(l) Duct systems that meet the following requirements:

- Constant volume, single zone, space-conditioning system; and
- Less than 5,000 square feet of conditioned floor area; and
- Surface area of the ducts in the unconditioned spaces is >25 percent of the total.

Shall be sealed to a leakage rate <6 percent of the nominal air handler airflow rate as confirmed through field verification and diagnostic testing

California Mechanical Code Requirements Jan 1, 2020

603.10.1 Duct Leakage Tests

- Ductwork shall be leak-tested in accordance with the SMACNA Air Duct Leakage Test Manual
- Test representative sections totaling not less than 10 percent of total duct area
  - If the 10 percent fails, then test 40 percent.
  - If the 40 percent fails, then test 100 percent.
- Sections shall be selected by the building owner or designative representative
- Applies to all ductwork regardless of pressure class

For all duct systems not covered by 140.4(l)

Rationale for Leakage Acceptance Testing

- Stakeholder outreach has revealed uncertainty about how, when, and where to carry out the testing to comply with mechanical code requirements
- Clear specifications will address ambiguities and will result in consistent testing with results that can be compared from one project to another
- An Acceptance Test in Title 24, Part 6 Reference Appendices is an appropriate mechanism to clarify test procedures, clarify when testing is required, and confirm that tests will be carried out by trained professionals (ATTs)

Rationale for Seal Class A

- ASHRAE 90.1 has required seal class A for all ductwork and plenums with pressure class ratings since 2010
- Contractors are comfortable sealing to this class
- Provides consistency and predictability for air distribution systems
- Has become common practice, but it is not required in California
- Lower seal classes have been shown to leak more than expected

SMACNA Air Duct Leakage Test Manual

Seal Class	**C**	**B**	**A**
Sealing Applicable	Transverse joints only	Transverse joints and seams	Joints, seams, and all applicable wall penetrations
Applicable Pressure Class	2” w.g.	3” w.g.	4” w.g. and up

VAV system duct of 1” (250 Pa) and 1/2” w.g. (125 Pa) construction class upstream of the VAV boxes shall meet Seal Class C.

Background of VAV Box Leakage

- AHRI/ASHRAE RP-1292 (available online)
  - Compared energy consumption of series and parallel fan powered VAV terminal units
  - Series units – leakage is not a problem – leakage is part of induced air
  - Parallel units – leakage is a big problem – air is bypassing occupied space
- ANSI/ASHRAE Standard 130-2016 (available for purchase)
  - Laboratory method of testing air terminal units (first published in 1996)
  - Test method for leakage among other performance characteristics
- SMACNA System Air Leakage Testing Manual – Isolated Item Test (Draft)
  - Field test for inline equipment and accessories
  - First test ductwork alone, then with installed terminal unit to determine leakage
- Many manufacturers already self-report leakage

Energy and Cost Impacts

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

Methodology for Energy Impacts Analysis

- Quantify the reduction in leakage from Seal Class A and tighter VAV boxes
- Determine energy savings from reduced air flow

Tools Used	Spreadsheet analysis CBECC-Com
Building Prototypes Used	Apartment High Rise, Hotel 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

- Compliant with 2019 building code
- Seal Class B for all ductwork
  - Leakage Class 8 for rectangular
  - Leakage Class 4 for round

Proposed Conditions

- Compliant with 2019 building code
- Seal Class A for all ductwork
  - Leakage Class 4 for rectangular
  - Leakage Class 2 for round
- Certified leakage of VAV boxes

Evaluated over 15-year period of analysis

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted (million square feet)	Percent of Statewide New Construction Impacted by Testing and Sealing	Percent of Statewide New Construction Impacted by VAV Certification	Statewide New Construction Impacted by Testing and Sealing and VAV Certification in 2023 (million square feet)
Small Office	10	100%	0%	0
Large Office	36	100%	100%	36
Restaurant	5	100%	0%	0
Retail	32	100%	0%	0
Grocery Store	8	100%	0%	0
Non-Refrigerated Warehouse	30	100%	0%	0
Refrigerated Warehouse	2	100%	0%	0
Schools	12	100%	100%	12
Colleges	7	100%	100%	7
Hospitals	9	100%	100%	9
Hotel/Motels	11	100%	100%	11
Total	**163**	**100%**	**46%**	**75**

2023 Construction Forecast: Existing Buildings – VAV Boxes

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent Impacted by Proposal	Statewide Existing Floorspace Impacted by Proposal in 2023 (million square feet)
Small Office	477	0%	0
Large Office	1,665	7%	111
Restaurant	239	0%	0
Retail	1,491	0%	0
Grocery Store	394	0%	0
Non-refrigerated Warehouse	1,402	0%	0
Refrigerated Warehouse	76	0%	0
Schools	725	7%	48
Colleges	380	7%	25
Hospitals	489	7%	32
Hotel / Motel	452	7%	30
Total	**7,789**	**3%**	**247**

Incremental Cost Information

- Cost collection methodology
  - Interviews with manufacturers and contractors
  - Cost of sealing to a higher class, cost of certification
- Costs were found to be ...
- 5-10 percent higher to go from Seal Class B or C to Seal Class A
- Negligible costs per VAV box to certify, potentially higher to field test

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview

- Contractors have reported that they often meet Seal Class A
- Contractors have reported they are comfortable field testing the leakage of terminal units
- ASHRAE 130 can be used to certify VAV box leakage
- Statewide CASE Team is exploring options for certified product list:
  - Manufacturer certification to the Energy Commission
  - Potential trade association maintaining a list of certified products
- Many manufacturers already publish leakage values from their own testing

Are there other accessories ready for leakage certification?

How do we prepare the rest of the accessory market for certification in coming cycles?

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance and Enforcement

Acceptance testing for duct leakage:

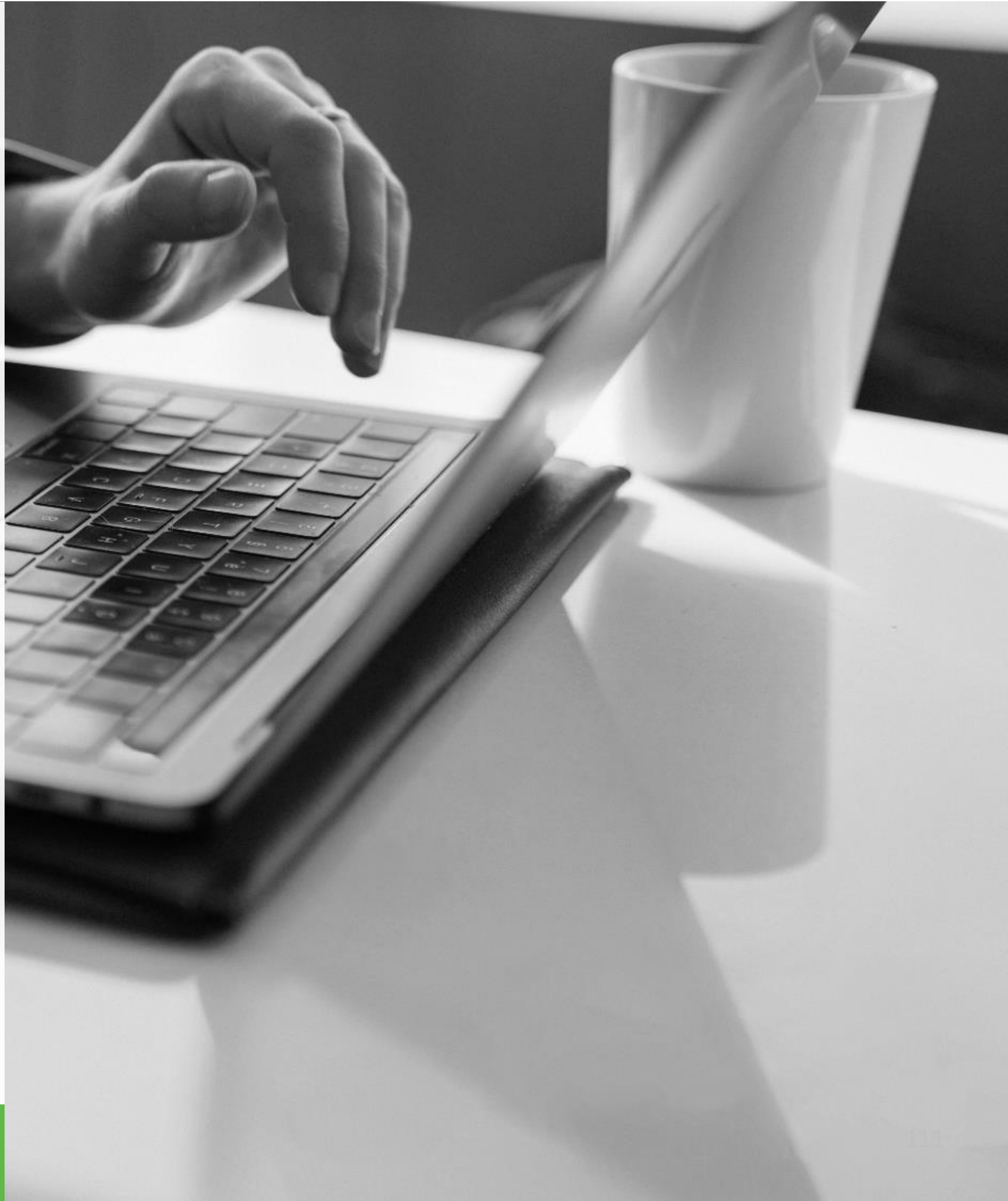
1. Should ATTs who perform the leakage testing for ductwork have additional certifications (e.g., certified air balancers)?
2. What documentation do ATTs need to support testing?
3. How can testing be randomized without disrupting construction schedules?

VAV box certification:

1. Who should perform the testing of VAV boxes?

Proposed Code Changes

- Draft Code Change Language



Draft Code Change Language

- **Updated** draft code language for this submeasure is available onscreen. Let's review.
- Mandatory requirement for Seal Class A in Section 120.4
- Mandatory requirement for VAV leakage in Section 120.4
- Duct leakage testing specifications in NA 2.1
- VAV leakage testing by Isolated Item Test in NA 2.1

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Computer Room Efficiency

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Computer Room Efficiency

Hillary Weitze, *Red Car Analytics*
Jeff Stein, *Taylor Engineering*
March 12, 2020

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

Today's Objectives

The focus of today's meeting includes:

1. **Review** Energy and Cost Calculations Assumptions
2. **Review** Revised Code Language

Proposal Background

Code Change Proposal Summary

Submeasure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Uninterruptible Power Supply (UPS) Efficiency	Prescriptive	Yes	140.9(a)	NRCC-PRC-E
Increased Temperature Threshold for Economizers	Prescriptive	Yes	140.9(a)	NRCC-PRC-E
Heat Recovery	Prescriptive	Yes	140.9(a)	NRCC-PRC-E; NRCA-PRC-17-F (new)
Power Usage Effectiveness (PUE) Monitoring	Mandatory	No	120.6(h)	NRCC-PRC-E; NRCA-PRC-17-F (new)
Mandatory Measures: • Reheat • Humidification • Fan Control	Mandatory	No	120.6(h)	NRCC-PRC-E

Description of Changes

- Multiple cases established for triggering computer room heat recovery requirements.
- PUE Monitoring submeasure changed from prescriptive to mandatory.
- Generator Crankcase heating, server utilization monitoring, and liquid cooling submeasures dropped.

Where Computer Room Requirements Apply

Submeasure	Trigger	Exceptions
Uninterruptible Power Supply (UPS) Efficiency	Computer rooms with ITE* design load greater than 20 W/sf and AC-output UPS	UPSs utilizing NEMA 1-15P or 5-15P input plugs
Heat Recovery	Building computer room ITE design load and heating load exceed minimum values (varies by climate zone – see Section 140.9(a) for more detail)	1. Heating system has coefficient of performance of at least 3.0 at design conditions 2. Computer rooms in existing buildings
Power Usage Effectiveness (PUE) Monitoring	1. At least 2,000 kW computer room ITE design load; and 2. At least 80 percent of building cooling capacity serves computer rooms; and 3. Computer room uses UPS	N/A

*ITE = information technology equipment load

Where Computer Room Requirements Apply

Submeasure	Trigger	Exceptions
Increased Temperature Threshold for Economizers	Computer rooms with ITE design load greater than 20 W/sf	Current exceptions without changes: 1. Computer rooms under 5 tons in building without economizer 2. New cooling system serving existing computer room up to 50 tons 3. New cooling system serving new computer room in existing building up to 20 tons Current exceptions with proposed changes: 4. Computer rooms less than 50 tons served by two systems (see 140.9(a) for more detail) Newly proposed exceptions: 5. Computer rooms where at least 80 percent of the annual heat output is recovered to provide heating for other spaces/loads.

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.**

Resources on

Presentation slides and **Submeasure summary** documents available that cover the following:

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

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

Energy and Cost Impacts

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

Submeasure A: UPS Efficiency

Submeasure B: Increased Temperature Threshold for Economizers

Submeasure C: Heat Recovery

Submeasure D: PUE Monitoring

Measure Description: UPS Efficiency

UPS prescriptive efficiency requirements and **testing requirements**, based on ENERGY STAR, for AC-output UPS units used in computer rooms.

The minimum average UPS efficiency considers UPS efficiency at **100%**, **75%**, **50%**, and **25%** load factors.

Methodology for Energy Impacts Analysis: UPS Efficiency

- Spreadsheet model of computer room using ACM rules was developed to show savings for both types of computer room cooling systems (DX CRACs and CHW CRAHs).
- Standard and Proposed Design UPS waste heat modeled based on part-load efficiency curve (25%, 50%, 75%, 100% load factor).
- Energy savings is due to reduced UPS waste heat (more efficient UPS) and lower cooling load from UPS.
- Energy savings is presented on a "per kW of IT load" unit basis.

Tools Used	Spreadsheet analysis
Building Simulation Cases/ Prototypes Used	Small computer room (200 kW IT load, CRAC cooling); large computer room (1,000 kW IT load, CHW CRAH cooling)
Climate Zones Modeled	CZ 1 through 16

Assumptions for Energy Impacts Analysis: UPS Efficiency

- **Energy analysis assumptions:**

	Baseline	Proposed
UPS Efficiency Source	Average Efficiency of ENERGY STAR v1.0 UPS > 100 kW that don't meet v2.0 efficiency	ENERGY STAR v2.0 Minimum UPS Efficiency for UPS > 100 kW
IT Equipment Load Schedule	DataReceptacle	DataReceptacle
Cooling System Efficiency	2019 Title 24, Part 6	2019 Title 24, Part 6

Definition of Baseline and Proposed Conditions:
UPS Efficiency

Baseline Conditions

- UPS Efficiency:

Load Factor	25%	50%	75%	100%
Efficiency	91.2%	94.0%	94.6%	94.6%

Case 1: Small Computer Room

- Cooling System: DX CRAC
- ITE design load: 200 kW
- No economizer (UPS waste heat load < 54,000 Btu/hr)

Case 2: Large Computer Room

- Cooling System: CHW CRAH w/ screw chillers
- ITE design load: 1,000 kW
- Air economizer

Proposed Conditions

- UPS Efficiency:

Load Factor	25%	50%	75%	100%
Efficiency	93.9%	95.3%	94.7%	94.9%

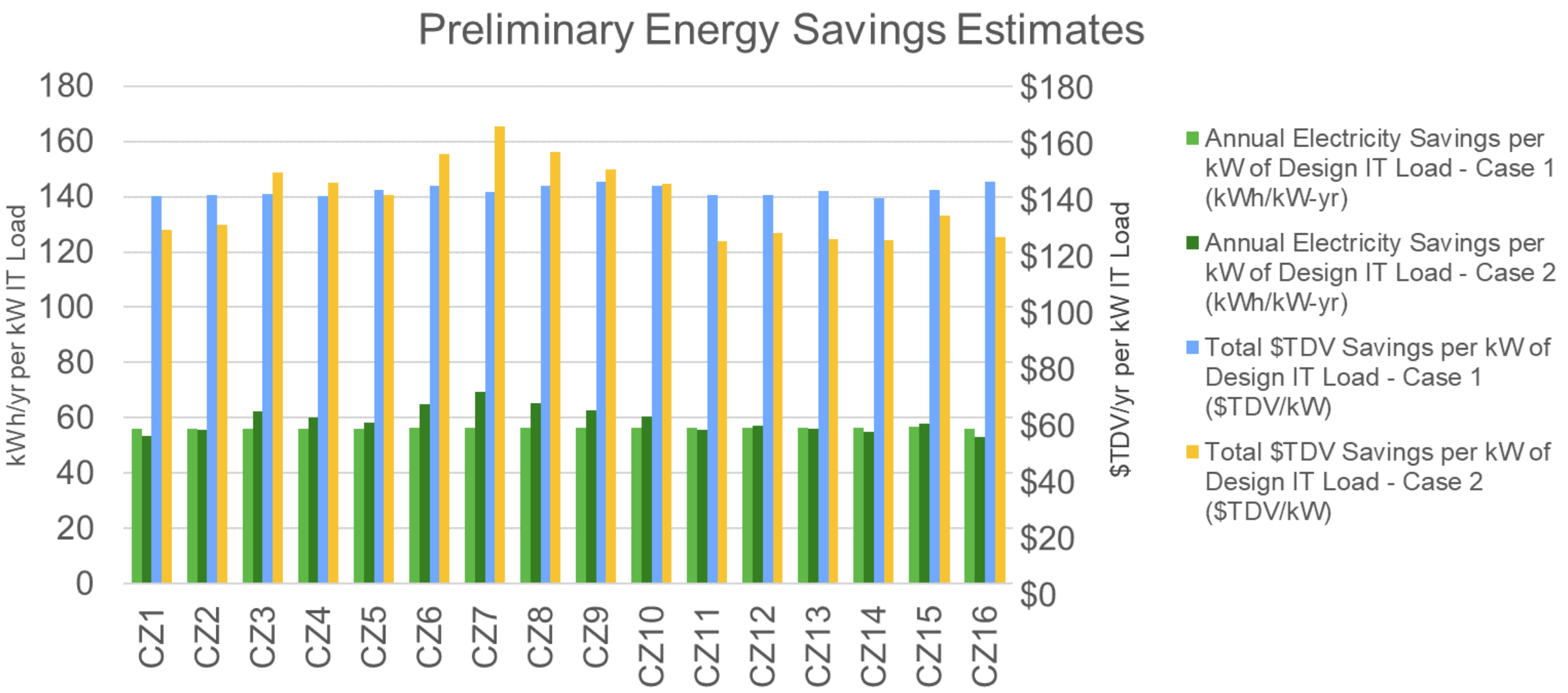
Case 1: Small Computer Room

- Same as Baseline

Case 2: Large Computer Room

- Same as Baseline

Per Unit Energy Savings: UPS Efficiency



Incremental Cost Information: UPS Efficiency

- **Cost data sources:**
  - UPS manufacturers/distributors
  - Construction projects
- **Costs include:**
  - Incremental equipment cost for more efficient UPS unit
  - Incremental installation labor, commissioning, and maintenance assumed to be $0

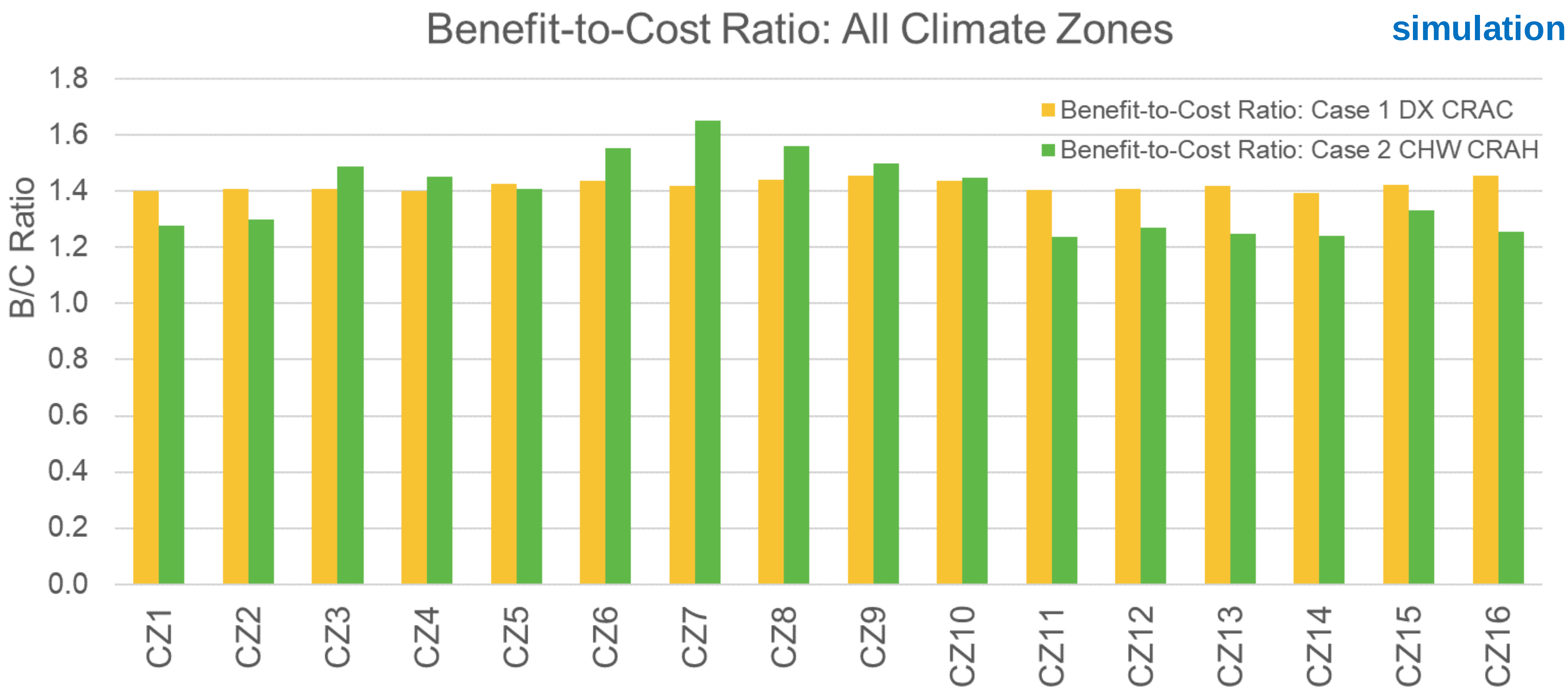
Incremental Per Unit Cost: UPS Efficiency

Over 15 Year Period of Analysis

Incremental First Cost ($/kW)		Incremental Maintenance Cost ($/kW)	
Equipment (UPS)	$100	Equipment Replacement	$0
Installation	$0	Annual Maintenance	$0
Commissioning	$0		
Total	**$100**	**Total**	**$0**

Cost Effectiveness Results: UPS Efficiency

The submeasure shows a positive B/C Ratio for all climate zones and both simulation cases.



