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

Nonresidential HVAC and Envelope Part 2.

We'll get started shortly.

In the meantime, please fill out the polls below.

Welcome: Connect Your Audio

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

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

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

Above: audio conference settings pop-up box

2022 TITLE 24 CODE CYCLE, PART 6

First Utility-Sponsored Stakeholder Meeting

Nonresidential HVAC and Envelope Part 2

Statewide CASE Team

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Meeting Guidelines

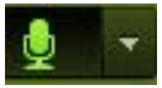
Muting Guidelines

Once you turn on your preferred audio connection, please **MUTE** your microphone.

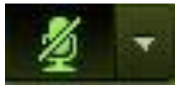
- Please keep yourself **MUTED.**
- Wait for instructions and/or permission to unmute yourself during designated Q&A periods.

Phone users – please mute your phone line.

Computer/device users – please mute your microphone by clicking on the microphone icon on your top ribbon.



NOT MUTED



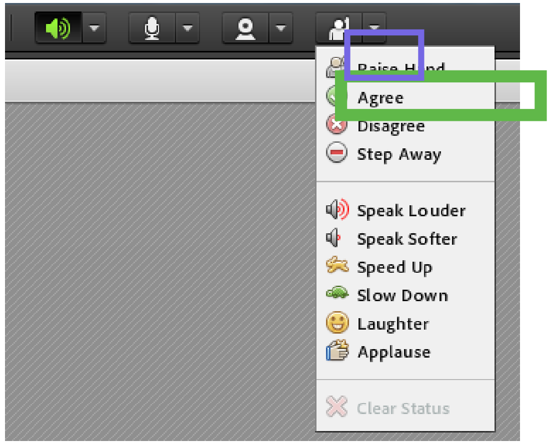
MUTED

Meeting Guidelines

Participation Guidelines

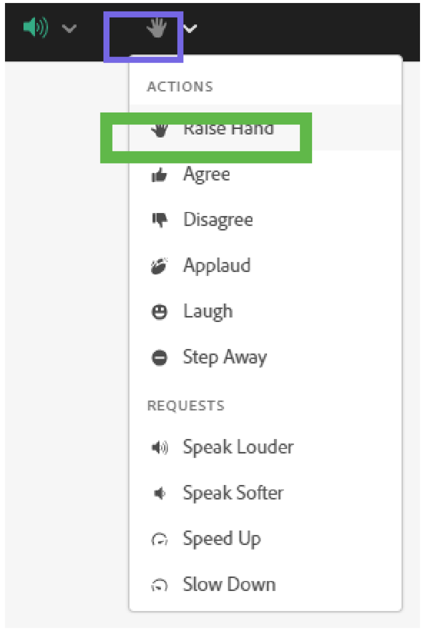
- **Questions & Comments**
  - Click **“*Raise Hand*”** if you would like to speak. Those with a hand raised will be called on by the speaker.
  - All questions and comments are also welcome via the chat window.

- **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 Ground Rules

- **We want to hear your thoughts**
  - Supporting and opposing viewpoints are welcome
- **When making comments**
  - Unmute yourself
  - Clearly state your name and affiliation prior to speaking
  - Speak loudly for phone audio
  - Place yourself back on mute
- **Calls are recorded** for note development, recordings will not be publicized
- Notes and presentation material will be posted on Title24Stakeholders.com

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:** HVAC Controls (Part II)	*8:45 am*
5	**Presentation II:** Air Distribution	*9:45 am*
6	**Presentation III:** Reduce Air Infiltration	*11:00 am*
7	**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% below 1990 levels by January 1, 2030

9

2022 Standards Schedule

Estimated Date	Activity or Milestone
November 2018 - April 2019	Updated Weather Data Files
November 2018 - July 2019	Measures Identified and Approved (Internal at the Energy Commission)
November 2018 - July 2019	Compliance Metrics Development
April 24, 2019	Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data workshop
November, 2019	Final Metrics Workshop
November, 2019	Research Version of CBECC Available with new weather data files and updated Metrics
July 2019 - March 2020	Utility-Sponsored Stakeholder Workshops
March, 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
March - August 2020	Commission-Sponsored Workshops
July, 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
July - September 2020	Express Terms Developed
January, 2021	45-Day Language posted and set to list serve, Start of 45-Day review/comment period
January, 2021	Lead Commissioner Hearing
April, 2021	Adoption of 2022 Standards at Business Meeting
May - November 2021	Staff work on Software, Compliance Manuals, Electronic Documents
May - November 2021	Final Statement of Reasons Drafted and Approved
October, 2021	Adoption CALGreen (energy provisions) - Business Meeting
December, 2021	CBSC Approval Hearing
January, 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January - December 2022	Standards Training (provided by 3rd parties)
June 1, 2022	6 Month Statutory Wait Period Deadline
January 1, 2023	Effective Date

2022 Standards Contact Info

Mazi Shirakh, PE
ZNE Technical Lead
Building Standard Staff.
Mazi.Shirakh@energy.ca.gov
916-654-3839

Payam Bozorgchami, PE
Project Manager, 2022 Building Standards
Payam.Bozorgchami@energy.ca.gov
916-654-4618