Period of evaluation: 15 years

Submeasure A: UPS Efficiency

Submeasure B: Increased Temperature Threshold for Economizers

Submeasure C: Heat Recovery

Submeasure D: PUE Monitoring

Measure Description: Increased Temperature Threshold for Economizers

This submeasure proposes:

- Increasing the prescriptive minimum outdoor temperatures for 100% economizing to 65°F dry-bulb or 50°F wet-bulb for any economizer type; and
- Decreasing the computer room equipment load threshold for when air containment is prescriptively required to 15 kW per room.

Methodology for Energy Impacts Analysis: Increased Temperature Threshold for Economizers

- Spreadsheet model of computer room using ACM rules was developed to show savings for both types of computer room cooling systems (DX CRACs and CHW CRAHs).
- Small computer room: energy savings is due to increased economizer hours and reduced fan energy savings with containment.
- Large computer room energy savings is due to increased economizer hours.
- Energy savings is presented on a “per kW of IT load” unit basis.

Tools Used	Spreadsheet analysis
Building Simulation Cases/ Prototypes Used	small computer room (50 kW IT load, CRAC cooling); large computer room (1,000 kW IT load, CHW CRAH cooling)
Climate Zones Modeled	CZ 1 through 16

Definition of Baseline and Proposed Conditions: Increased Temperature Threshold for Economizers

Baseline Conditions

All Cases

- Full air economizing at **55°F dry-bulb** OAT and below

Case 1: Small Computer Room

- Cooling System: DX CRAC
- ITE design load: 50 kW
- SAT/RAT = **60°F/75°F (15°F delta-T)**

Case 2: Large Computer Room

- Cooling System: CHW CRAH
- ITE design load: 1,000 kW
- SAT/RAT = **60°F/80°F** (20°F delta-T)

Proposed Conditions

All Cases

- Full air economizing at **65°F dry-bulb** OAT and below

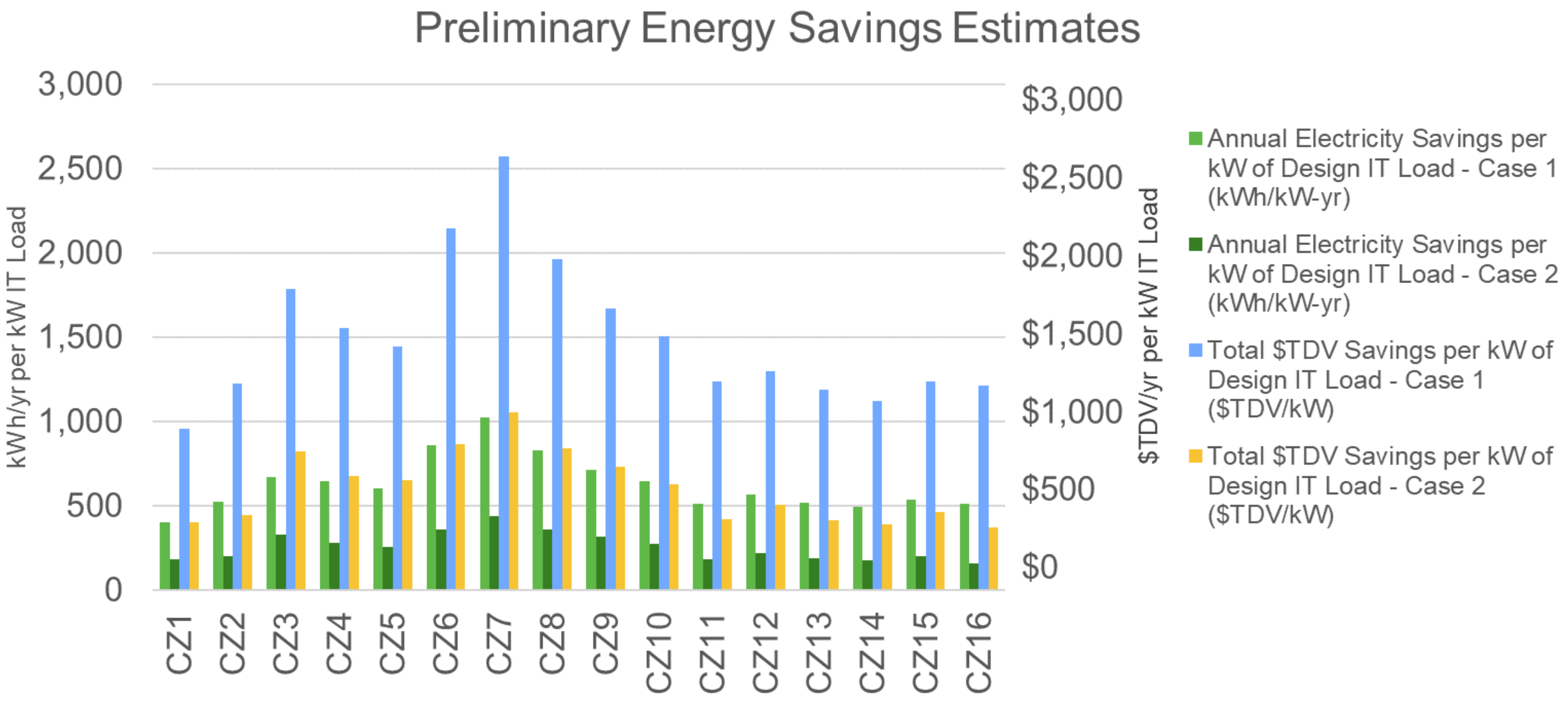
Case 1: Small Computer Room

- Cooling System: DX CRAC
- ITE design load: 50 kW
- SAT/RAT = **65°F/85°F (20°F delta-T)**

Case 2: Large Computer Room

- Cooling System: CHW CRAH
- ITE design load: 1,000 kW
- SAT/RAT = **65°F/85°F** (20°F delta-T)

Per Unit Energy Savings: Increased Temperature Threshold for Economizers



Incremental Cost Information: Increased Temperature Threshold for Economizers

- **Cost data sources:**
  - Return air chimney manufacturers/distributors
  - Construction projects
- **Costs include:**
  - Incremental equipment cost for return air chimney
  - Incremental commissioning and maintenance assumed to be $0

Image Source: http://powerquality.eaton.in/products-services/airflow-management/heat-containment-system.asp?cx=36

Incremental Per Unit Cost:
Increased Temperature Threshold for Economizers

Over 15 Year Period of Analysis

Case 1: DX CRAC

Incremental First Cost ($/kW)		Incremental Maintenance Cost ($/kW)	
Equipment (return air rack chimneys)	$280	Equipment Replacement	$0
Installation*	$70	Annual Maintenance	$0
Commissioning	$0		
Total	**$350**	**Total**	**$0**

*Installation = 2 hours per server rack * $175/hr

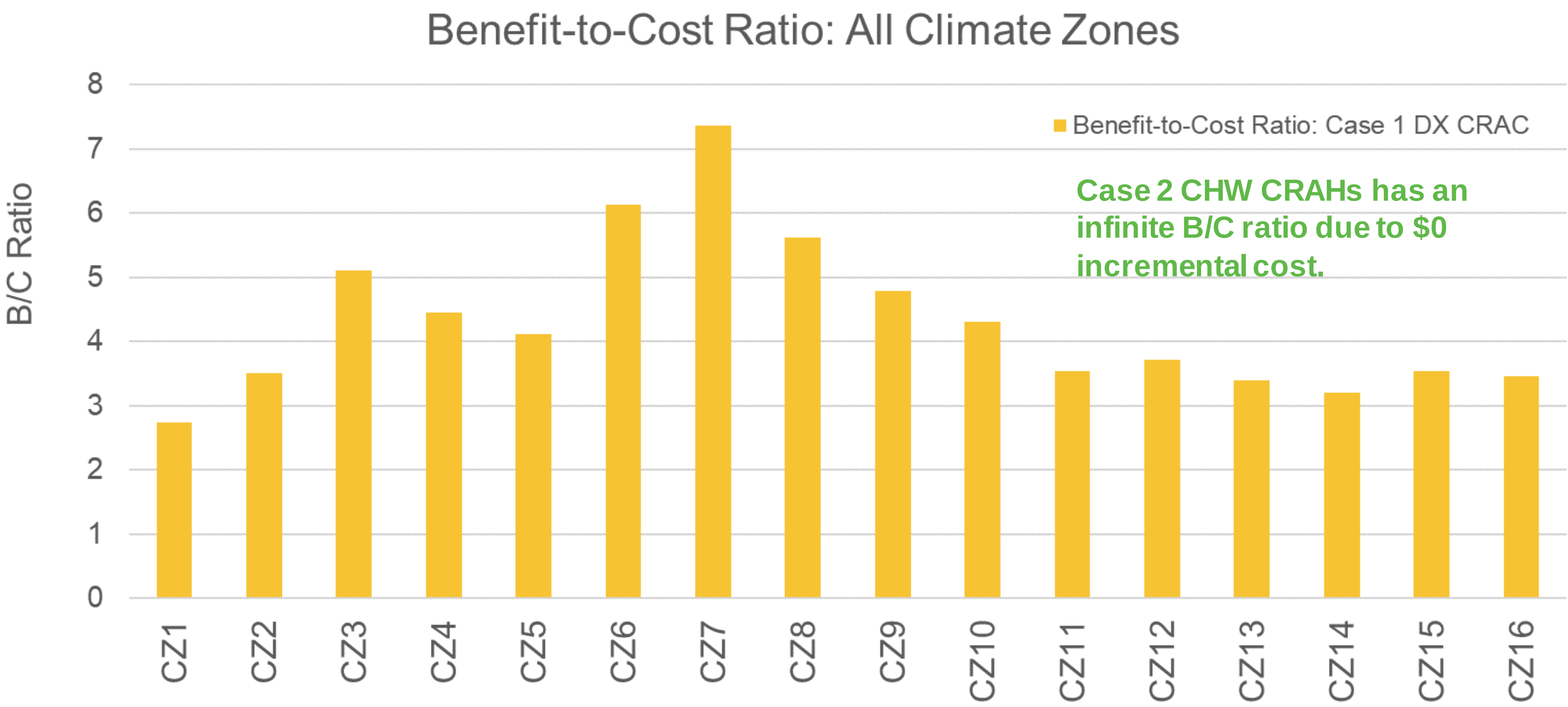
Do these assumptions look right?

Case 2: CHW CRAH

Incremental First Cost ($/kW)		Incremental Maintenance Cost ($/kW)	
Equipment	$0	Equipment Replacement	$0
Installation	$0	Annual Maintenance	$0
Commissioning	$0		
Total	**$0**	**Total**	**$0**

Cost Effectiveness Results: Increased Temperature Threshold for Economizers

The submeasure shows a positive B/C Ratio for all climate zones and both simulation cases.



Period of evaluation: 15 years

Submeasure A: UPS Efficiency

Submeasure B: Increased Temperature Threshold for Economizers

Submeasure C: Heat Recovery

Submeasure D: PUE Monitoring

Measure Description: Computer Room Heat Recovery

Prescriptive requirement for computer room heat recovery for buildings fall into one of the following cases (buildings must exceed both the ITE Design Load and Heating Design Load to trigger requirement):

Simulation Case	Climate Zone	Building Total ITE Design Load (kW)	Building Heating Design Load (Btu/hr)
1	All	> 50	> 200,000
2A	1, 2, 3, 4, 5, 11, 12, 13, 14, 16	> 200	> 4,000,000
2B	1, 2, 3, 4, 5, 11, 12, 13, 14, 16	> 500	> 2,500,000
2C	6, 7, 8, 9, 10, 15	> 300	> 5,000,000

Methodology for Energy Impacts Analysis: Computer Room Heat Recovery

- Energy savings are due to reduced heating load in non-computer room spaces.
- Energy savings are presented on a “per kW of IT load” unit basis.

	Case 1: computer room with nearby zones	*Case 2: large computer room with large heating load*
Tools Used	CBECC-Com -> EnergyPlus -> spreadsheet analysis	CBECC-Com -> EnergyPlus -> spreadsheet analysis
Building Simulation Cases/ Prototypes Used	Small Office + 500 kW IT load	Large Office + computer room
Climate Zones Modeled	CZ 1 through 16	CZ 1 through 16

Definition of Baseline and Proposed Conditions:

Computer Room Heat Recovery: *Case 2: large computer room with large heating load*

Baseline Conditions

Case 2: Large Computer Room + Large Office

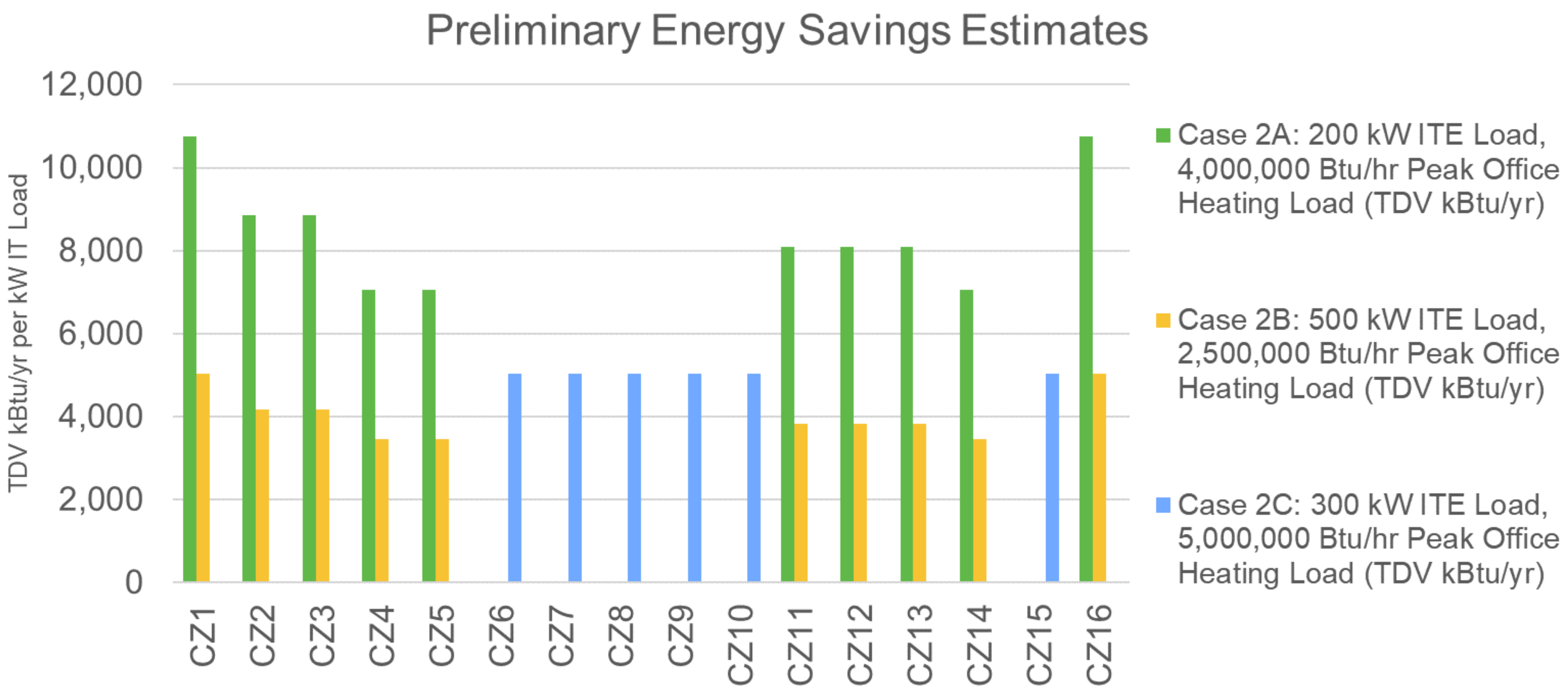
- Boiler Design Efficiency: 80%
- Boiler Type: Non-condensing natural gas
- Design Heating Hot Water Supply Temperature: 160°F

Proposed Conditions

Case 2: Large Computer Room + Large Office

- Boiler: same as baseline **(used only to boost recovered hot water from 140°F to 160°F)**
- Design Heating Hot Water Supply Temperature: 160°F
- Chiller Design Efficiency in Heat Recovery: **3.52 COP**
- Chiller Type: **heat recovery centrifugal**
- Chilled Water Supply Temperature: 55°F

Per Unit Energy Savings: Computer Room Heat Recovery:
Case 2: large computer room with large heating load



Incremental Cost Information: Computer Room Heat Recovery:
Case 2: large computer room with large heating load

- **Cost data sources:**
  - 3 heat recovery chiller vendors
  - Mechanical contractor
- **Costs include:**
  - Chiller & associated accessories first costs
  - Installation labor first costs
  - Controls first costs
  - Annual maintenance

Incremental Cost: Computer Room Heat Recovery:
Case 2: large computer room with large heating load
Over 15 Year Period of Analysis

Total Costs

Incremental First Costs ($)*		
Equipment (chiller, piping, etc.)	$35,800	$66,900
Installation Labor	$25,700	$39,700
Controls	$33,975	$38,975
Miscellaneous	$19,000	$19,000
Total	**$114,475**	**$164,575**

Incremental Maintenance Cost ($)	
Annual Maintenance	**$2,100**

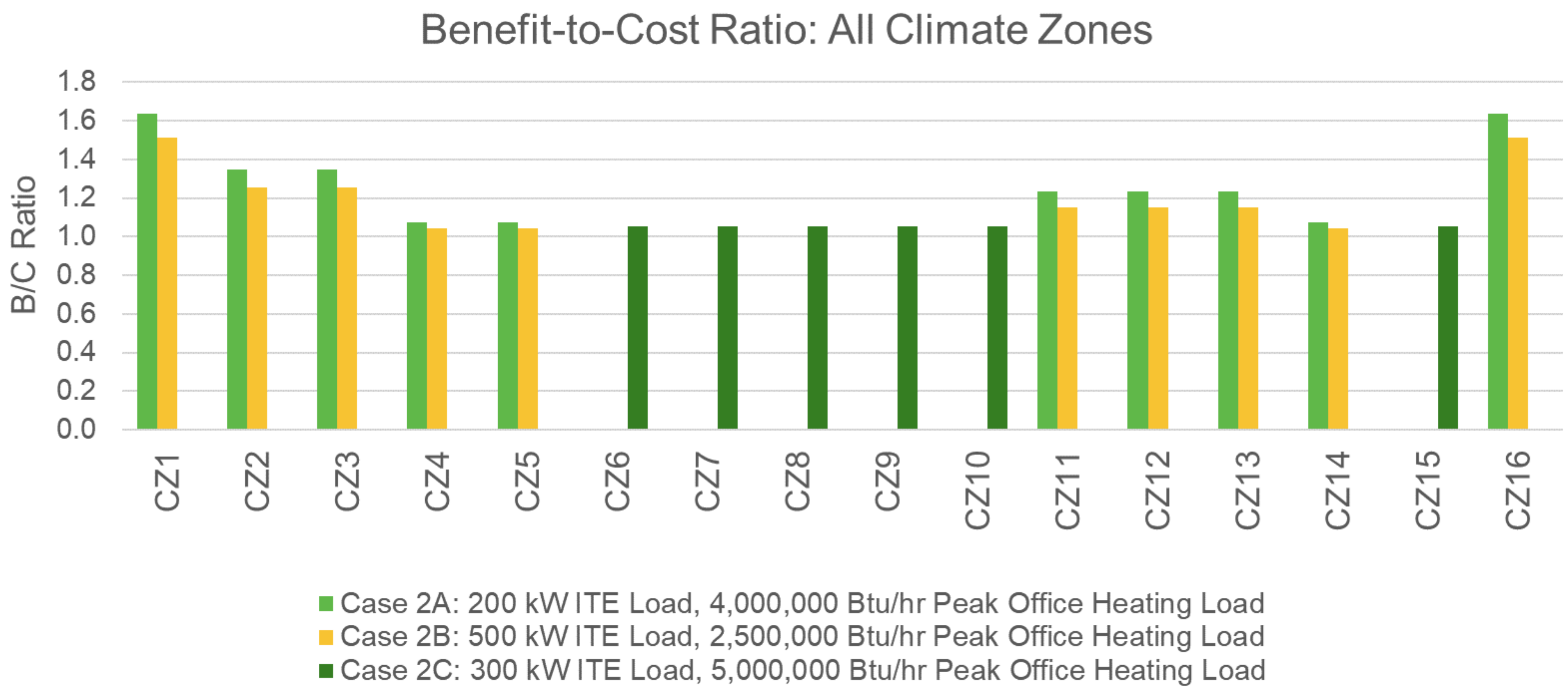
Per Unit Costs

Total Incremental First Cost ($/kW)	
Case 2A: 200 kW IT Load, 4,000,000 Btu/hr Peak Office Heating Load	$584.92
Case 2B: 500 kW ITE Load, 2,500,000 Btu/hr Peak Office Heating Load	$740.36
Case 2C: 300 kW ITE Load, 5,000,000 Btu/hr Peak Office Heating Load	$636.73

*Prices were linearly interpolated for chiller sizes between 40 and 150 tons.

Cost Effectiveness Results: Computer Room Heat Recovery:

Case 2: large computer room with large heating load



The submeasure shows a positive B/C Ratio for all climate zones and all simulation cases.

Period of evaluation: 15 years

Submeasure A: UPS Efficiency

Submeasure B: Increased Temperature Threshold for Economizers

Submeasure C: Heat Recovery

Submeasure D: PUE Monitoring

Measure Description: PUE Monitoring

Mandatory requirement for computer rooms **exceeding 2,000 kW ITE load** served by UPS to have metering installed to calculate Power Usage Effectiveness (PUE) and to provide this data to the building operator in an accessible manner.

Methodology for Energy Impacts Analysis: PUE Monitoring

- Large Office CBECC-Com prototype model was modified to convert the core zone on each floor to a Computer Room space type. After simulation, a 1% savings in computer room fan energy and computer room cooling energy was applied.
- Energy savings is due to decreased computer room HVAC energy.
- Energy savings is presented on a “per kW of IT load” unit basis.

Tools Used	CBECC-Com -> spreadsheet analysis
Building Simulation Cases/ Prototypes Used	Large Office with core zones modified to computer rooms (2,000 kW total IT load)
Climate Zones Modeled	CZ 1 through 16

Definition of Baseline and Proposed Conditions:
PUE Monitoring

Baseline Conditions

Case 1: Large Computer Room

- Cooling System: CHW CRAH
- ITE design load: 2,000 kW

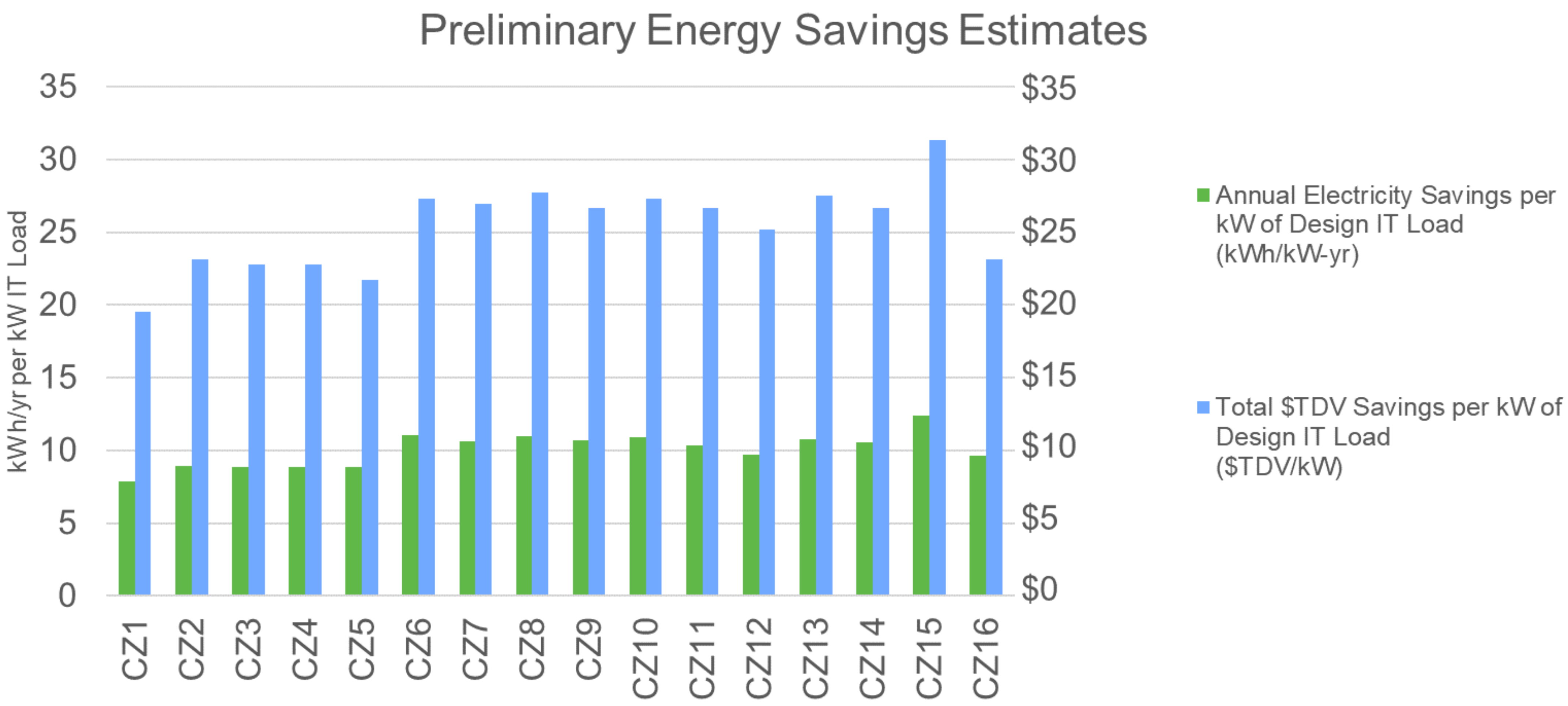
Proposed Conditions

Case 1: Large Computer Room

- Cooling System: **1% annual energy savings from baseline***
- ITE design load: 2,000 kW

*Studies by LBNL, CPUC, and EnergyStar show buildings that are monitored and use comparative metrics show 1.6%-14% annual energy savings on average.

Per Unit Energy Savings: PUE Monitoring



Incremental Cost Information: PUE Monitoring

- **Cost data sources:**
  - Controls contractors
  - Commissioning agents
- **Costs include:**
  - Controls contractor time to integrate metering points into dashboard
  - Commissioning time for Acceptance Test
- **Costs do not include:**
  - Electrical meters (this mandatory requirement is only triggered if UPS output meter is already included on project)

Incremental Per Unit Cost: PUE Monitoring

Over 15 Year Period of Analysis

Incremental First Cost ($/kW)		Incremental Maintenance Cost ($/kW)	
Equipment (whole building submeter)	$6.52	Equipment Replacement	$0
Installation	$1.32	Annual Maintenance	$0
Commissioning	$0.64		
Total	**$8.48**	**Total**	**$0**

Assumptions

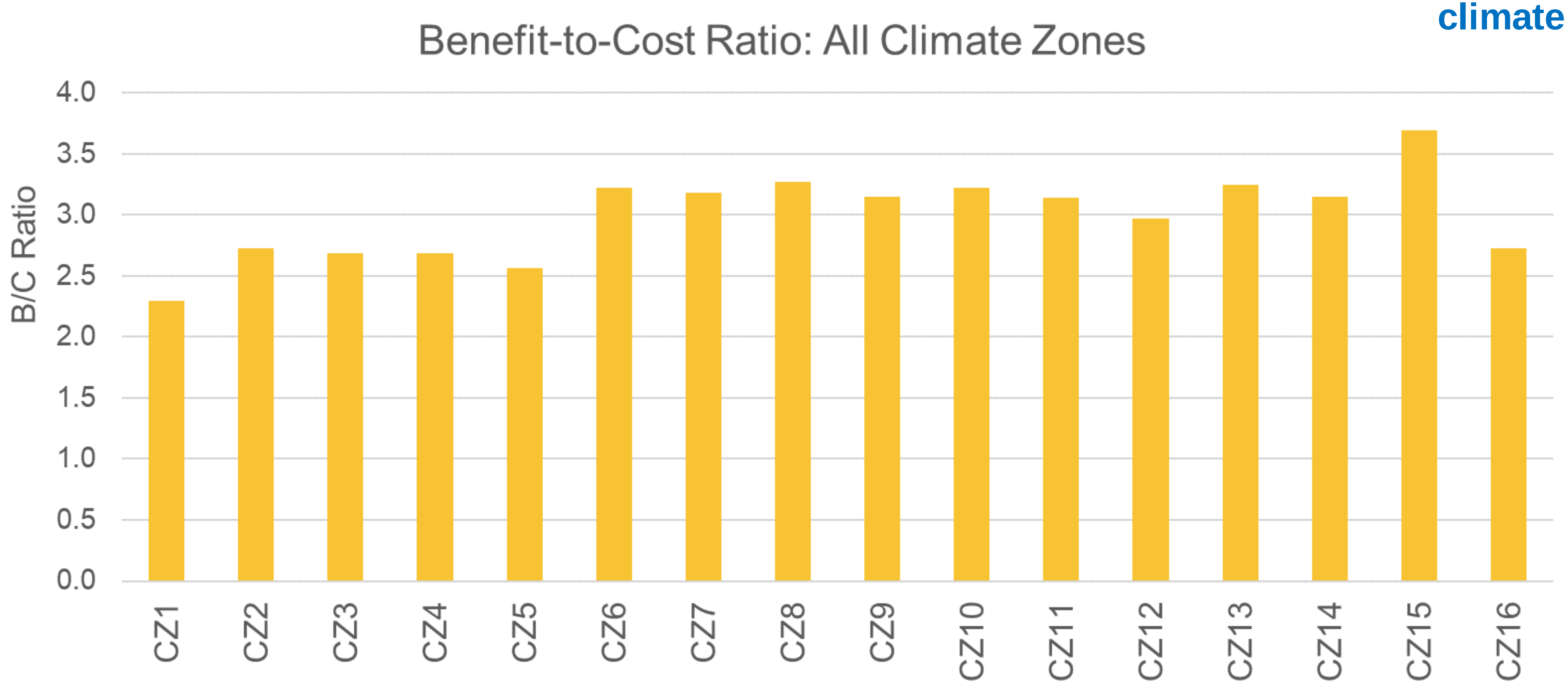
Installation = 12 hours * $220/hr

Commissioning = 8 hours * $160/hr

Do these assumptions look right?

Cost Effectiveness Results: PUE Monitoring

The submeasure shows a positive B/C Ratio for all climate zones.



Period of evaluation: 15 years

2023 Construction Forecast: New & Existing Buildings

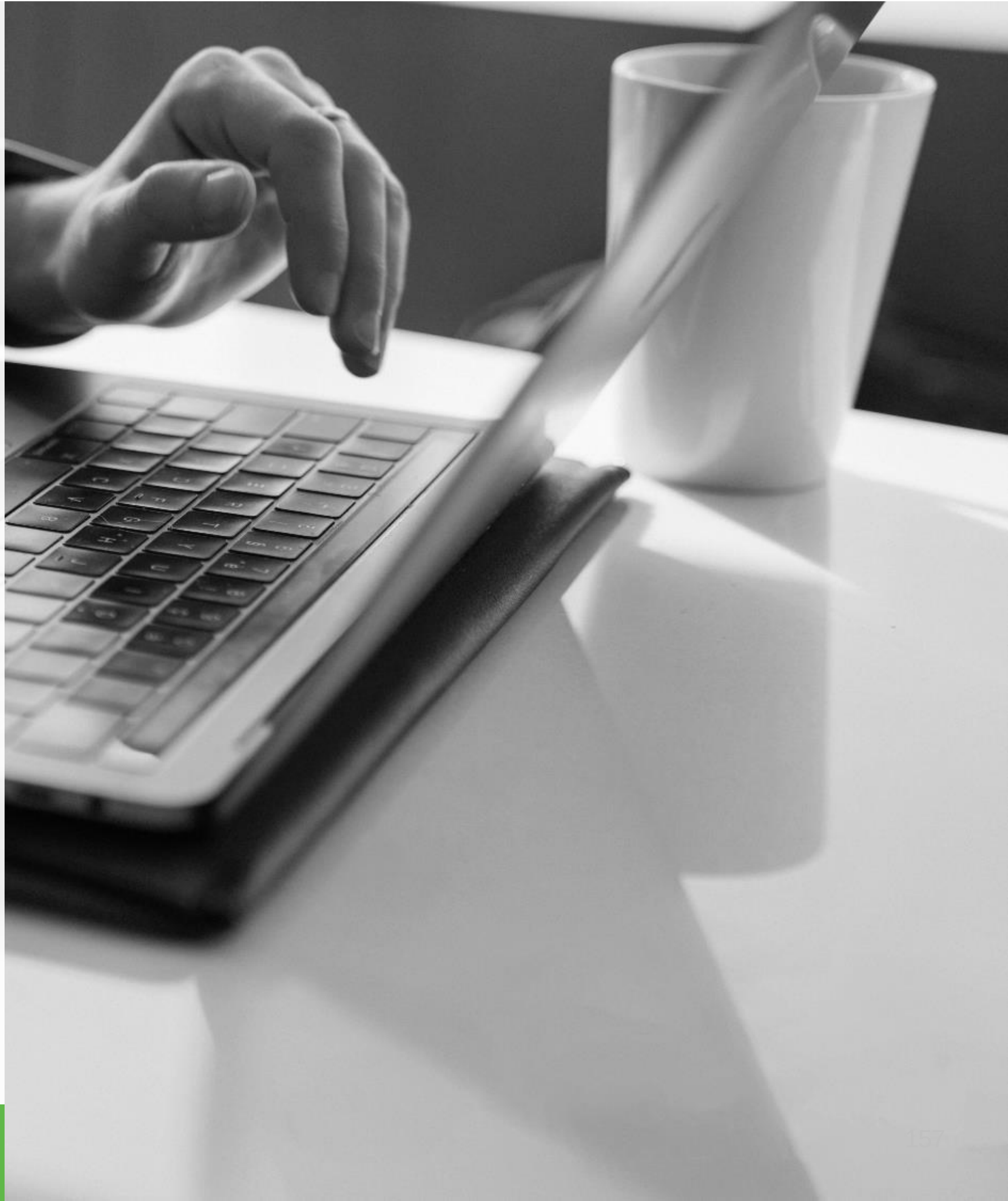
Submeasure	Building Type	Percent of Total Statewide New Construction Stock in 2023 Impacted by Proposal		Percent of Total Statewide Existing Stock in 2023 Impacted by Proposal	
		Small Computer Room Case**	Large Computer Room Case***	Small Computer Room Case**	Small Computer Room Case**
UPS Efficiency, Increased Temperature Threshold for Economizers*	Small Office	**2%**	0%	**2%**	0%
	Large Office	0%	**2%**	0%	**2%**
	Colleges	0%	**2%**	0%	**2%**
Heat Recovery	Small Office	**1%**	0%	0%	0%
	Large Office	0%	**1%**	0%	0%
	Colleges	0%	**1%**	0%	0%
PUE Monitoring	Large Office	n/a	**1%**	n/a	**1%**
	Colleges	n/a	**1%**	n/a	**1%**

*Values match 2013 assumptions for computer room efficiency measures.
**Commercial floor area translated to IT load assuming 20 W/sf.
***Commercial floor area translated to IT load assuming 100 W/sf.

Do these assumptions look right?

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates (see Appendix)



Draft Code Change Language

- **Updated** draft code language for this submeasure is available in the **resources tab.**
- **Key Changes:**
  - Simplified UPS language points to ENERGY STAR for requirements
  - Heat recovery requirements are better defined
  - PUE monitoring is mandatory instead of prescriptive

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Appendix – Computer Room Efficiency

Software Updates: UPS Efficiency

- **Current modeling capabilities:** none
- **Proposed modeling capabilities:**

New Software Feature	Standard Design	Proposed Design
Separation of UPS Energy	Standard Design matched to Proposed Design	User input for if Proposed Design computer room has a UPS? (Yes/No)
UPS Location	Standard Design matched to Proposed Design	User input for if UPS is in dedicated or shared computer room?
UPS part-load efficiency at 25%, 50%, 75%, and 100% load factors	Standard Design UPS part-load efficiency at 25%, 50%, 75%, and 100% load factors	User input for UPS part-load efficiency at 25%, 50%, 75%, and 100% load factors
UPS Cooling System Type	Matched to Standard Design computer room cooling system type	User input (CRAC or CRAH)
Compliance Results	Add calculation of UPS waste heat and associated fan and cooling energy.	
	Add new compliance regulated load line item for UPS waste heat.	

Software Updates: Increased Temperature Threshold for Economizers

	Current Modeling Capability	Proposed Software Update	Update Type
Standard Design	Full air economizing at outside 55°F dry-bulb/50°F wet-bulb and below	Full air economizing at outside 65°F dry-bulb and below	Parameter change
	Supply Air Temperature = 60°F	Supply Air Temperature = 65°F	Parameter change
	Zone/Return Air Temperature = 80°F	Return Air Temperature = 85°F (if containment is prescriptively required); Return Air Temperature = 80°F (if containment isn't required)	Parameter change
Proposed Design	Supply Air Temperature = adjustable	Add user input for if Proposed Design computer room has containment? (Yes/No) • If Yes, Proposed Design SAT/RAT = 65°F/85°F • If No, Proposed Design SAT/RAT = 65°F/80°F • **Allow Option for 25F with containment?**	Change to user-input method
	Zone/Return Air Temperature = 80°F		

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

High Efficiency Boilers and Service Water Heating

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | High Efficiency Boilers

George M. Chapman, ***Energy Solutions***

March 12, 2020

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Today's Objectives
2. Proposal Background
3. Cost and Energy Calculations
   - *Gas Boiler Systems*
   - *Gas Service Water Heating*
   - *Oxygen Concentration*
4. Questions and Next Steps

Today's Objectives

The focus of today's meeting includes:

1. **Review** Energy and Cost Calculations and Savings
2. **Gather** feedback on assumptions, with particular emphasis on oxygen concentration incremental costs and modeling approaches, and preliminary results

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, 15th 2019.**

Resources on

Presentation slides and Submeasure summary documents available that cover the following:

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

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

Proposal Background

Code Change Proposal Summary

Submeasure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
Gas Boiler Systems	Prescriptive	Yes	140.4	NRCC-MCH-E, NRCC-PLB-E
Gas Service Water Heating Systems	Prescriptive	Yes	140.5	NRCC-MCH-E, NRCC-PLB-E
Process Boilers Oxygen concentration	Mandatory	Yes	120.6	NRCC-PRC-E
Commercial Boilers Oxygen concentration	Mandatory	Yes	120.9	N/A

Description of Changes

- Made final determinations as to the concentration levels and associated threshold for oxygen trim control.