Larry Froess, PE
CBECC Software Lead
Larry.froess@energy.ca.gov
916-654-4525

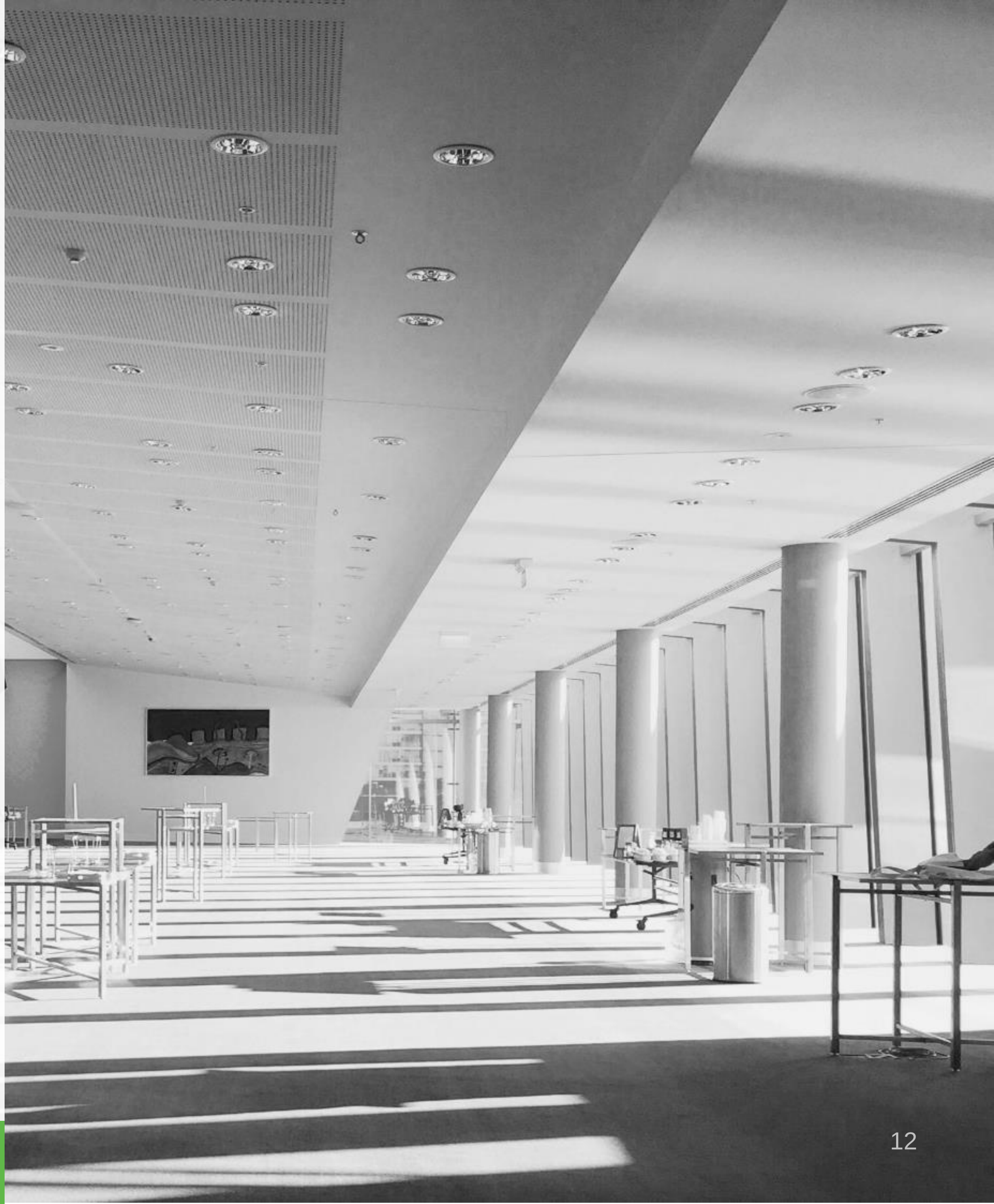
Peter Strait
Supervisor
Building Standards Development
Peter.Strait@energy.ca.gov
916-654-2817

Christopher Meyer
Manager
Building Standards Office
Christopher.Meyer@energy.ca.gov
916-654-4052

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 supporting the California Energy Commission** in developing proposed changes to the California Energy Code (Title 24, Part 6)
- Achieve significant energy savings through the development of **feasible**, **enforceable**, **cost-effective, and non-proprietary** code change proposals for the 2022 code update, and beyond

Requirements for a Successful Code Change Proposal

The utilities support the California Energy Commission by proposing changes to the Energy Code that are:

Feasible | Cost effective | Enforceable | Non-proprietary

Utility-Sponsored Stakeholder Meetings

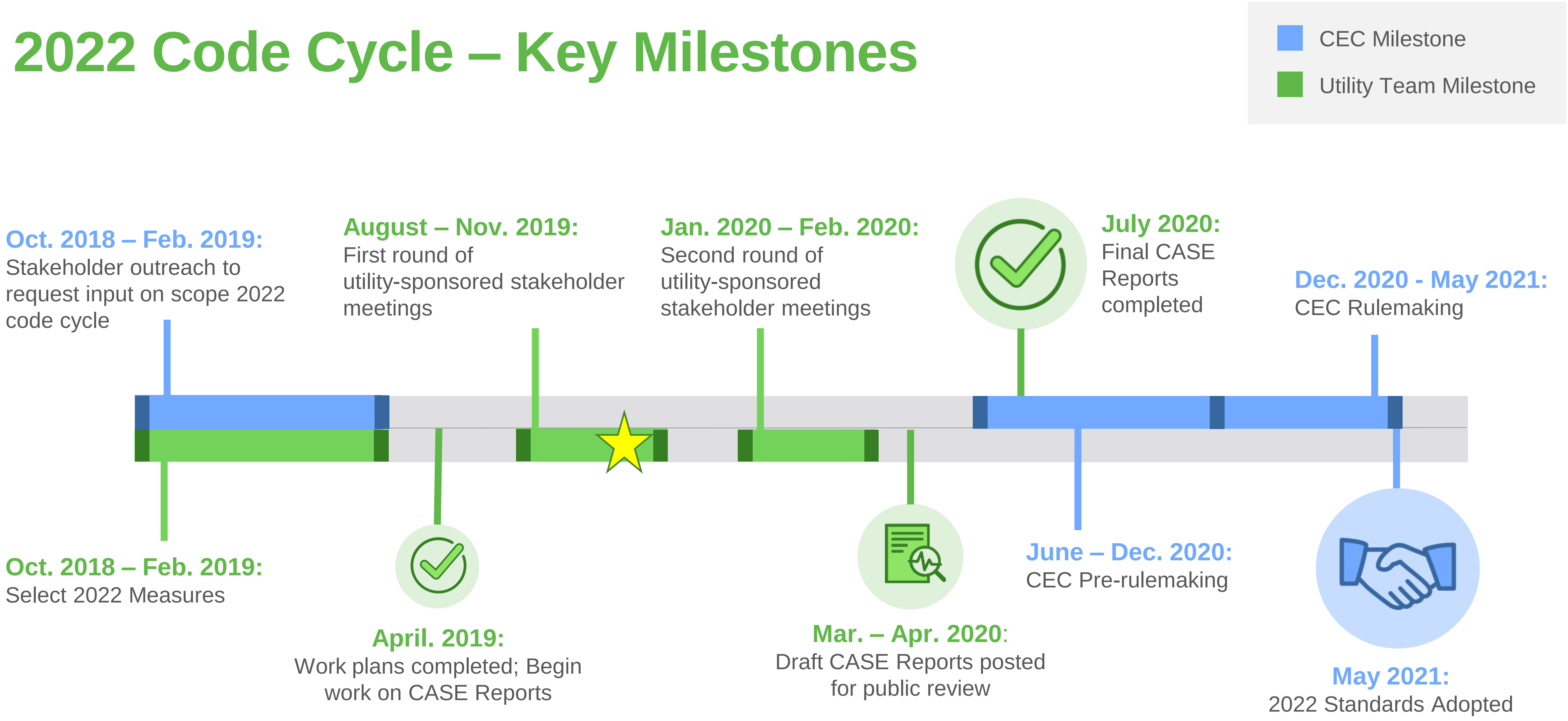
- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- Sign up to receive email notifications

First Round Utility-Sponsored Stakeholder Meetings

Meeting Topic	Building Type	Date
Multifamily HVAC and Envelope	MF, NR	Thursday August 22, 2019
Outdoor Lighting and Daylighting	MF, NR	Thursday September 5, 2019
Indoor Lighting	NR	Thursday September 12, 2019
Covered Processes Part 1: Controlled Environment Horticulture	NR	Thursday, September 19, 2019
Multifamily & Nonresidential Water Heating	MF/NR	Thursday, October 3, 2019
Single Family HVAC	SF	Thursday, October 10, 2019
Nonresidential HVAC Part 1: Data Centers, Boilers, & Controls	NR	Tuesday, October 15, 2019
Nonresidential Envelope Part 1	NR	Thursday, October 24, 2019
Nonresidential HVAC and Envelope Part 2: Air Distribution, & Controls	NR	Tuesday, November 5, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019

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

2022 Code Cycle – Key Milestones



Comply With Me

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

www.EnergyCodeAce.com

offers **No-Cost**

Tools ♠ Training ♠ Resources

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

SDGE — A Sempra Energy utility® SoCalGas — A Sempra Energy utility® Southern California EDISON — An EDISON INTERNATIONAL® Company PG&E Pacific Gas and Electric Company®

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.

EnergyCode Ace™
Helping you play your cards right

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

Kelly Cunningham
Pacific Gas & Electric
Kelly.Cunningham@pge.com

Christopher Kuch
Southern California Edison
Christopher.Kuch@sce.com

James Kemper
Los Angeles Department of Water and Power
James.Kemper@ladwp.com

Jeremy Reefe
San Diego Gas & Electric
jmreefe@sdge.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

HVAC Controls Part 2: Air Efficiency

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC

Shaojie Wang, *Energy Solutions*

Tim Minezaki, *Energy Solutions*

Jeff Stein, *Taylor Engineering*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Background
2. Market Overview and Analysis
3. Technical Feasibility
4. Cost and Energy Impacts
5. Compliance and Enforcement
6. Proposed Code Changes
7. Discussion and Next Steps

Background

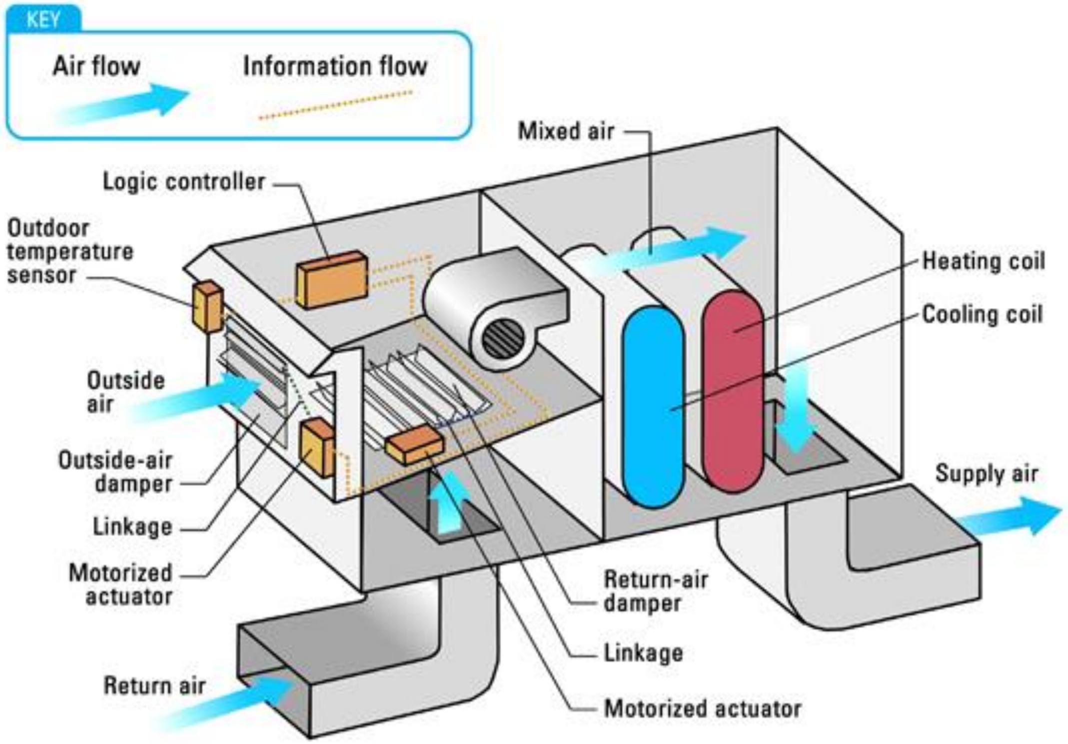
- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Submeasures	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Forms Updated
1. Expand economizer requirements	Prescriptive	Yes	120.2(i): Economizer FDD 140.4(e)1: Economizers	Yes
2. Expand integrated economizer	Prescriptive	Yes	140.4(e)2E: Economizers	Yes
3. Change Intake/exhaust locations	Prescriptive	Yes	Section 140.4(+): new subsection on Economizer Outside Air and Exhaust Air Separation	Yes
4. Powered-modulated Relief Systems	Prescriptive	Yes	Section 140.4(+): new subsection on economizer relief	Yes