Submeasure A: Gas Boiler Systems

Submeasure B: Gas Service Water Heating

Submeasure C: Oxygen Concentration

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023	Statewide New Construction Impacted by Gas Boiler Submeasure	Statewide New Construction Impacted by Service Water Heating Submeasure	Statewide New Construction Impacted by Commercial Oxygen Concentration Submeasure
Nonresidential	162.78 million ft^2	55 million ft^2	8 million ft^2	40 million ft^2
Multifamily	51,966 dwelling units	20300 dwelling units	5100 dwelling units	3500 dwelling units

- Spreadsheet analysis will be completed to determine the impacts of the process boilers oxygen concentration requirement since no building prototypes show industrial loads

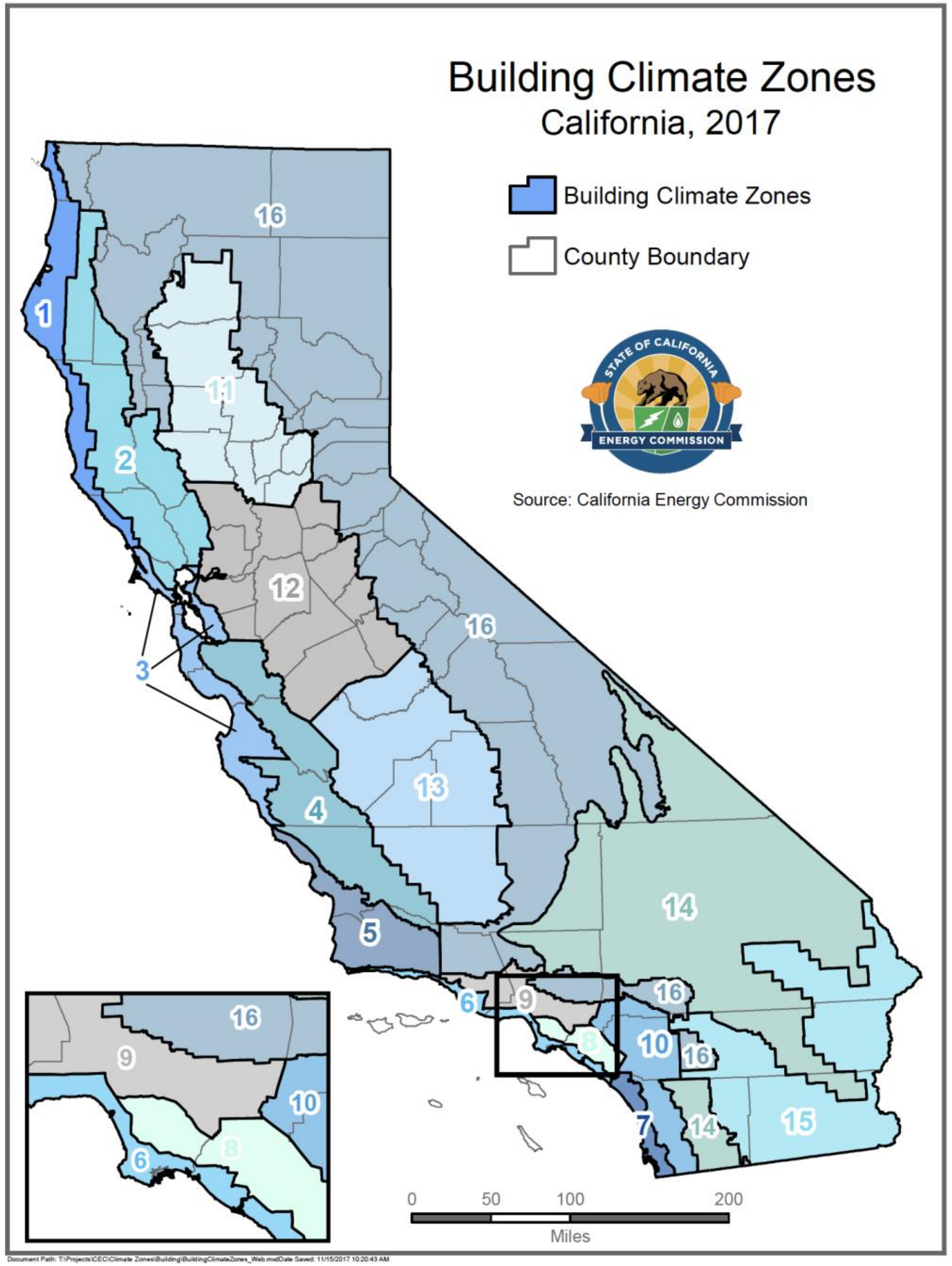
Methodology for Energy Impacts Analysis

- Per-unit energy impacts were calculated as savings per **square foot** for nonresidential buildings and per **dwelling unit** for multifamily buildings.
  - This allows for comparison across building types and enables a calculation of statewide savings using CEC construction forecasts published in terms of floor area by building type.
- DOE's Commercial Building Energy Consumption Survey and ASHRAE building prototype data were used to estimate square footage of building types that are impacted by the gas boiler and service water heating system thresholds

Tools Used	Energy Plus, 2022 CBECC-Com Research Version, CBECS
Building Prototypes Used	Large office building, Secondary Schools, High Rise Apartments
Climate Zones Modeled	All climate zones are modeled.

Climate Zones

- Energy and cost savings results vary by California climate zones for all submeasures
- Boiler and oxygen concentration results are impacted by ambient temperature
- Service water heating results are impacted by inlet water temperature



Submeasure A: Gas Boiler Systems

Submeasure B: Gas Service Water Heating

Submeasure C: Oxygen Trim Control

Submeasure Overview: Gas Boiler System

- The gas boiler system submeasure will align thermal efficiency requirements for gas boiler systems with input rated capacities between 1 and 10 million Btu/h with requirements in ASHRAE 2019 Addendum BC.
  - This addendum requires thermal efficiency of these systems to be at least 90%

- This submeasure also includes the hot water distribution design requirements from the ASHRAE addendum that help ensure condensing occurs.

Energy and Cost Impacts

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

Assumptions for Energy Impacts Analysis

- Nominal boiler thermal efficiency is assumed to be **84** percent and **90** percent for the standard and proposed designs, respectively.
    - Changes to Federal boiler efficiency levels will take effect January 10, 2023, for gas boilers with inputs between 300,000 Btu/h and 2,500,000 Btu/h
    - This raises minimum thermal efficiency from 80% to 84%.

- Boiler thermal efficiency is assumed to be solely a function of the boiler part-load ratio

Definition of Baseline and Proposed Conditions

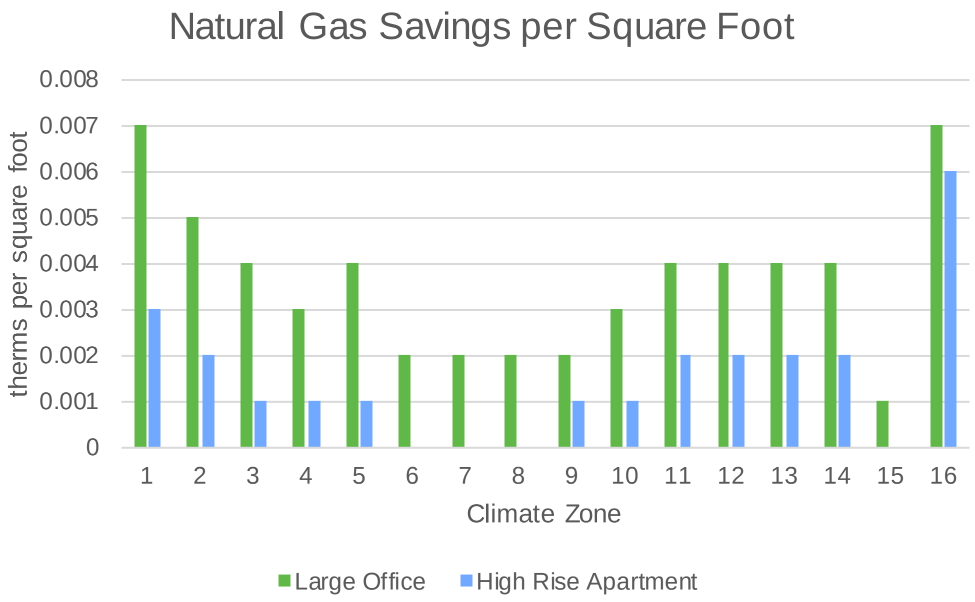
Baseline Conditions

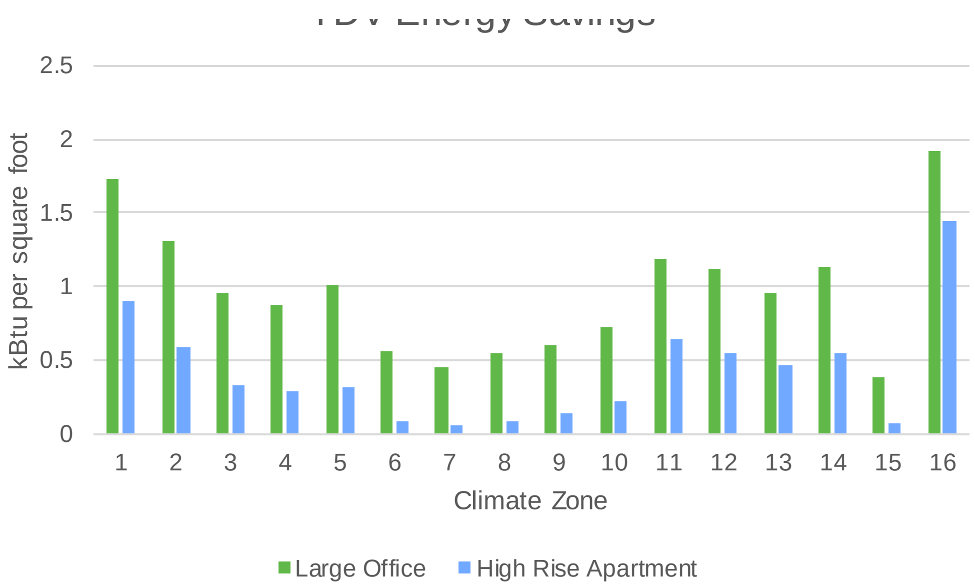
- Nominal thermal efficiency of **84% per boiler**
- Hot water return temperature assumed to be **140°F**
- All other conditions are in accordance with the Standard Design presented in the 2019 ACM

Proposed Conditions

- Nominal thermal efficiency of **90% per boiler**
- Hot water return temperature assumed to be **120°F**
- All other conditions are in accordance with the Standard Design presented in the 2019 ACM

Per Square Foot First-Year Energy Savings Results by Climate Zones

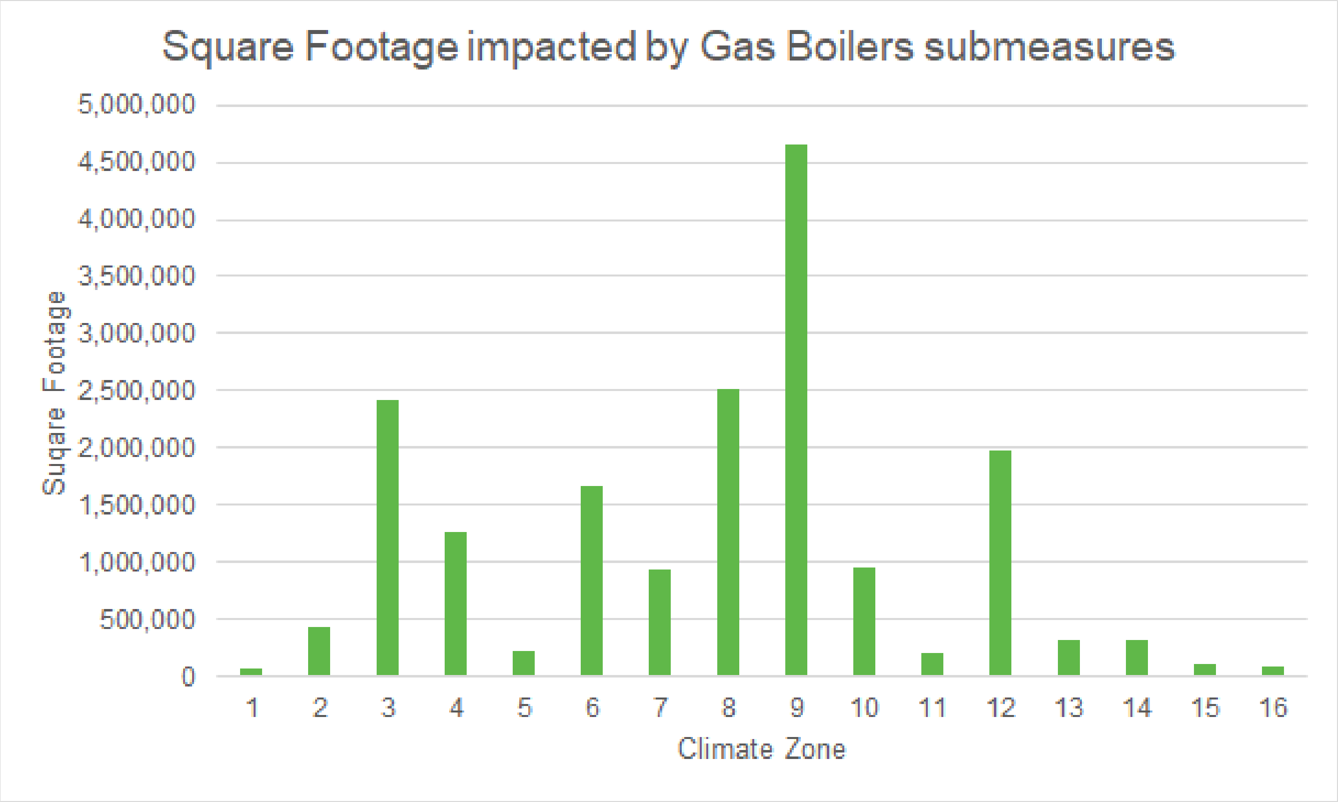




- As expected, the colder the climate zone, the more significant savings are.

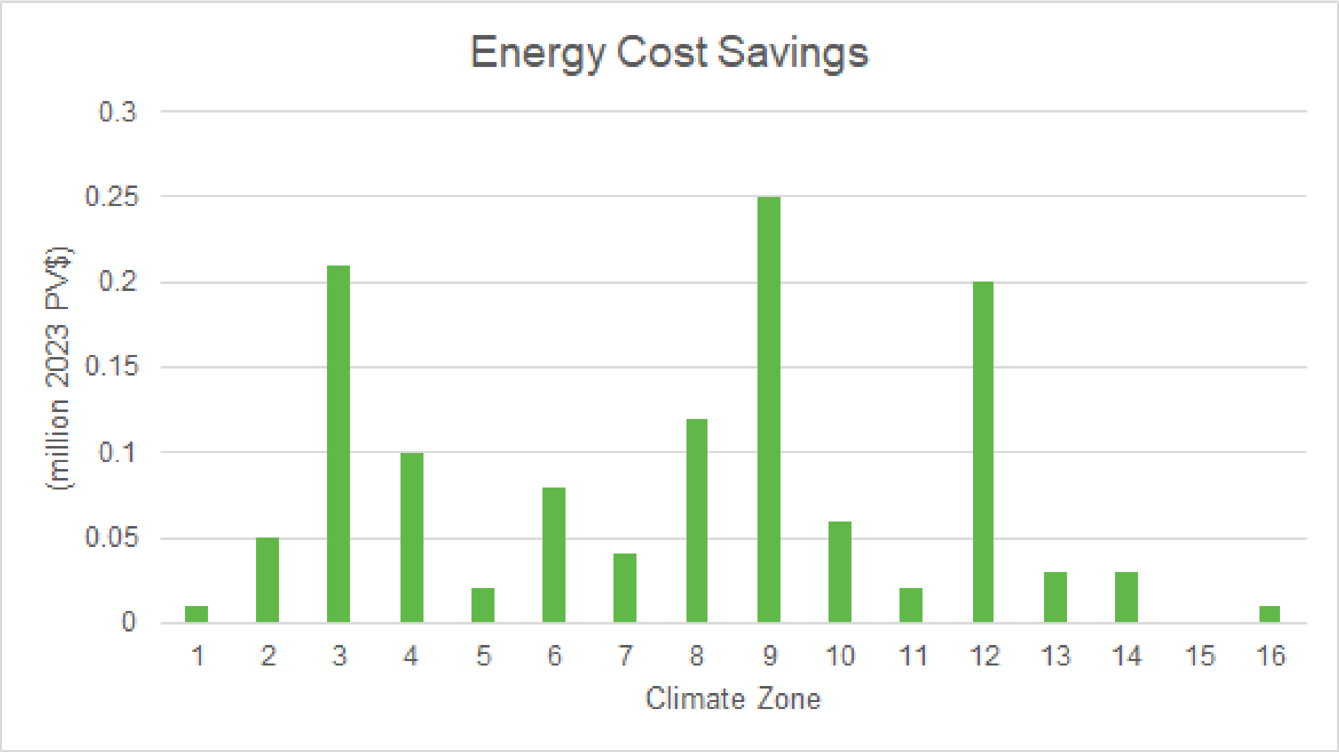
Measure Impacts

- 2023 New Construction square footage impacted for large office buildings



Statewide Energy Savings

- 15-Year Present Valued Energy Savings by climate zone
- As expected, savings are highest in climate zones with the highest amount of impacted square feet are impacted
- **Total savings:** 1.23 million 2023 PV$



Incremental Cost Information

- Several incremental cost measures were reported by California Program Administrators Workpapers published by CPUC and were confirmed through stakeholder feedback
- Incremental cost includes the increase in equipment costs associated with condensing boilers compared to standard boilers.
- There is no assumed increase in labor costs for new construction.

Cost Description	Equipment Cost ($/MBtu/h)
Base Case	$ 12.60
Standard Design	$ 17.73
Incremental Cost	**$ 5.13**

Source: http://deeresources.net/workpapers, Workpaper PGECOHVC101, Revision 5

Incremental Per Unit Cost

Over 15 Year Period of Analysis

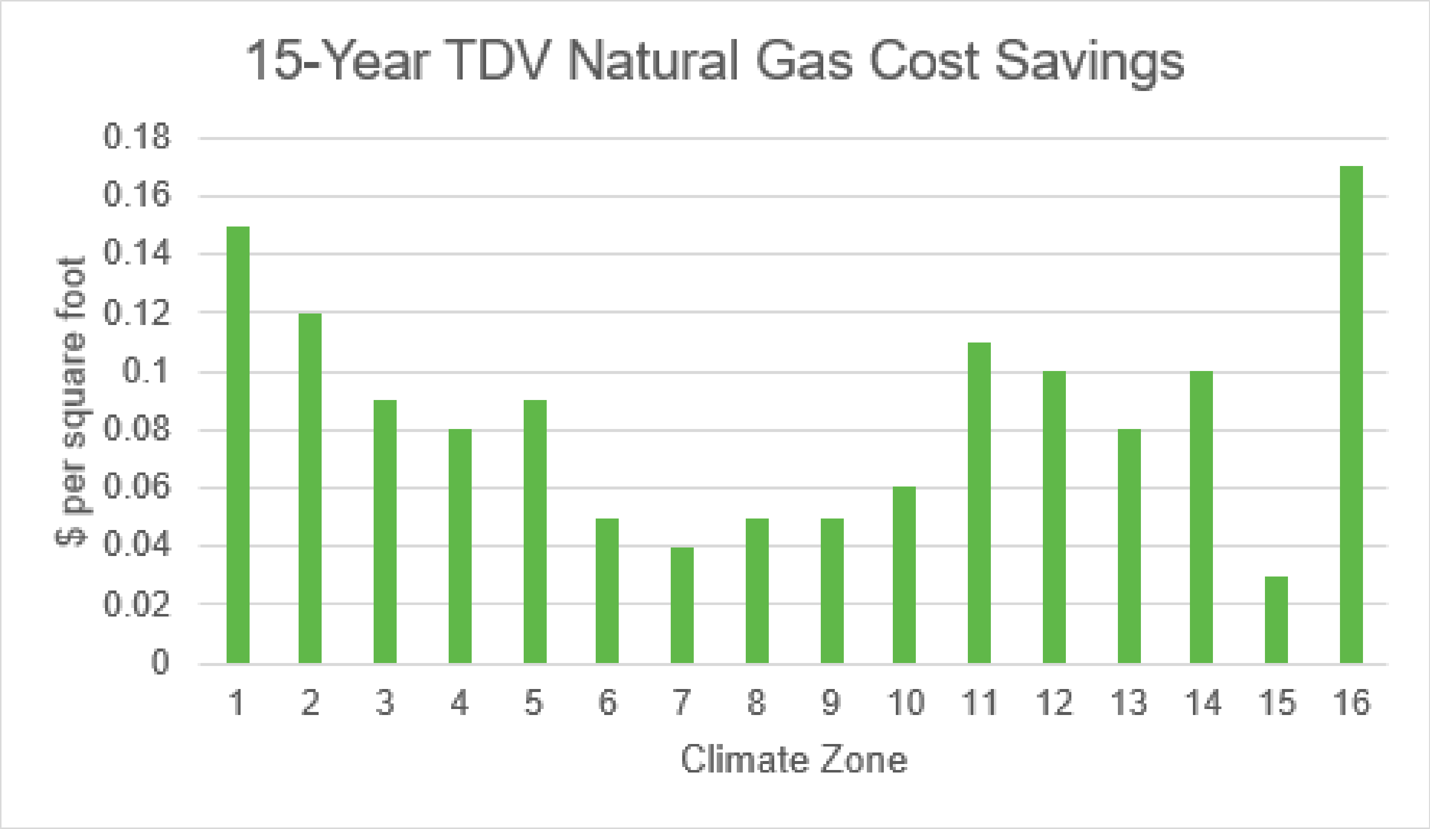
Incremental First Cost		Incremental Maintenance Cost	
Equipment	$5.13 per MBtu/h	Equipment Replacement	$0
Installation	$0	Annual Maintenance	($400)
Commissioning	$0		
Other	$0		
Total	**$5.13 per Mbtu/h**	**Total**	**$400.00**

$4,775.17

Maintenance cost over 15 years discounted by 3 percent.