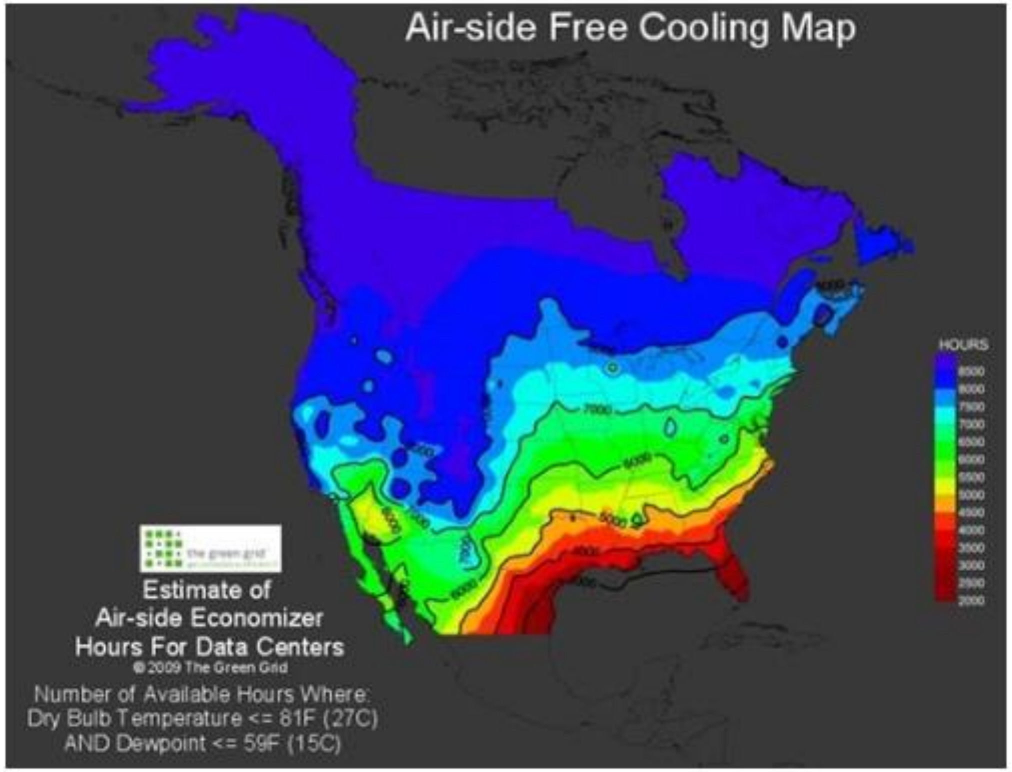
Context and History

- Why are we proposing these sub measures?
  - Economizers are a proven way to save energy in California and have shown to save nonresidential buildings up to 30 percent of the cost to cool buildings (Heinemeier 2014).



Context and History

- Economizers are ideal for climates with mild weather where actuators turn valves or dampers to provide “free cooling” to reduce energy usage on the cooling system.



Context and History

1. Recent advancements in HVAC design have meant that economizers for smaller packaged units more cost effective
2. Advances in variable speed compressors have made integrated economizers possible at lower capacities.
3. Performance issues remain for some economizers and creating better separation of air intake and exhaust can reduce "short-cycling" also known as exhaust re-entrainment that limit economizer effectiveness.
4. Powered-modulated relief for packaged HVAC units are widely available to release excess outdoor air and maintain building pressure, also important for proper packaged unit operation.

2019 Code Requirements

Title 24, Part 6 Prescriptive Requirements	ASHRAE 90.1 Prescriptive Requirements	ASHRAE 189.1 Prescriptive Requirements	ASHRAE 62.1 Prescriptive Requirements
Section 140.4 (e) 1 • Design total mechanical cooling capacity over 54,000 Btu/hr • Capable of providing 100% outside air Section 120.2 (i) • Require economizer fault detection and diagnostics (FDD) with a mechanical cooling capacity over 54,000 Btu/hr	Section 6.5.1 • Design total mechanical cooling capacity over 54,000 Btu/hr for specific climate zones Section 6.5.1.1.1 • Capable of providing 100% outside air Section 6.5.1.1.5 • Requirements for relief air damper Section 6.5.1.3.a • Requirements for air economizer integration	Section 7.4.3.3 • Design total mechanical cooli ng capacity over 33,000 Btu/hr for specific climate zones • Requires two stage of capacity control with cooling capacity less than 54,000 Btu/h	Section 5.5.1 • Requires for minimum distance between outdoor air intakes and outdoor contaminant source

Proposed Code Change Overview

Description of changes:

1. Require economizers for smaller units: lower the threshold for economizers in mechanical cooling systems from 54,000 Btu/hr systems to 36,000 Btu/hr system.
2. Require integrated economizers for HVAC units.
3. Create better separation of intake and exhaust by setting minimum distances from intake/exhaust openings to prevent exhaust re-entrainment.
4. Powered-modulated relief for packaged HVAC units with economizers

Market Overview

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

Market Overview and Analysis

- Current Market
  - Economizers are a mature technology that is included as part of many HVAC packaged units and built-up HVAC systems.
  - Major sellers of HVAC systems include Carrier, Lennox, Trane, Daikin McQuay, Emerson, Rheem, Honeywell
  - Major sellers of variable speed compressors include Chicago Pneumatic, Ingersoll Rand, Quincy compressor, EMAX, Atlas Copco
  - Utility programs exist for HVAC maintenance but not for new systems.

- **Do you agree with this description? What else should we know?**

Current Practices

- Previous ASHRAE language that had been incorporated into Title 24 Part 6 has the potential to be updated due to advances in variable speed compressor technology that can lead to increased efficiency of packaged unit compressor turndown

Recently, the concept of SAV™ (staged air volume) systems on packaged rooftop units has been introduced. An SAV system saves energy by automatically adjusting the indoor fan motor speed in sequence with the unit's cooling, heating, and ventilation needs. Studies show that properly controlled indoor fan systems can reduce power consumption of the entire unit by up to 57%[2] when coupled with the proper compressor and unit control system, without sacrificing space conditioning comfort.

First introduced by ASHRAE Standard 90.1-2010 with a scheduled effective date of January 1, 2012, two-speed indoor fan control was written into state code by California's Title 24, and has been mandated by the US Department of Energy (DOE) to be written into enforceable state building codes by October 18, 2013. SAV systems meet all aspects of these code requirements while providing even better energy savings.

http://www.utcccs-cdn.com/hvac/docs/1001/Public/08/04-581059-01.pdf

Current Practices

- Design requirements can be changed so that there is a minimum separation between the economizer exhaust openings. This will help improve the indoor air quality in the buildings. ASHRAE 62.1 has requirements for minimal separations.

Market Trends

- The economizer market is expected to have a Compound Annual Growth Rate (CAGR) of 9.1% from 2018 to 2025

https://www.marketwatch.com/press-release/global-economizer-market-trends-forecast-2023-industry-analysis-by-regions-type-and-applications-2019-05-20

Market Barriers and solutions

- Market barriers
  - Economizer performance has poor persistence in the field, limiting actualized savings
  - Solution: While the Statewide CASE Team has attempted to address these issues in the Economizer Fault Detection Devices (California Statewide CASE Team 2017) CASE Report and subsequent code language recommendations, it would be important to determine the degree to which operational problems persist in the field and possible ways to mitigate equipment failure.

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Are the recent technical improvements on variable speed compressors substantive enough to require fully integrated economizers?
- What HVAC unit-capacity does exhaust re-entrainment become an issue? (small, medium, large, very large)
- A separate Dedicated Outdoor Air Systems (DOAS) HVAC controls submeasure will cover economizer considerations for Variable-Refrigerant-Volume (VRV) systems

Technical Barriers and Solutions

- Economizer technology may not be feasible for all HVAC system types, especially with an industry trend toward decoupled VRV/DOAS* systems which utilize less airflow
  - Solution: CASE authors will confirm with manufacturers and installers if feasible configurations of VRV systems with air-side economizers exist
  - *Note: DOAS systems are a separate submeasure of HVAC Controls that was presented as part of HVAC Controls Part 1 meeting on October 15

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental Costs
  - Energy Cost savings

Incremental Cost Information

- How we collected costs of base case technology and proposed technology
  - RS Means or other cost-estimating publications or software
  - Interviews with manufacturers, distributors or contractors
  - What was included in the costs
- How we will further collect information
  - Data from manufacturers and stakeholders
- **What other sources of costs did we leave out?**

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
1. Expand economizer requirements	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings
2. Expand integrated economizer	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings
3a. Change Intake/exhaust locations	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings
3b. Power-modulated relief systems	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings

California Energy Commission Prototype Building Types

Energy Commission Building Type ID	Energy Commission Description	Relevant Prototypes	
		Prototype Name	Floor Area (%)
Small Office	Offices less than 30,000 square feet	OfficeSmall	100%
Large Office	Offices larger than 30,000 square feet	OfficeMedium	50%
		OfficeLarge	50%
Restaurant	Any facility that serves food	RestaurantFastFood	100%
Retail	Retail stores and shopping centers	RetailStandAlone	10%
		RetailLarge	75%
		RetailStripMall	5%
		RetailMixedUse	10%
Grocery Store	Any service facility that sells food and or liquor	N/A	N/A
Non-Refrigerated Warehouse	Non-refrigerated warehouses	Warehouse	100%
Refrigerated Warehouse	Refrigerated Warehouses	N/A	N/A
Schools	Schools K-12, not including colleges	SchoolPrimary	60%
		SchoolSecondary	40%
Colleges	Colleges, universities, community colleges	OfficeSmall	5%
		OfficeMedium	15%
		OfficeMediumLab	20%
		PublicAssembly	5%
		SchoolSecondary	30%
		ApartmentHighRise	25%
Hospitals	Hospitals and other health-related facilities	N/A	N/A
Hotel/Motels	Hotels and motels	HotelSmall	100%
Miscellaneous	All other space types that do not fit another category	N/A	N/A

2023 Construction Forecast

Building Prototype	Percent of New Construction Impacted by Proposed Requirement	Million Square footage of New Construction Impacted by Proposed Requirement
Small office	100%	476.52
Large office	100%	1665.45
Restaurant	100%	238.92
Retail	100%	1490.53
Grocery store	100%	394.19
Schools	100%	724.95
Colleges	100%	379.99
Hotel/motels	100%	451.77

Definition of Baseline and Proposed Conditions:
Expand Economizer Requirements

Baseline Conditions

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

Proposed Conditions

- Minimally compliant with 2019 Code
- Cutoff cooling capacity with airside economizer: 36,000 Btu/h
- Airside economizer control: Differential Drybulb
- Period of evaluation: 15 years

Definition of Baseline and Proposed Conditions:
Expand Integrated Economizers

Baseline Conditions

- Minimally compliant with 2019 Code
- Period of evaluation:15 years

Proposed Conditions

Apply changes to minimum compressor turndown and the corresponding wider economizer operation

- Cooling capacity < 240,000 Btu/h, Minimum compressor displacement ≤25% full load
- Cooling capacity ≥ 240,000 Btu/h, Minimum compressor displacement ≤10% full load
- Period of evaluation:15 years

Definition of Baseline and Proposed Conditions:
Change Intake/exhaust locations

Baseline Conditions

- Current field-level economizer effectiveness, including 30% exhaust re-entrainment with no minimum separation between intake and exhaust openings
- Period of evaluation:15 years

Proposed Conditions

- 0% exhaust re-entrainment with 10 foot minimum separation between intake and exhaust openings
- Period of evaluation:15 years

Definition of Baseline and Proposed Conditions:
Change Intake/exhaust locations

Baseline Conditions

- Barometric relief with XX% of air economizer run time
- Exhaust flow rate exceeding 2,000 cfm
- Period of evaluation:15 years

Proposed Conditions

- Powered-modulated relief with 100% of air economizer run time
- Exhaust flow rate exceeding 2,000 cfm
- Period of evaluation:15 years

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

Designer to specify products that:

- Have economizers if > 36,000 btu/h capacity
- Have integrated economizers that utilize variable speed compressors
- Have modulating fan for economizer relief

Designers should ensure

- Significantly wide clearances from exhaust and intake

2. Permit Application Phase

AHJ should check that:

- Mechanical schedules indicate product compliance
- Mechanical drawings highlight Exhaust Air and Outside Air intakes the sufficiently separate airflow when necessary

Compliance Verification Process

3. Construction phase

- Any ducted modifications from exhaust and intake are implemented for compliance

4. Inspection Phase

- none

Market Actors

Market actors involved in implementing this measure include:

- Researchers at Washington State University support a robust program for energy code support and have produced material on efficient economizer operations
- AirTro Inc and CALCOMS are contractors who will provide useful information on installation feasibility
- Manufacturers such as Carrier, Trane, Acutherm, and Krueger will be able to provide useful information as to the expected costs of new requirements and product design
- Utility programs focused on HVAC maintenance such as PG&E's HVAC Quality Maintainence program based on ASHRAE/ACCA/ANSI Std 180

EnergyCode Ace™
Helping you play your cards right

Comply With Me

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

www.EnergyCodeAce.com

offers **No-Cost**

Tools · Training · Resources

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

SDGE — A Sempra Energy utility® · SoCalGas — A Sempra Energy utility® · Southern California EDISON — An EDISON INTERNATIONAL® Company · PG&E Pacific Gas and Electric Company®

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.