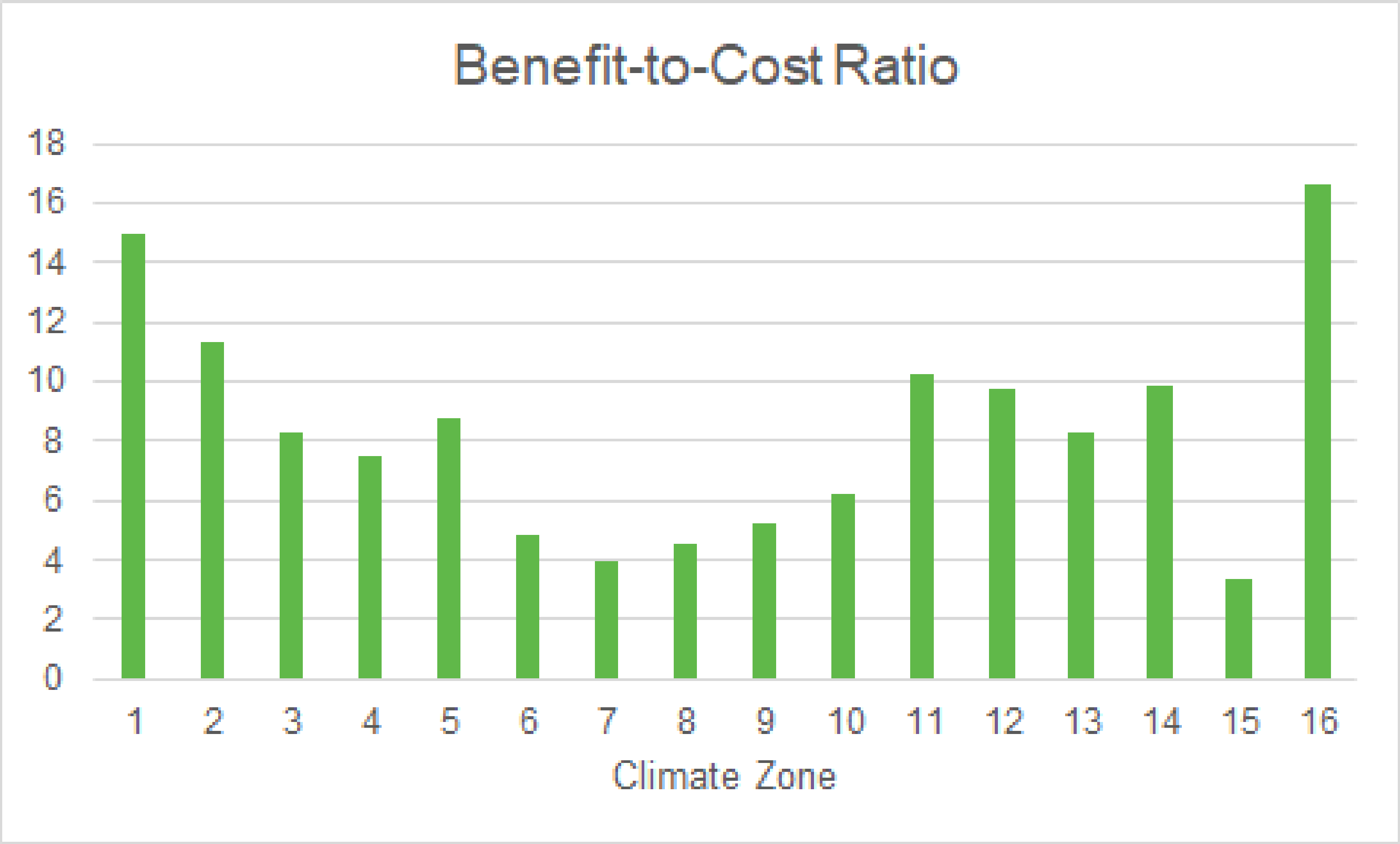
15-year Cost Savings Results by Climate Zone – Large Office

- There are assumed to be no electricity savings.
- Again, savings are strongest in colder climate zones.



Cost Effectiveness Results per Square Foot – Large Office

- The gas boilers system submeasure is cost effective in all climate zones and extremely so in the cooler climate zones.



Submeasure A: Gas Boiler Systems

Submeasure B: Gas Service Water Heating

Submeasure C: Oxygen Trim Control

Energy and Cost Impacts

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

Submeasure Overview: Gas Service Water Heating

- The service water heating system submeasure will align thermal efficiency requirements for gas water heating systems with input rated capacities between 1 and 10 million Btu/h with requirements in ASHRAE 2019.
  - This submeasure would require thermal efficiency of these systems to be at least 90%
  - This applies to new construction only

Assumptions for Energy Impacts Analysis

- The nominal water heater thermal efficiency is assumed to be **80 percent and 90 percent** for the standard and proposed designs, respectively.
- The proposed **90% efficiency** is assumed for all climate zones.

Expanded methodology for Energy Impacts Analysis

- ASHRAE building prototype data yielded BTU intensity per square foot and this allowed the CASE team to determine the rough size of a building to be within the proposed scope.
- The following building types were determined to be impacted by the gas service water heating measure:

ASHRAE Building Type	Required Square Footage
Secondary school	370,000
Large hotel	136,000
Hospital	269,000
High-rise apartment	140,000
Full-service restaurant	27,500

- Analyses were conducted in order to translate these ASHRAE building types to CBECC-Com prototypes

- Source: https://www.energycodes.gov/development/commercial/prototype_models

Definition of Baseline and Proposed Conditions

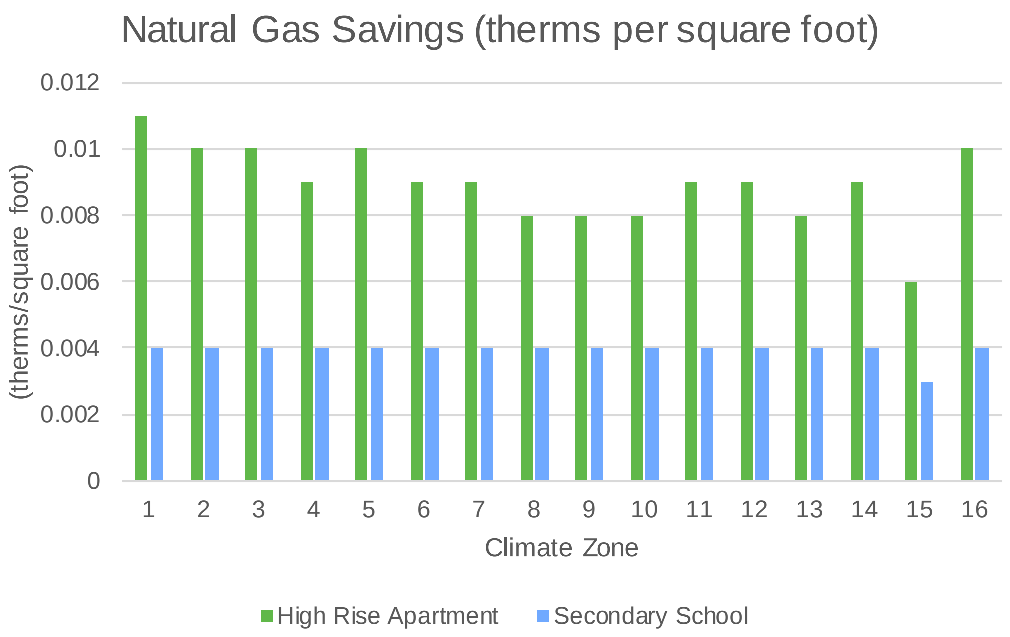
Baseline Conditions

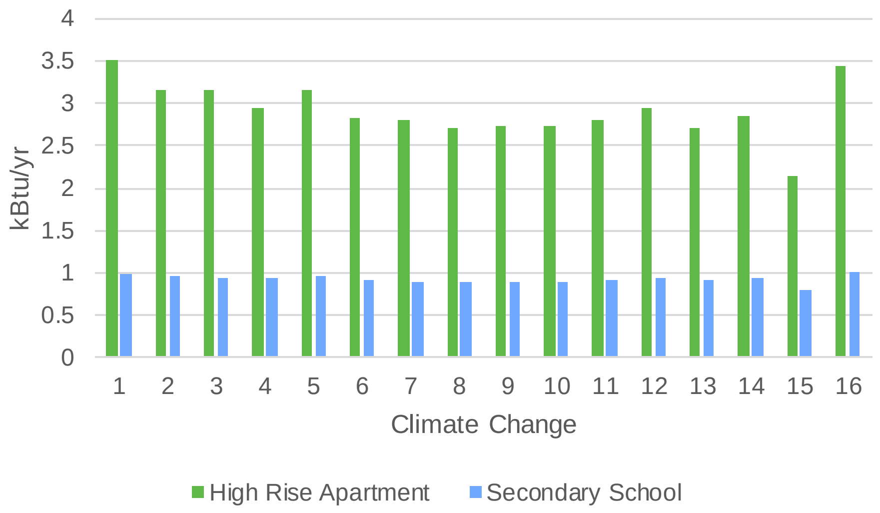
- Instantaneous or commercial hot water heater with thermal efficiency of **80%** in accordance with Title 20 regulations
- All other conditions are in accordance with the Standard Design presented in the 2019 ACM

Proposed Conditions

- Nominal thermal efficiency of **90%** per gas service water heater
- All other conditions are in accordance with the Standard Design presented in the 2019 ACM

Per Square Foot first-year Energy Savings Results

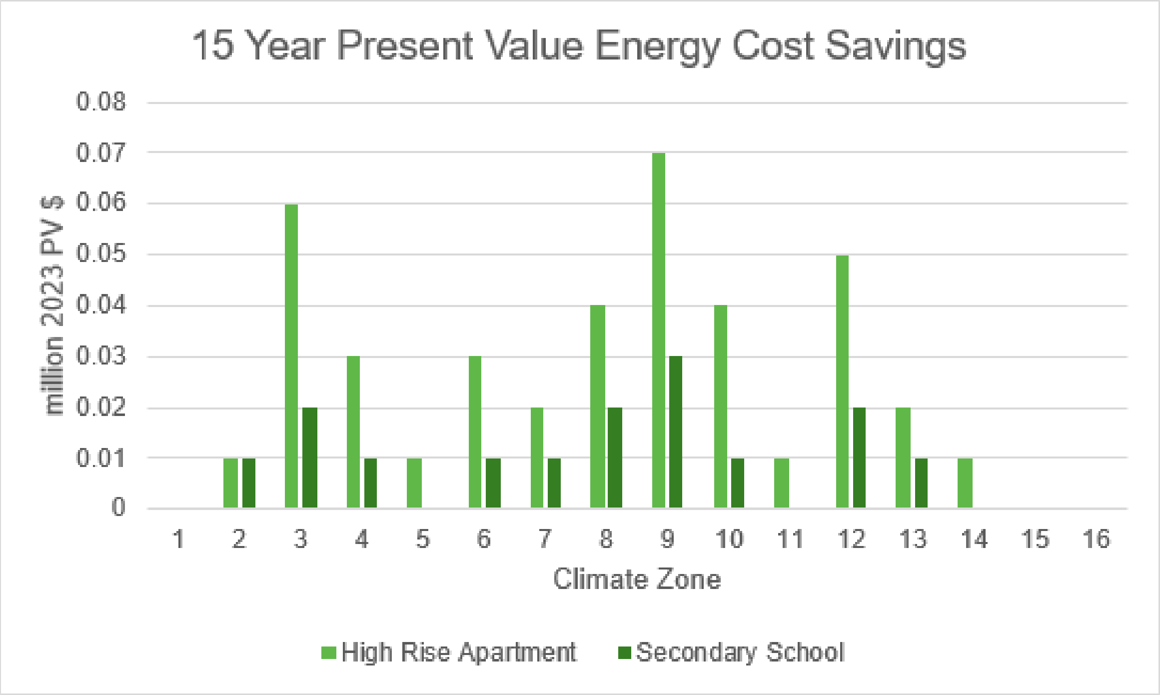




- Differences between climate zone are due to variations in inlet water temperature among the different climate zones.
- The variation between climate zones is much less than that of boilers.

Statewide Energy Savings

- 15-Year Present Valued Energy Savings by climate zone
- As expected, savings are highest in climate zones with the highest amount of impacted square feet are impacted
- **Note**: These costs savings only take into account secondary schools and high rise apartments



Incremental Per Unit Cost

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	$4.07 per MBtu/h	Equipment Replacement	$0
Installation	$0	Annual Maintenance	($400)
Commissioning	$0		$0
Other	$0		$0
Total	**$4.07 per Mbtu/h**	**Total**	**$400.00**

$ 4,775.17

Maintenance cost over 15 years discounted 3%.

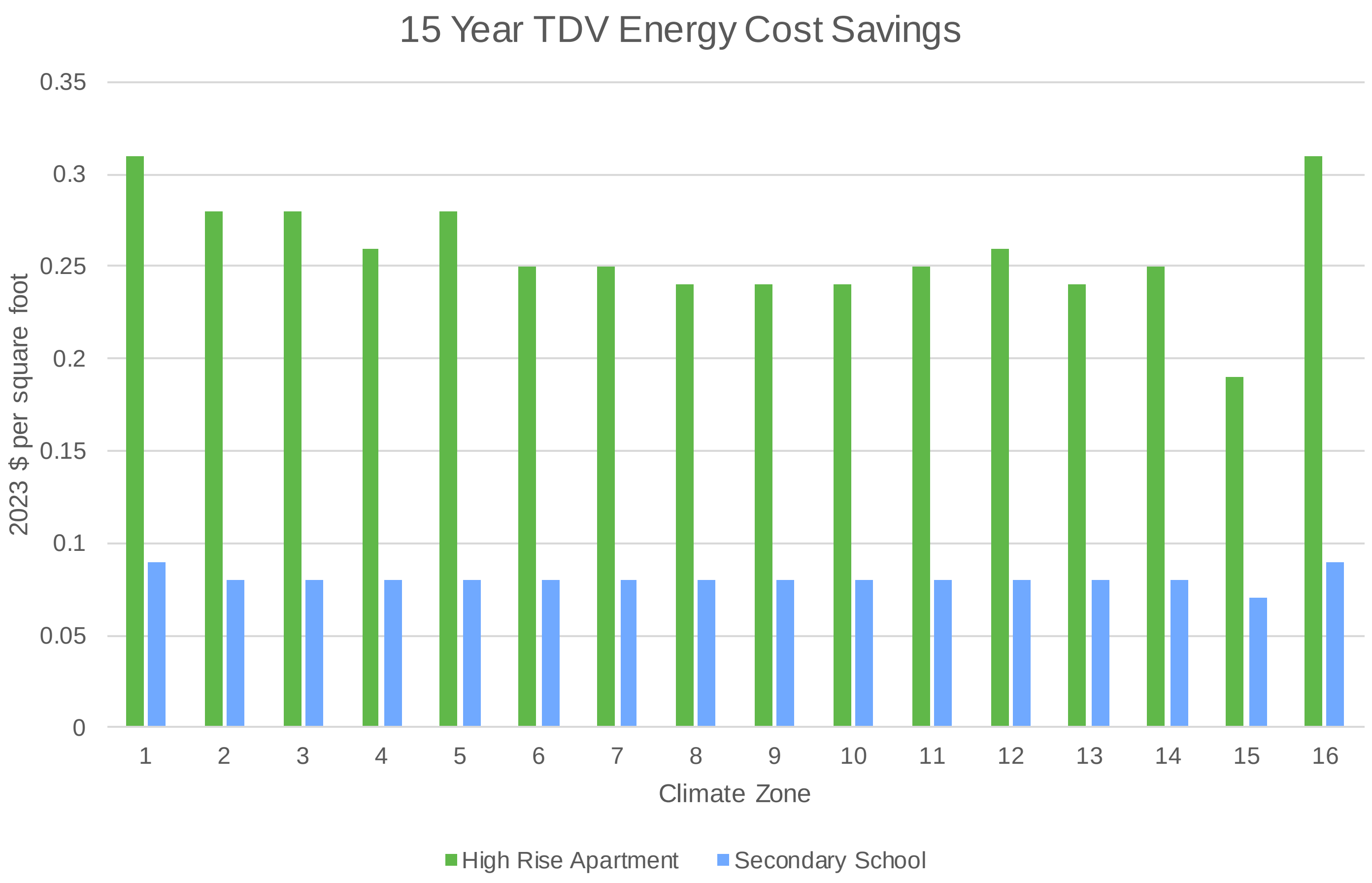
Incremental Cost Information

- Several incremental cost measures were reported by California Program Administrators Workpapers published by CPUC and confirmed through stakeholder feedback.
- Incremental cost includes the increase in equipment costs associated with condensing water heaters compared to standard water heaters.
- There is no assumed increase in labor costs for new construction.

Cost Description	Equipment Cost ($/MBtu/h)
Base Case	$ 17.94
Standard Design	$ 22.01
Incremental Cost	**$ 4.07**

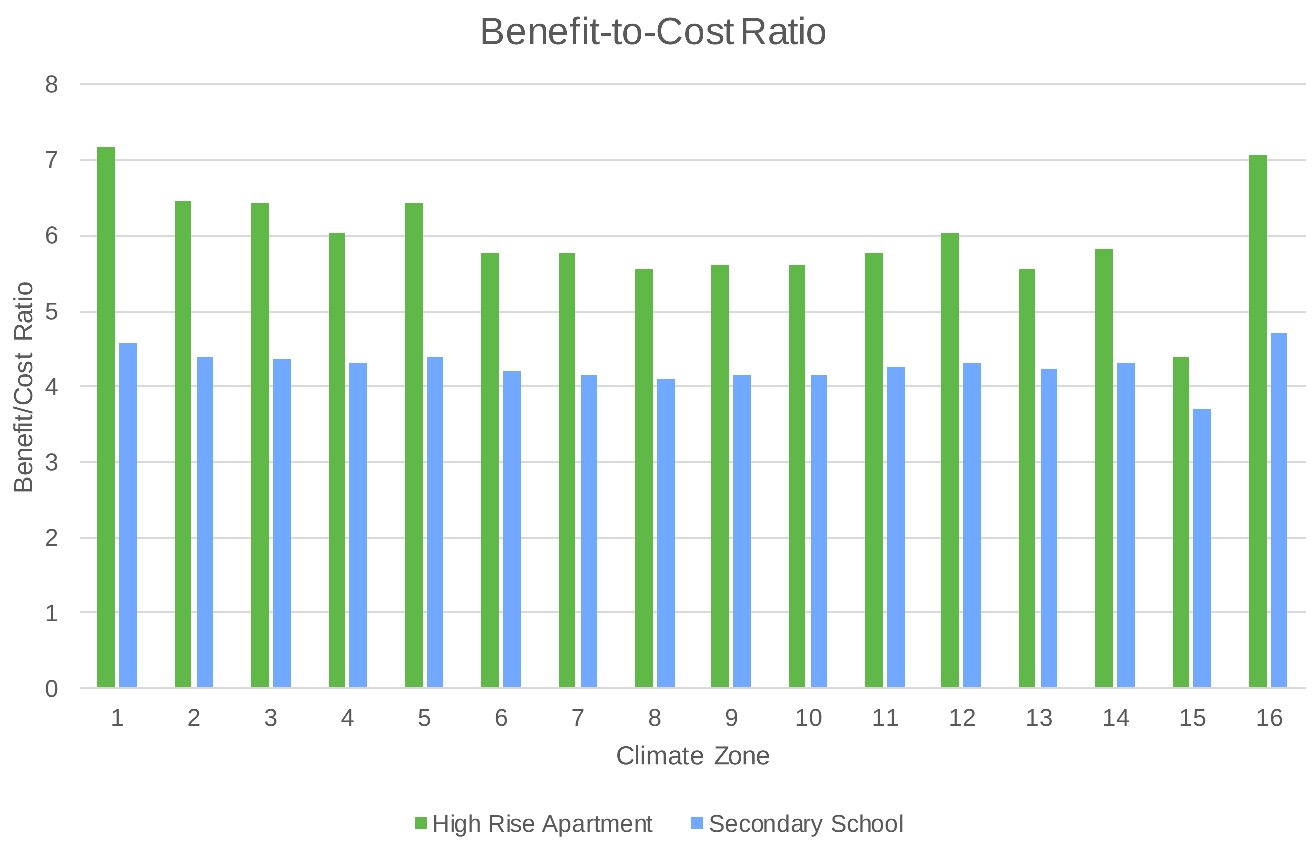
Source: http://deeresources.net/workpapers, WPSCGNRWH120206C, Revision 6

Cost Effectiveness Results



- Savings vary slightly by climate zone with cooler climate zones having the most savings

Cost/Benefit Ratio by Climate Zone



- This submeasure is cost effective in all climate zones for both building types modelled.

Submeasure A: Gas Boiler Systems

Submeasure B: Gas Service Water Heating

Submeasure C: Oxygen Concentration

Assumptions for Energy Impacts Analysis

- Based on feedback from manufacturers, process and commercial boilers with capacities above 5 MMBtu/h are replaced **every 20 years**.

- Savings for the oxygen concentration submeasure are modeled for large offices for commercial boilers.