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to open the draft language from the **resources tab**
- **Are there specific concerns about meeting the total mechanical cooling capacity design requirements?**
- **How often are you specifying powered modulated relief for cooling air handlers?**
- **What is minimum distance between relief air outlet and outdoor air intake?**
- **How often are you installing cooling air handlers with airside economizer and what high limit control devices do you design to such as fixed drybulb, differential drybulb, and fixed enthalpy + fixed drybulb?**

Software Updates

- Proposed modeling capabilities
  - Update air economizer cutoff cooling capacity from 54,000 Btu/h to 36,000 But/h
  - Add packaged unit compressor turndown to 25% for 240,000 Btu/h cooling capacity and less
  - Add packaged unit compressor turndown to 10% for 240,000 Btu/h cooling capacity and larger
  - Add 30% exhaust re-entrainment with economizer systems that do not meet the prescriptive OA/EA separation
  - Add modulating return fan or relief fan with design exhaust flow rates exceeding 2,000 cfm

Discussion and Next Steps

Poll

This measure proposed to add 30% exhaust re-entrainment with economizer systems that do not meet the prescriptive OA/EA separation. Do you agree this requirement?

A. Yes
B. Yes but with different percentage of exhaust re-entraiment
C. No

Poll

This measure proposed to include modulating relief or return fan with design exhaust flow rate exceeding 2,000 cfm or barometric relief with 0.06” building static pressure. Do you agree this requirement for airside economizer?

A. Yes
B. Yes but with different design exhaust flow rate
C. No

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- 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

Comments on this measure are due by November 19, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

Shaojie Wang, *Energy Solutions*

swang@energy-solution.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

HVAC Controls Part 2: Guestroom Controls

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC Controls

Ben Brannon, *Arup*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

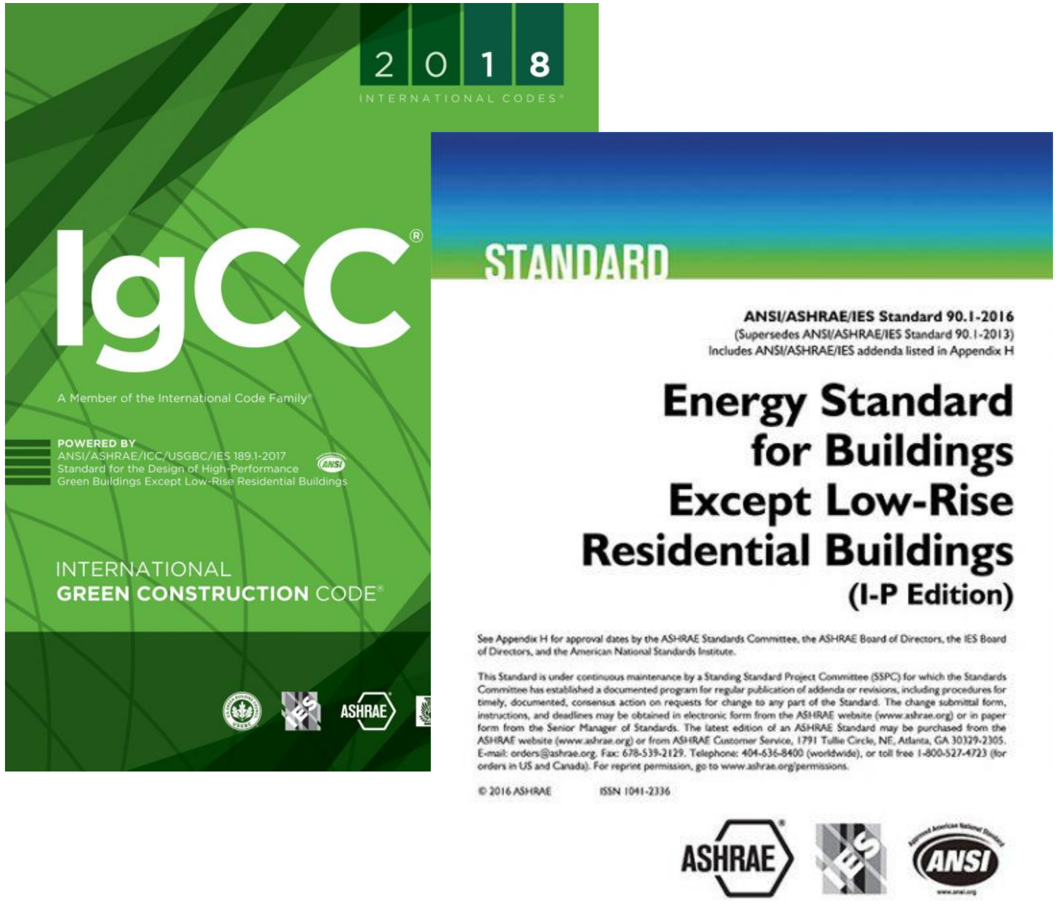
Building Types	System Type	Type of Change	Software Updates Required
Hotels/Motels	HVAC	Mandatory	*Potentially*

This proposal integrates the HVAC occupancy controls of ASHRAE 90.1-2016 & ASHRAE 189.1-2017 (IgCC-2018) into Title 24 Part 6 2022.

Context and History

Currently required in ASHRAE 90.1-2016 & IgCC 2018 (ASHRAE 189.1-2017)

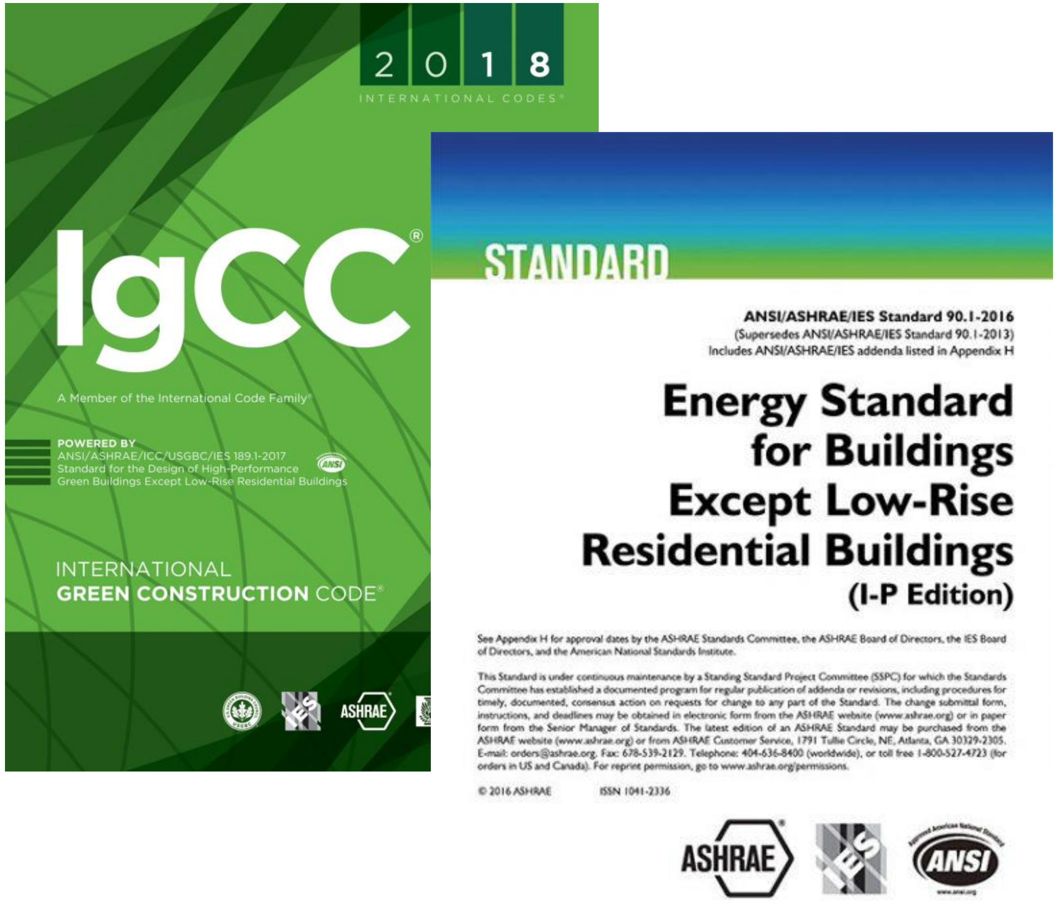
> *"…When the guest room is unrented and unoccupied, HVAC set points shall be automatically reset to 80°F or higher in the cooling mode and to 60°F or lower in the heating mode. Unrented and unoccupied guest rooms shall be determined by either of the following:…"*



Context and History

Currently required in IgCC 2018 (ASHRAE 189.1-2017)

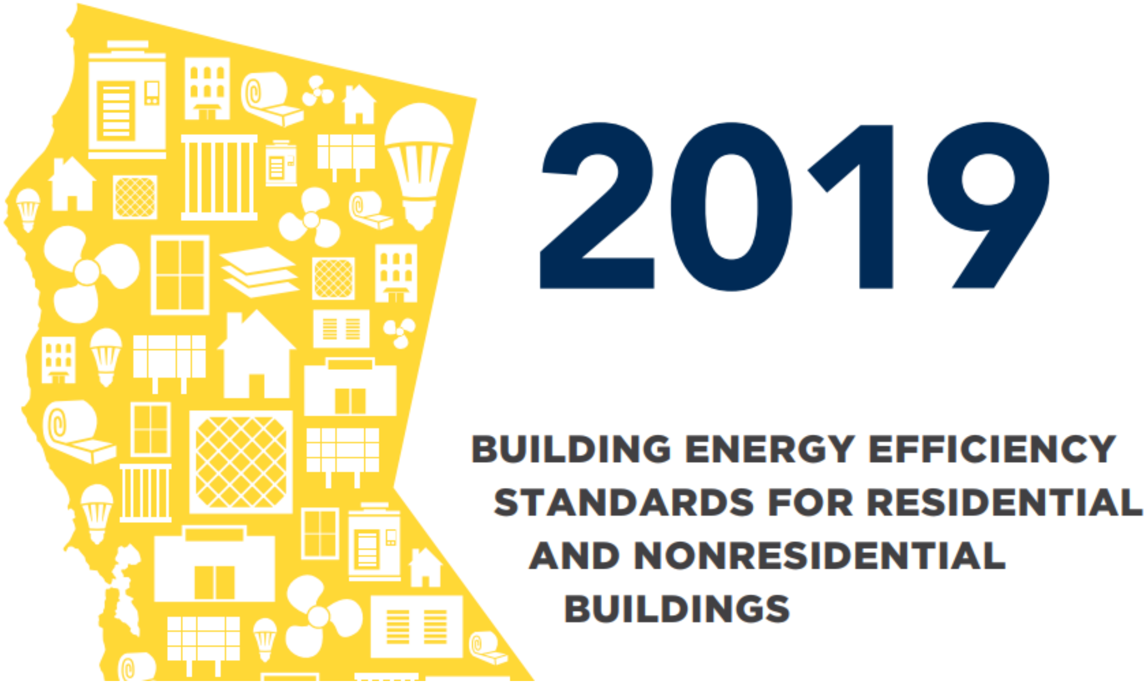
> *"…ventilation systems shall have an automatic preoccupancy purge cycle that shall provide outdoor air ventilation at the design ventilation rate for 60 minutes, or at a rate and duration equivalent to one air change. In guest rooms with a networked guestroom control system, the purge cycle shall be completed within 60 minutes prior to the time the room is scheduled to be occupied. Where guest rooms are not connected to a networked guest room control system, the preoccupancy purge cycle shall occur daily…*



Context and History

Similar controls for lighting existing in Title 24 Part 6 [130.1(c)8]

> *"Hotel motel guest rooms shall have captive card key controls, occupancy sensing controls, or automatic controls such that, no longer than 20 minutes after the guest room has been vacated, lighting power is switched off."*



Proposed Code Change Overview

- Draft code language for this sub-measure is available in the **resources tab**
- Description of change
  - **ASHRAE 90.1-2016 & IgCC 2018 language** will be integrated to replace existing language (retaining the most
  - All occupancy-based control requirements are proposed be **consolidated** (not yet done)

Market Overview

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

Market Overview and Analysis

- Current Market / Market Trends
  - **No new technologies** are required for this proposal (operational measure)
  - Occupancy detection is already required for lighting + HVAC control
- Market Barriers
  - Integration of Lighting and HVAC control systems

Energy and Cost Impacts

Methodology and Assumptions

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

Methodology for Energy Impacts Analysis

- Hotel prototype buildings will be simulated in all 16 California climate zones
- Models will be developed in CBECC-Com initially
  - Edited in EnergyPlus to **allow for diversity in occupancy schedules**
    - Otherwise the load and resets on chiller temperatures won't be accurate

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Expanded set of occupancy schedules
- 2019 ventilation/temperature setpoint requirements

Proposed Conditions

- Minimally compliant with 2019 Code
- Expanded set of occupancy schedules
- **Proposed 2022 ventilation/temperature setpoint requirements**

Assumptions for Energy Impacts Analysis

- Overall occupancy will remain unchanged from current prototype
  - This will be split into 5-10 profiles to account for diversity on central HVAC plants
  - Identical in baseline and proposed models
- Cleaning will be assumed to happen once per day for 15 minutes between 8 and 11am

Assumptions for Energy Impacts Analysis

- Per-square-foot or per-unit savings will be multiplied by the statewide new construction forecasts for hotel and motel building types, for each climate zone.