2023 Construction Forecast: Existing Buildings

Building Type	Total Statewide New Construction Permitted in 2023	Statewide Existing Buildings Impacted by Commercial Boilers Oxygen Concentration measure in 2023
Nonresidential	7,788 million sq feet	67 million sq feet

- The process boilers savings will be completed in a spreadsheet analysis since no building prototypes have industrial loads

Definition of Baseline and Proposed Conditions for Commercial Boilers

Baseline Conditions

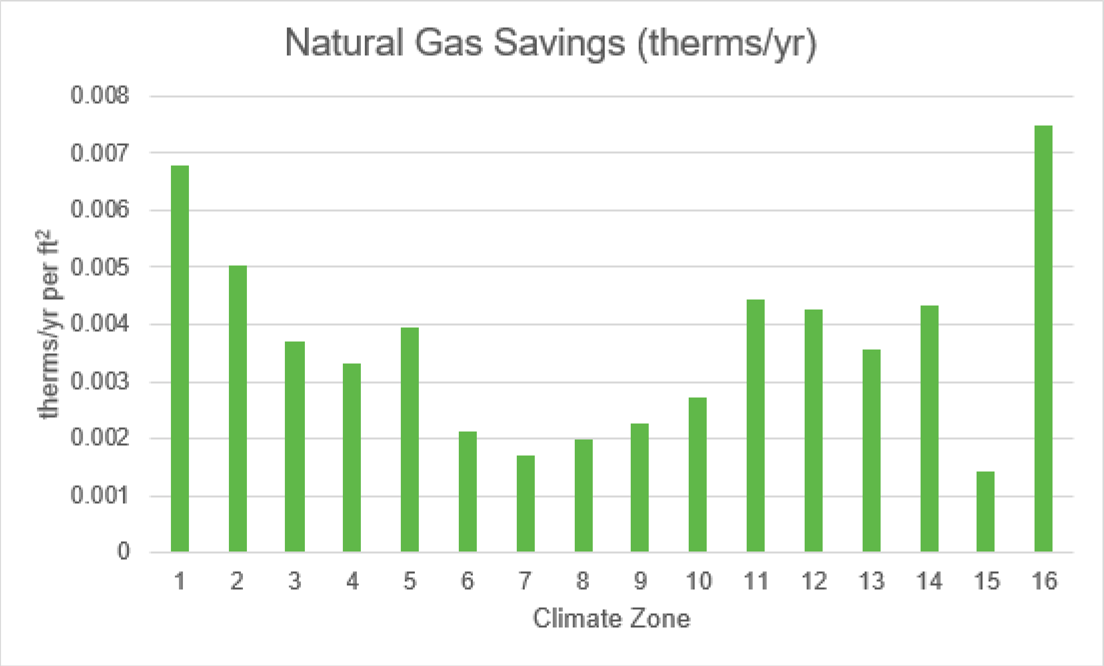
- Combustion efficiency of **84.7%** was used at 200°F difference between combustion and flue gas temperature
- **5%** oxygen concentration is assumed

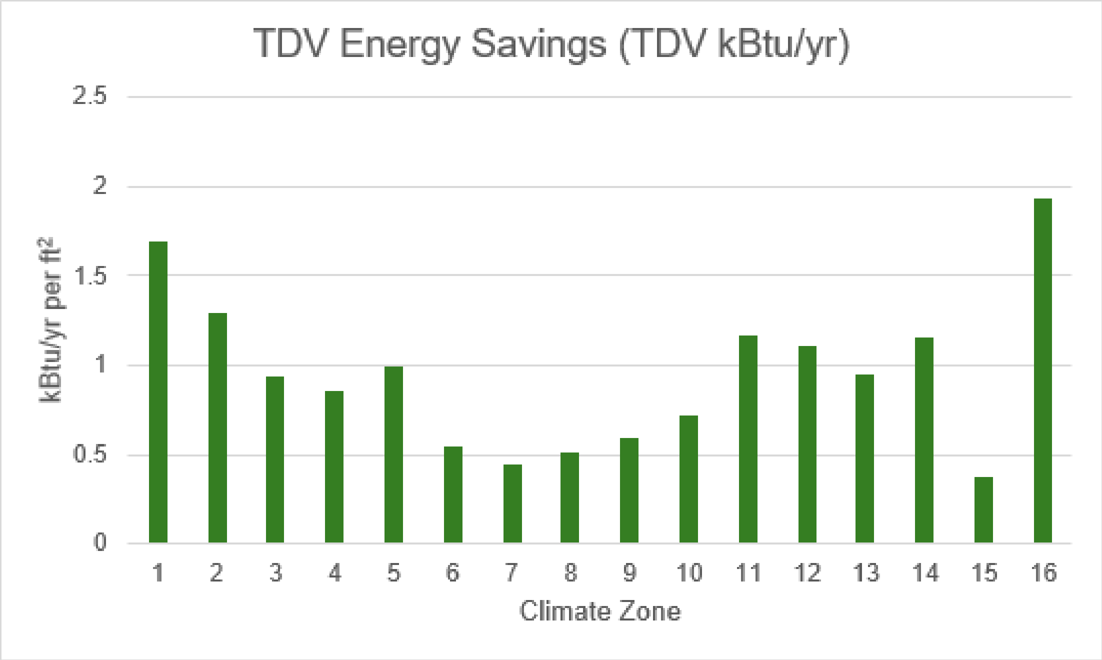
Proposed Conditions

- **90%** combustion efficiency at 200°F difference between combustion and flue gas temperature
- **3%** oxygen concentration

Per Square Foot first-year Energy Savings Results: Large Office by climate zone (commercial boilers)

- As with prior submeasures, savings are most substantial in climate zones with more space heating needs





Definition of Baseline and Proposed Conditions for Process Boilers

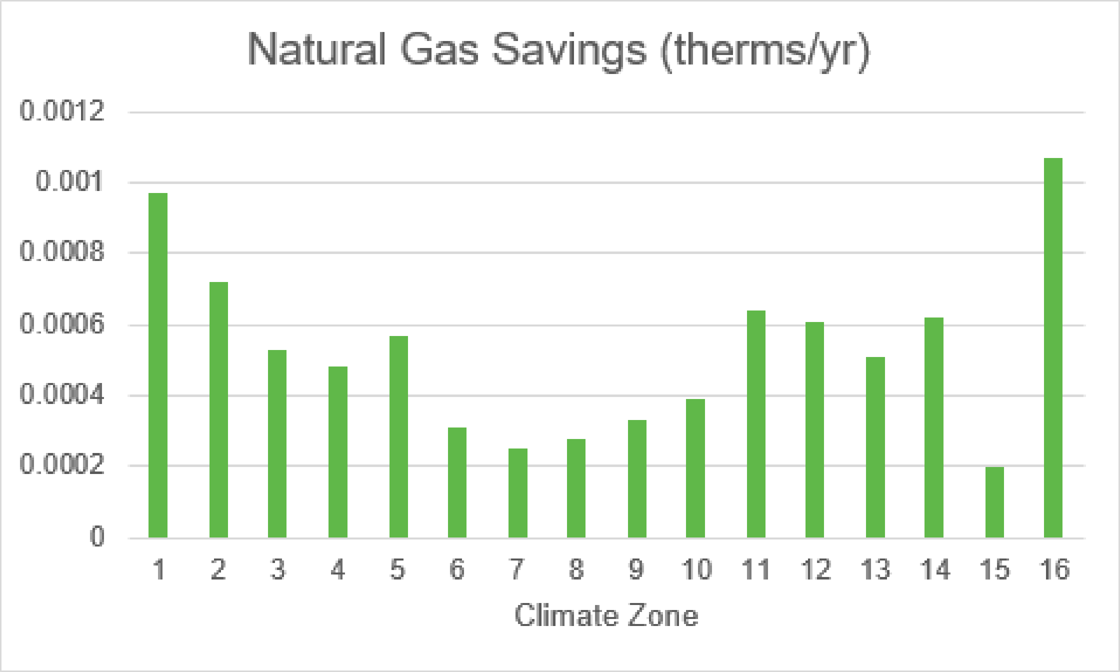
Baseline Conditions

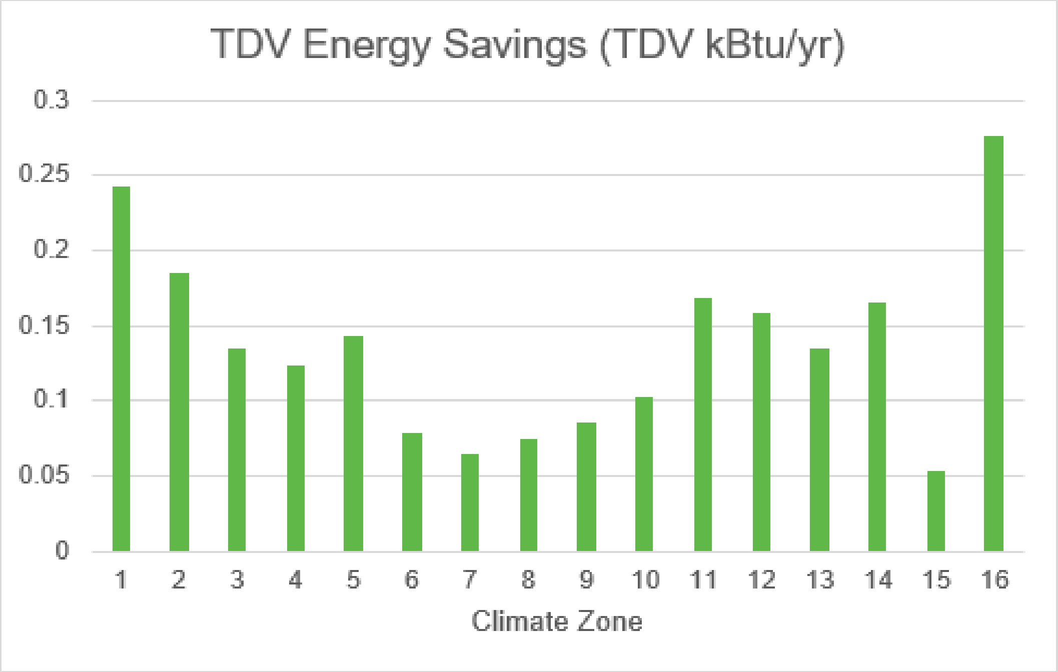
- Combustion efficiency of **79.5%** was used at 400°F difference between combustion and flue gas temperature
- **5%** oxygen concentration is assumed

Proposed Conditions

- **80.4%** combustion efficiency at 400°F difference between combustion and flue gas temperature
- **3%** oxygen concentration

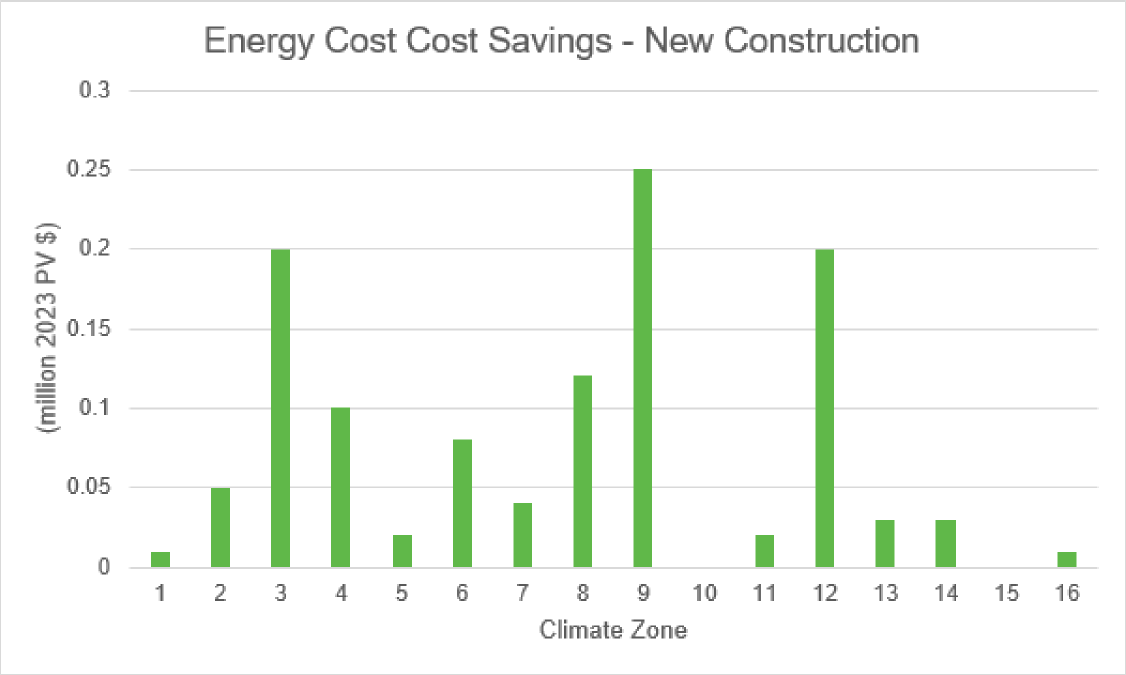
Per Square Foot first-year Energy Savings Results: Large Office by climate zone (Process boilers)

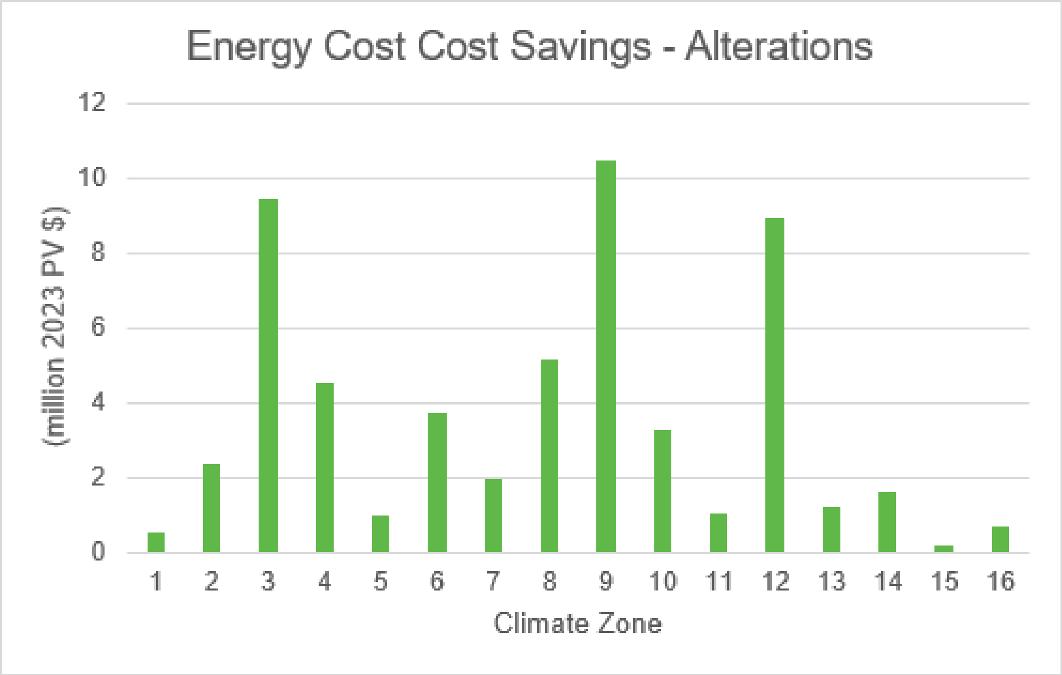




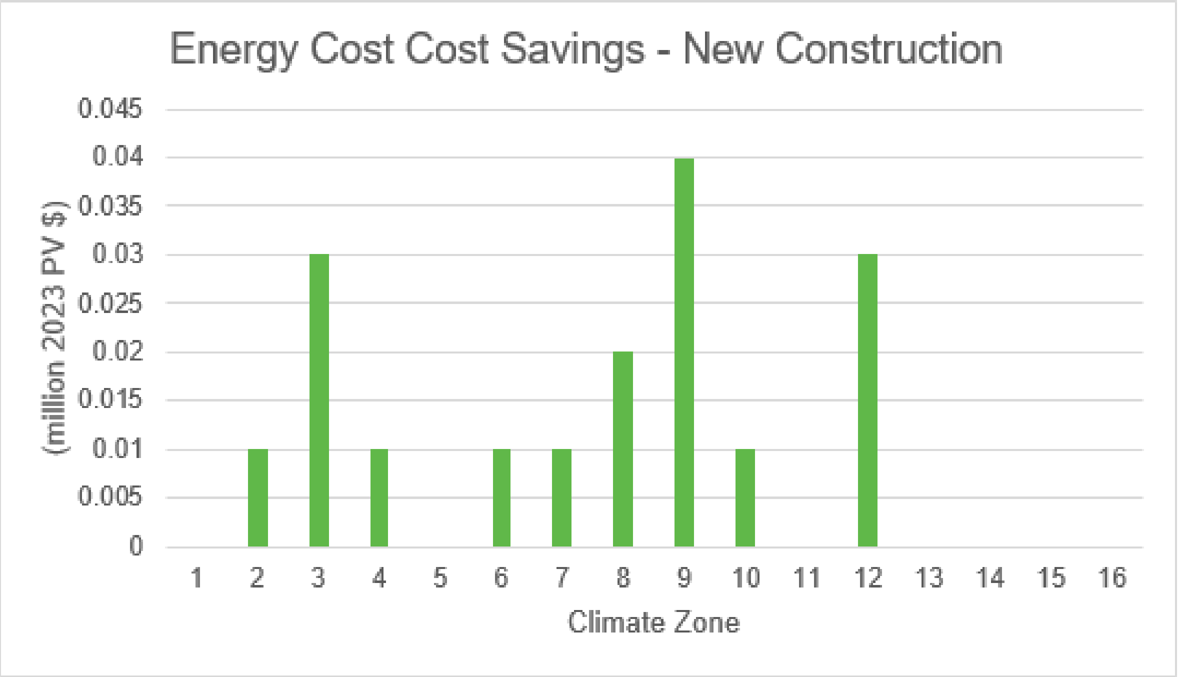
Statewide Energy Savings – Commercial Boilers O2 trim

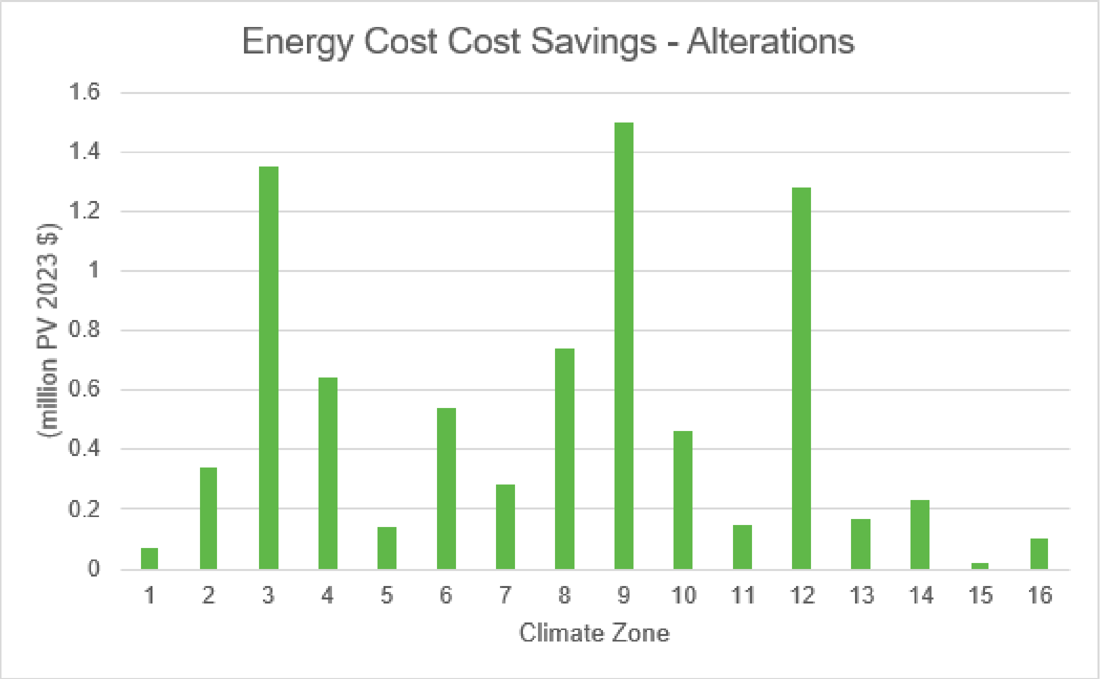
- 15-Year Present Valued Energy Savings by climate zone
- As expected, savings are highest in climate zones with the highest amount of impacted square feet are impacted





Statewide Energy Savings – Process Boilers





Incremental Cost Information

- Incremental cost assumptions from the 2013 CASE Report on process boilers was used for these calculations
  - Base case is the least cost option to achieve 5 percent excess oxygen. This submeasure is required to achieve 3 percent excess oxygen.
- There is an increase in maintenance costs due to more frequent adjustment of the boiler's air to fuel ratio.
  - The annual increase in maintenance cost was assumed to be $800.

Equipment Type	Cost Description	Equipment Cost
Parallel Positioning	Base Case	$ 8000
Oxygen Trim Control	Standard Design	$ 19,500
Incremental Cost		**$ 11,500**

- The incremental costs for including oxygen trim controls in a new condensing/non-condensing boiler is assumed to be **$7500** based on stakeholder feedback

Source: http://title24stakeholders.com/wp-content/uploads/2017/10/2013_CASE-Report_Process-Boilers.pdf

Incremental Per Unit Cost

Over 15 Year Period of Analysis

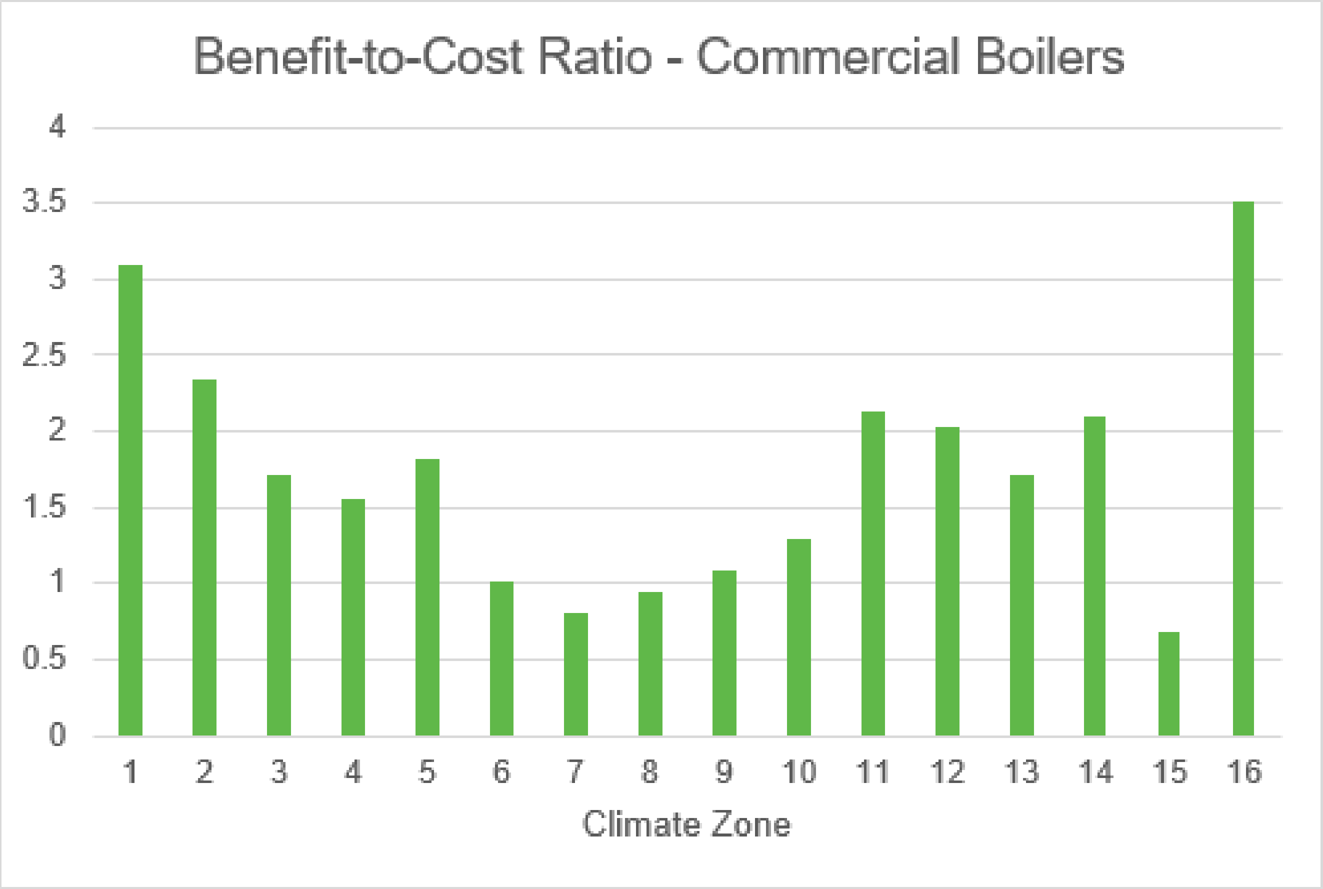
Incremental First Cost		Incremental Maintenance Cost	
Equipment	$11,500	Equipment Replacement	$0
Installation	$0	Annual Maintenance	($400)
Commissioning	$0		
Other	$0		
Total	**$11,500.00**	**Total**	**$400.00**

15 year maintenance cost is estimated to be $4,775.17

Cost for oxygen trim control does not vary based on boiler size

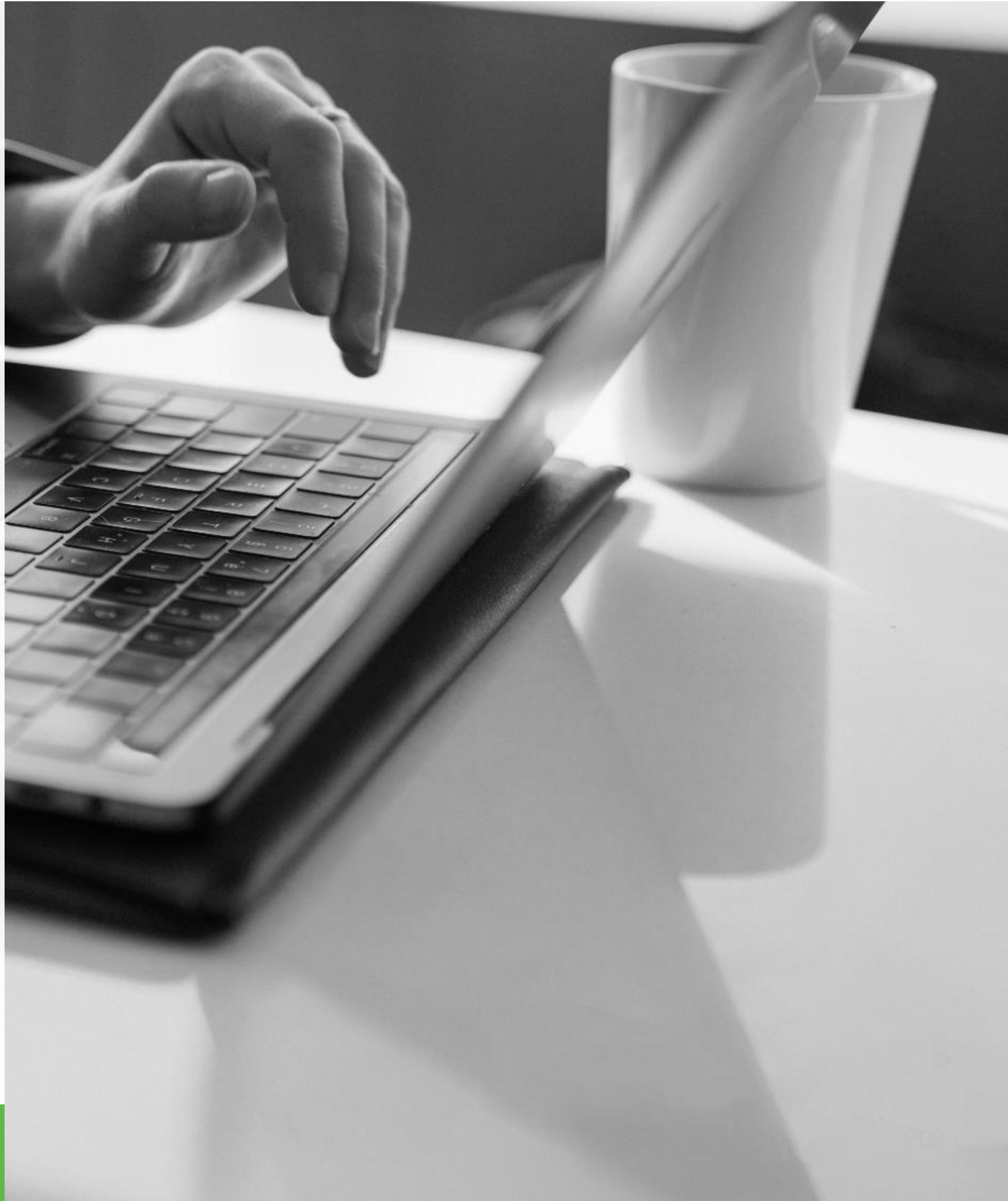
Cost Effectiveness Results

- For large office buildings, going from a standard boiler to a condensing boiler with oxygen trim controls is cost effective in all but 3 climate zones.



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.**
- **Oxygen concentration** code language has been clarified to show that the proposal is to lower stack-gas oxygen concentration from 5% to 3% over firing rates of 20 to 100 percent for both commercial and process boilers with rated input at or above 5 MMBtu/h
- Code language for the **service water heating** and **boiler system** submeasures was not changed in a major way
  - Some parts of the proposed language was moved into different sections of Title 24, Part 6

Software Updates

- **Current modeling capabilities**
  - 80 percent thermal efficiency for larger gas, propane, or oil-fired boilers with output heating capacities of 300,000 Btu/h or more
  - Return water temperature 140°F
  - 80 percent thermal efficiency for a gas storage water heater with input heating capacities of larger than 75,000 Btu/h or gas instantaneous water heater with an input of larger than 200,000 But/h
  - No oxygen trim control
- **Proposed modeling capabilities**
  - 90% boiler thermal efficiency for the output heating capacities of 1,000,000 – 10,000,000 Btu/h.
  - Return water temperature 120°F
  - 90% service water heater thermal efficiency for the output heating capacities of 1,000,000 – 10,000,000 Btu/h
  - Add oxygen trim control

Statewide Material Impacts

Material Impacts from the **Gas Boiler and Service Water Heating** submeasures:

Material	Impact
Mercury	No Change
Lead	No Change
Copper	No Change
Steel	Increase
Plastic	Increase
Cast Iron	Decrease
Calcium Carbonate	Increase
Others (Identify)	No Change

Material Impacts from the **Oxygen Concentration** submeasure:

Material	Impact
Mercury	No Change
Lead	No Change
Copper	Increase
Steel	Increase
Plastic	Increase
Others (Identify)	No change

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Variable Capacity HVAC Compliance Software Revisions

Codes and Standards Enhancement (CASE) Proposal

Single Family | Variable Capacity HVAC Software Revisions

David Springer, *Frontier Energy Inc.*
Curtis Harrington, *UCD Western Cooling Efficiency Center*
March 12, 2020

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

1. Today's Objectives
2. Proposal Background
3. Cost and Energy Calculations
4. Market and Code Language Updates
5. Questions and Next Steps

Today's Objectives

The focus of today's meeting includes:

1. **Review** Energy Calculations and Cost Assumptions
2. **Update** Market Analysis
3. **Revisit** Technical Considerations
4. **Review** Compliance and Enforcement Requirements
5. **Present** Updated Code Language
6. **Provide More Detail** on Software Changes

Proposal Background

Code Change Proposal Summary

- Code change will improve modeling accuracy of variable capacity systems to avoid unintentional installed system performance penalties
- The key change since the Round 1 Stakeholder Meeting is to include alterations involving replacements with variable capacity systems

Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated	Changes from Round 1
Compliance option for new single-family residential buildings and prescriptive requirement for existing residential buildings	Yes	150.0(m)13C & D 150.1(b)3B 150.2((b)1F	Residential ACM Reference Manual Residential Compliance Manual	Include Alterations (replacements)

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 10, 2019.**

Resources on Title24stakeholders.com

Presentation slides and **Submeasure summary** documents available that cover the following:

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

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

Energy and Cost Impacts

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

Methodology for Energy Impacts Analysis

- Developed a stand-alone duct performance model based on laboratory testing and verified against the California Simulation Engine (CSE) at a range of airflows
- Calculated energy impacts using the stand-alone model and using heating and cooling loads from CBECC-Res for cases with and without roof deck insulation

Tools Used	Stand-alone model developed from lab test data and using CBECC-Res loads
Building Prototypes Used	Energy Commission 2100 ft^2 single story and 2700 ft^2 two-story prototypes
Climate Zones Modeled	All climate zones to be modeled

Assumptions for Energy Impacts Analysis

- **Current single speed CSE model:**
  - Uses the SEER, EER, and AFUE or HSPF to calculate energy use (steady state)
  - Delivered cooling is modeled as if the unit is cycling on/off at 100% capacity
  - Duct losses are always calculated at full speed (350 cfm per ton), ignoring duct loss impacts on system COP
- **Proposed variable capacity model developed by WCEC accounts for:**
  - Decrease in distribution effectiveness when variable capacity systems are installed with attic ducts
  - Attic temperatures with and without insulation at the roof deck
  - Reduced attic temperatures at low-load conditions

Modeling Methods for Energy Impacts Analysis

- **Results show the energy impact of no action on this measure**
  - One and two-story single family prototypes modeled in all climate zones
  - Heating and cooling impacts for one year only – no statewide impacts due to insufficient market data
- **Baseline Case and Modeling – change in distribution effectiveness not accounted for**
  - Prescriptive building design except ducts in a vented attic with and without deck insulation
  - Variable capacity heat pump system with an efficiency representative of products in that class
  - Modeled energy use using 2022 version of CBECC-Res
- **Proposed Case and Modeling – change in distribution effectiveness included in model**
  - Building design identical to the Baseline
  - Ducts modeled at reduced capacity (airflow) as a function of hourly heating and cooling load using a stand-alone model developed by WCEC
  - Results used to adjust Baseline results from CBECC-Res

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Prescriptive design except:
  - Representative multispeed compressor (20 SEER / 10 HSPF) and multispeed fan
  - Ducts in attic with and without R-19 deck insulation
- Attic ducts modeled as currently (R-value based on climate zone; and 350 cfm/ton airflow)

Proposed Conditions

- Prescriptive design except:
- Same compressor as baseline
- Attic ducts modeled with reduced airflow at part load conditions

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023 (homes)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (homes)
Single Family	119,045	5%	5,952

- Statewide new construction estimates provided by the Energy Commission
- Percent of variable capacity systems installed in new homes estimated from a contractor survey

2023 Construction Forecast: Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (homes)	Percent of Homes Impacted by Proposal	Statewide Homes Impacted by Proposal in 2023
Single Family	8,828,191	Unknown	Unknown

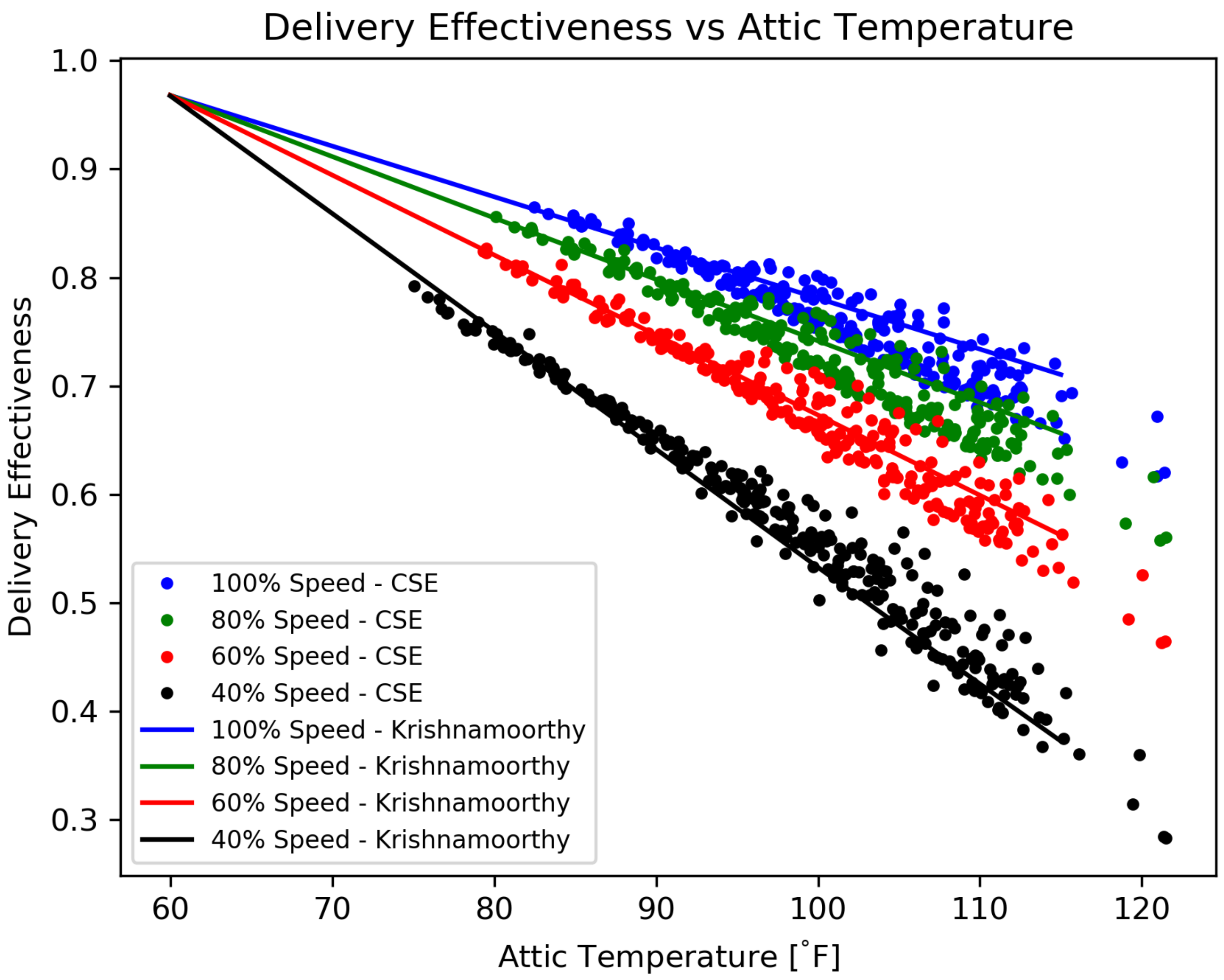
- No data are available on the number of replacements of existing single-speed systems with variable capacity systems in existing homes, let alone the number of all replacements.
- "We don't know how many alterations are actually happening, we don't know how many are not being permitted." - Judy Roberson, Staff Workshop on Promotion of Regulatory Compliance in the Installation of Central Air Conditioning and Heat Pumps, June 29, 2018.
- **Estimates from stakeholders are welcome.**

Energy Use Impact: CBECC-Res Modification Details

- **Model duct loss at part load**
  - Determine speed required to meet the load
  - Calculate duct loss based on reduced airflow
  - Iterate to find the speed at which the load is met
- **May utilize a part load ratio curve** to account for improvements to equipment efficiency at low load
- **May include cycling losses** using a typical degradation coefficient

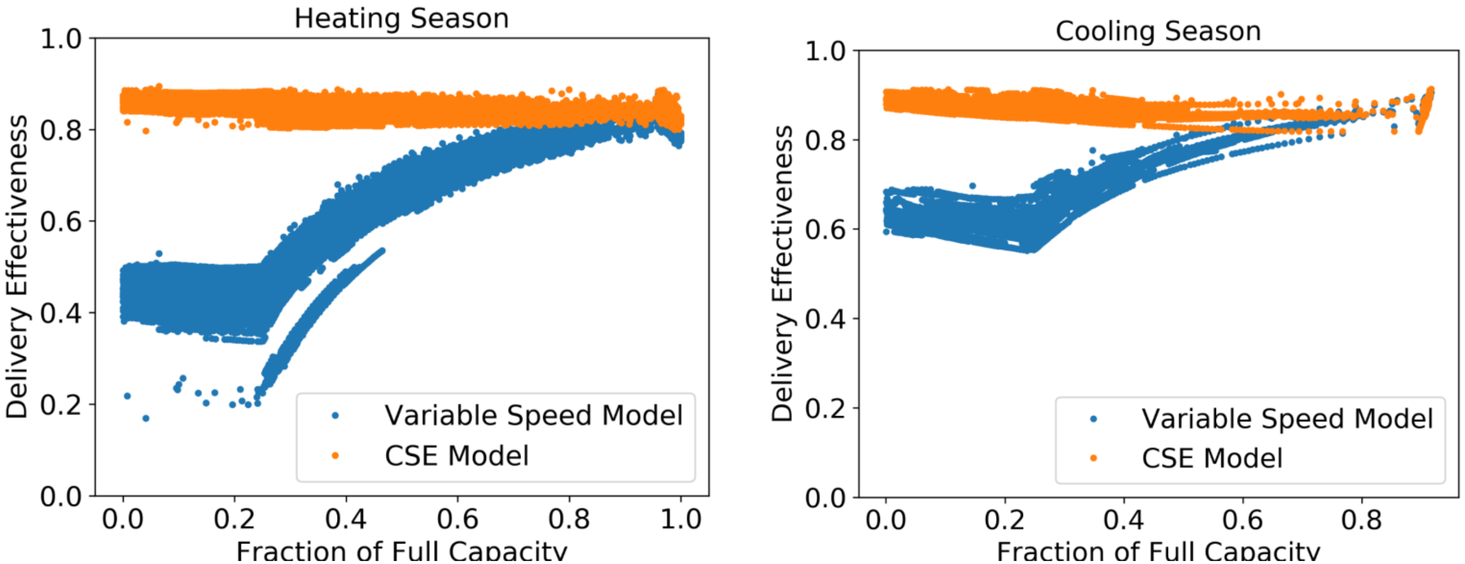
Energy Use Impact: Duct Model Verification

- Model parameters:
  - Prototype 2100 ft^2 house in Climate Zone 12
  - SEER 20 heat pump
- Results: CSE model of duct loss agrees with Krishnamoorthy model developed from WCEC lab tests

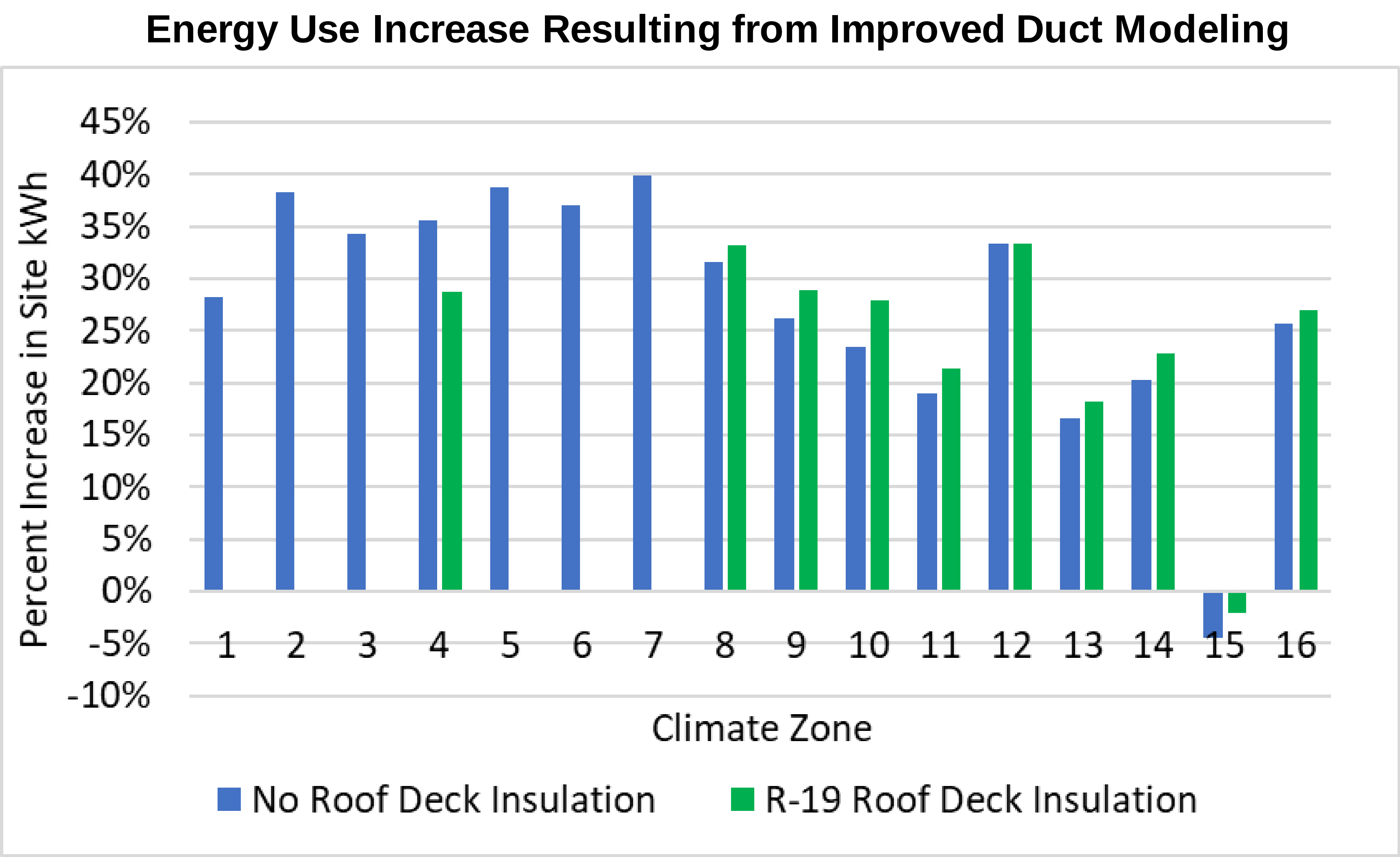


Energy Use Impacts: Delivery Effectiveness for CZ12 Simulation

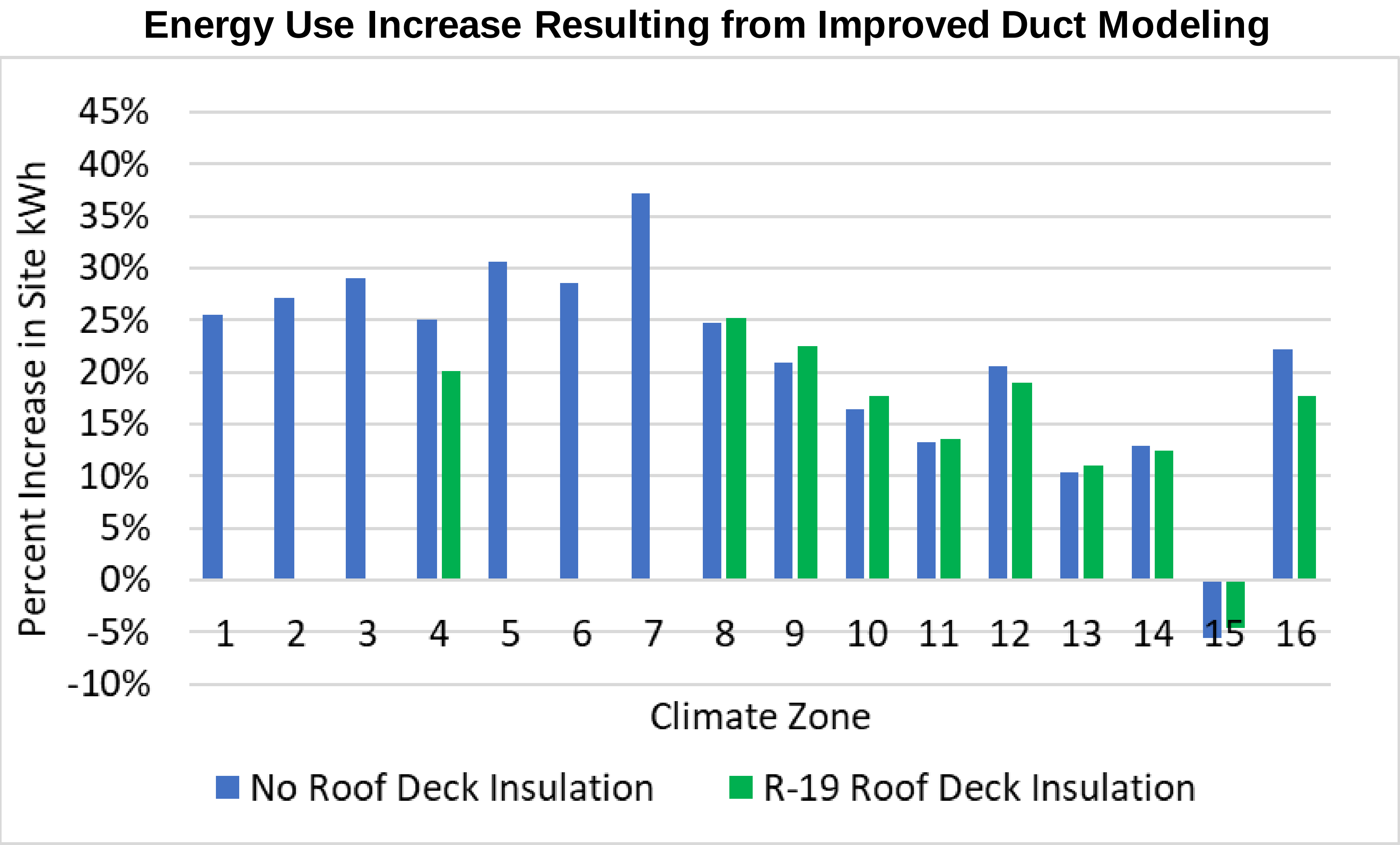
- CSE shows relatively constant effectiveness across all hours
- Variable speed model shows poor effectiveness at lower speeds
  - Minimum speed is 25%, equipment cycles on and off below that point
- CSE overestimates delivery effectiveness at part load



Energy Use Impact: 2100 ft² Prototype - Heat Pump



Energy Use Impact: 2700 ft^2 Prototype – Heat Pump



Software Updates

- **Current system modeling methods**
  - Delivered cooling and heating is modeled as if the unit cycles on and off at 100% capacity for variable capacity as well as single speed units
  - Duct losses are always calculated at full speed
  - AHRI-rated SEER and EER values are used to calculate energy use
- **Proposed modeling capabilities**
  - If the HVAC system type is designated as Multi-Speed in CBECC-Res, when ducts are in a vented attic losses are calculated based on airflow that is a function of the hourly load
  - If the system type is designated as both Multi-Speed and Zonally Controlled, HERS verification of an "Integrated Zonal Control System" is triggered and duct loss is calculated as if a single speed system is installed (no change from current methods)

Incremental Cost Information

- **New construction costs will vary depending on the design and compliance method**
  - Attic ducts with compliance penalties offset by other improvements (tradeoffs)
  - Ducts in conditioned space
  - Integrated variable capacity – zonal control system
- **Existing home costs**
  - May be negative when replacing with single speed instead of variable capacity equipment
  - Will be higher if variable speed system with integrated zoning is used for compliance

Market Overview

- Market Share and Trends
- Contractor Survey Results

Market Share and Trends

- Variable capacity equipment market and availability
  - Annual quantity of variable capacity systems installed in new and existing homes is **unknown**
  - CalCERTS data suggests that **2% of new installations** have multispeed compressors
  - About **25 to 30% of MAEDBS listings** are for variable capacity systems

Modern Appliance Efficiency Database System (MAEDBS) Title 20 Listings

Product Type	Total Listings	Compressor Motor Design		
		Single	Dual	Multiple
Air Conditioners	2,714	69%	21%	8%
Heat Pumps	2,395	71%	18%	7%

Will tougher Title 24 standards for 2020 lead to increased use of high efficiency, variable capacity systems?

Contractor Survey Findings

- Minimal use of multispeed systems in new homes
- Installation of multispeed systems with integrated zoning is relatively rare though all major manufacturers produce systems with that capability
- Mixed reception to proposed code changes

Contractor	Specialty	System Types Installed			Primary Reason for Installing Multispeed	Support Proposed Code Changes?
		Multispeed	Multizone	Integrated Multispeed/Zoning		
A	New home construction	**5%**	**60%**	Almost never	Compliance	None
B	New home construction	**5%**	**40%**	Sometimes	Homeowner value	CBECC improvements and integrated zoning
C	Replacements & Service	20%	0%	Almost never	**Can't convince customer to downsize**	CBECC improvements and integrated zoning
D	Replacements & Service	90%	70%	Almost always	Improve comfort/reduce noise	None
E	Replacements & Service	40%	0%	Almost never	Improve comfort/reduce noise	CBECC improvements
F	Replacements & Service	5%	2%	Almost always	Integrate with zoning	None

Technical Considerations

- Primary consideration is application of integrated variable speed-zonal control systems

Technical Considerations – Integrated Zoning

- Known systems that can control the indoor unit fan and compressor speed based on zone calls:
  - *Carrier Infinity SYSTXCCUIZ01-V*
  - *Trane ComfortLink II*
  - *Rheem EcoNet*
  - *Lennox Harmony III and LZP-4*
- Each has unique installation and commissioning requirements – training is needed

How available and effective is manufacturer training?

Compliance and Enforcement

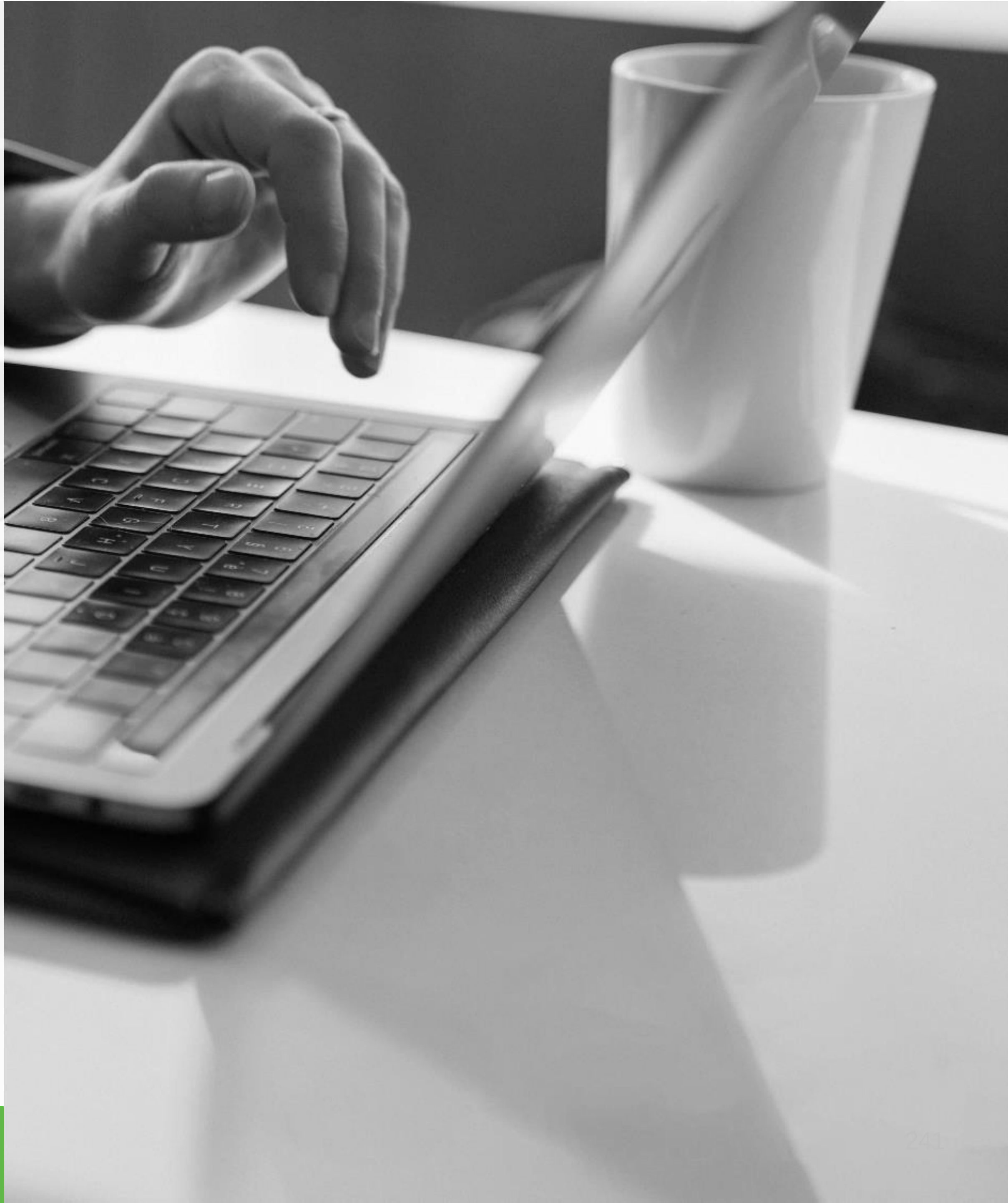
- Performance Compliance
- New proposal covering alterations

Compliance and Enforcement

- Will use the CBECC-Res input for "Multi-speed Compressor" to modify duct loss calculations and to facilitate verification
- Proposing to add a directory listing under the Energy Commission's Manufacturer Certification for Equipment and Products for *Integrated Variable Capacity – Zonal Control Systems* (see https://ww2.energy.ca.gov/title24/equipment_cert/)
- Proposed prescriptive requirements for HVAC replacements may lower the already very low compliance rate where variable capacity systems are planned to be installed

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.**

- Since first stakeholder meeting in 2019:
  - **Section 100.1** – Added definition for Integrated Zonal Control System
  - **Section 150.0** – Cleanup only: Removed efficacy verification exceptions for furnaces manufactured prior to July 2019, moved exception from 150.0(m)13D to 150.0(m)13C.
  - **Section 150.1** – No change since prior meeting (verification of variable capacity systems)
  - **Section 150.2** – Added requirement that for alterations involving installation of variable capacity equipment, ducts must be located in conditioned space or fully buried in attic insulation, or that certified zonal control systems must be installed. Applies to Climate Zones 2 and 8-15 only

Thank You

Questions?

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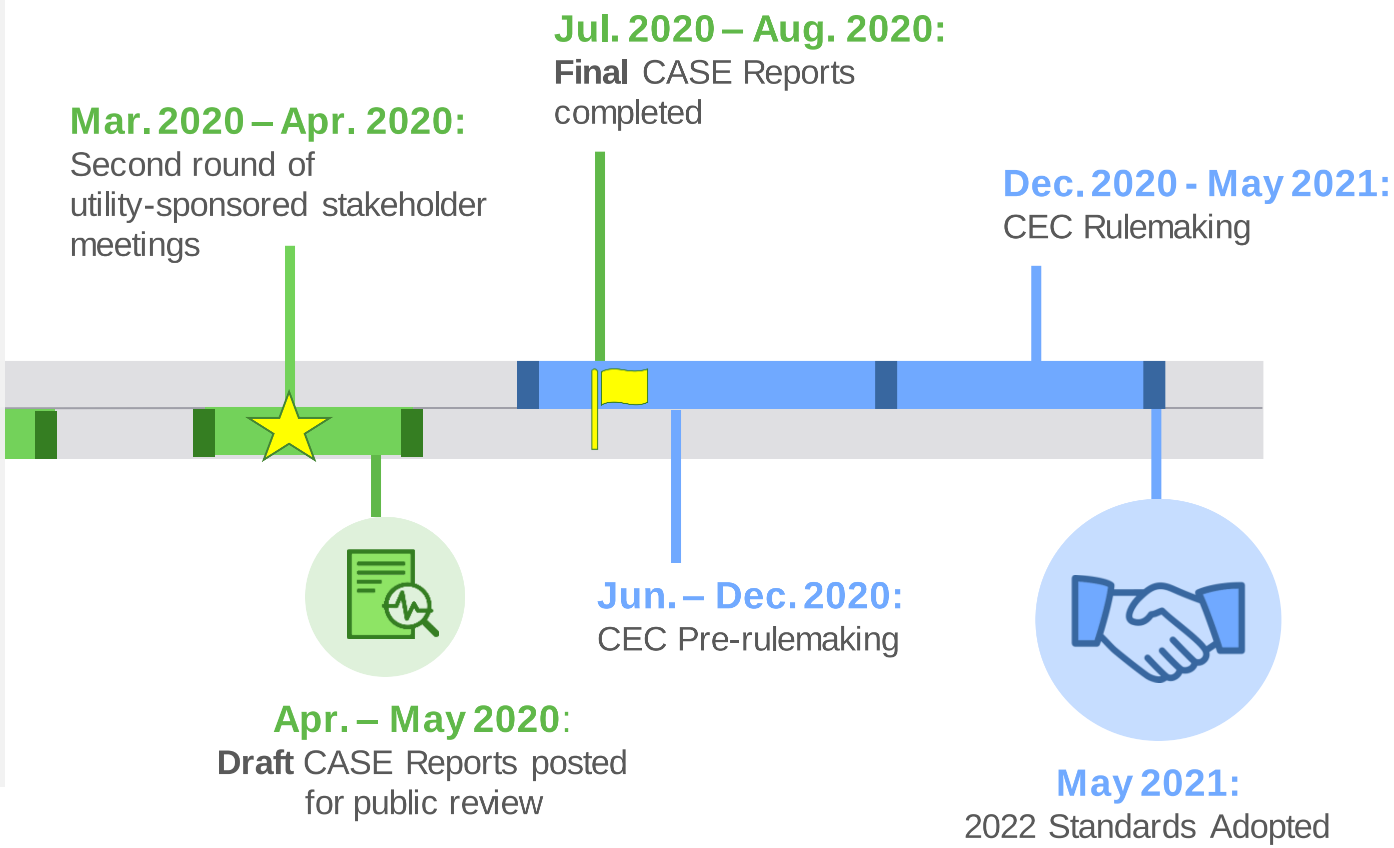
CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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 **April 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
Water Heating and Multifamily All Electric Package	MF	Tuesday, March 17, 2020
Single Family Grid Integration	SF	Thursday, March 19, 2020
~~Multifamily HVAC and Envelope~~	~~MF~~	~~Thursday, March 26, 2020~~ To be rescheduled.
Covered Processes Part 1: Refrigeration System Opportunities	NR	Thursday, April 2, 2020
Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)	NR	Tuesday, April 14, 2020
Covered Processes Part 2: Controlled Environmental Horticulture	NR	Thursday, April 16, 2020
Nonresidential Envelope Part 1: High Performance Envelope	NR	Thursday, April 23, 2020

Thank you for your participation today

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Please complete the closing polls below