Building Type	Impacted Area
New Construction Hotels	TBD
Impacted Existing Hotels	TBD

Methodology for Energy Impacts Analysis

- Results planned to be available later in early 2020
- **Anticipated savings should be less than 5% of whole building energy use, with no anticipated additional costs**

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Mechanical designers include **adjusted** controls sequences

2. Permit Application Phase

- Plans reviewer check that sequences meet the code requirements

3. Construction phase

- Controls Contractor program in the sequences

4. Inspection Phase

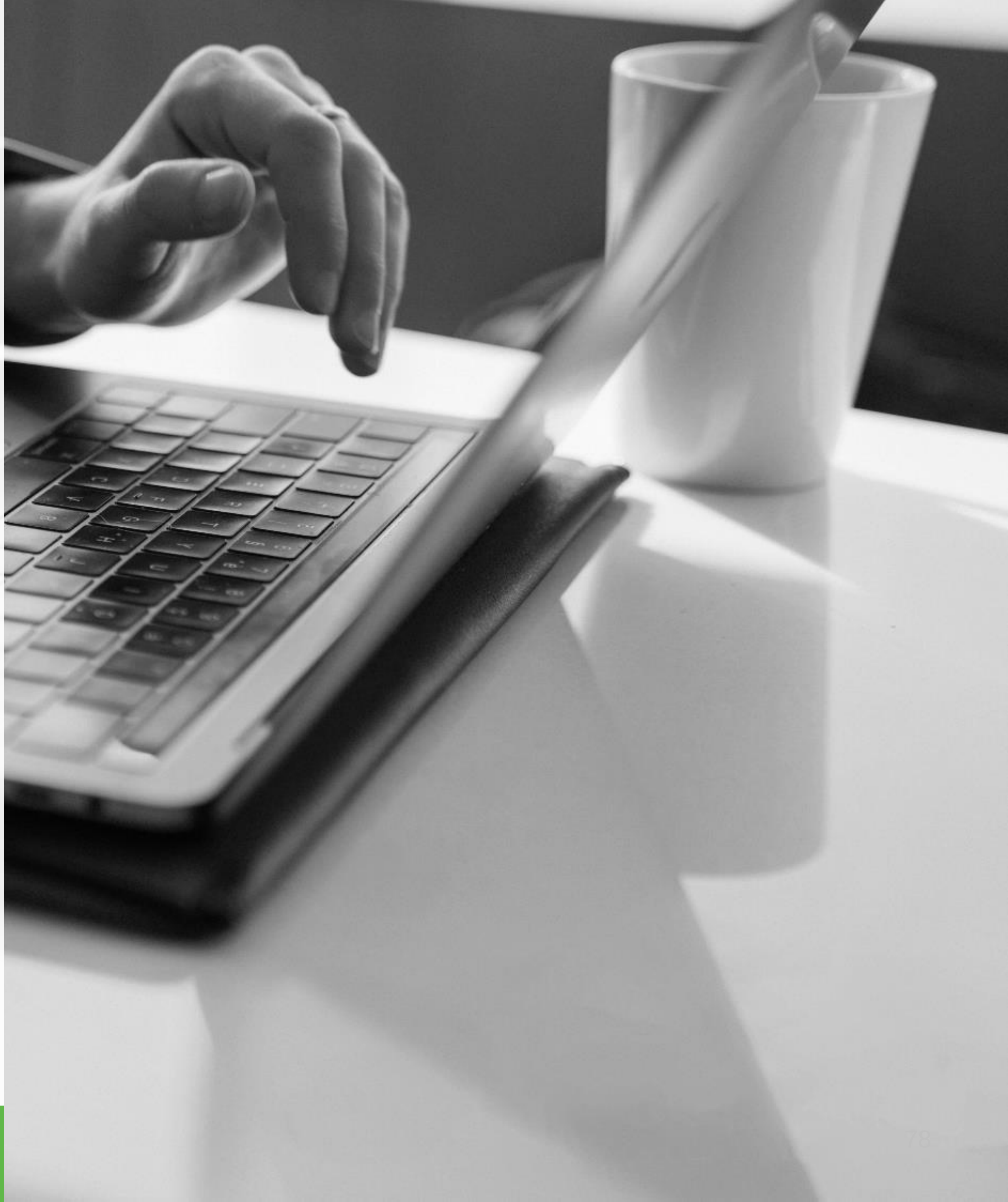
- Acceptance test technicians ensure sequences have been programmed correctly.

Market Actors

- **HVAC Designer**
  - New controls sequence requirements and equipment to interface with
- **HVAC Controls Contractor**
  - New controls sequence requirements and equipment to interface with
- **Lighting Designer**
  - Potential additional coordination with HVAC to utilize occupancy sensing equipment
- **Acceptance Test Technician**
  - Slightly changed scope, potential for integration between MECH and LTG
- **Plans Examiner**
  - Verify controls sequences
- **CEC**
  - Possible updates required to CBECC-Com

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab** and specifically note:
  - Changes to setpoint and ventilation requirements
  - Addition of purge requirement
  - Consolidation/reorganization of language
  - Potential update to occupancy controls in lighting to match mechanical language (*i.e. universally define when a room is deemed unoccupied*)
    - *This is not yet in the draft language*

Software Updates (potentially)

Current Conditions

- Occupancy controls for lighting

Proposed Conditions

- More detailed diversity in occupancy profiles
- Adjustments to setpoints (with new setbacks/setups)
- Ventilation shutoff
- Modeling of cleaning staff (potentially)

Discussion and Next Steps

Poll

This measure proposed to retain the 5°F setup/setback currently in Title 24, Part 6, which is more strict than 90.1. Do you agree that this setup/setback is beneficial from an energy standpoint?

A. It should be higher than 5°F
B. 5°F (Current T24 value) is reasonable
C. 4°F (Current 90.1 value) is reasonable
D. It should be lower than 5°F

Poll

Do you agree that it will be beneficial to consolidate all occupancy based sensing/measurement requirements (from all disciplines and code sections) into the same section, which would then be referenced by other sections?

A. Yes
B. It doesn't matter to me
C. No

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- 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
- **Comments on this measure** are due by November 19, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

Ben Brannon, *Arup*

ben.brannon@arup.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Air Distribution

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC

Chad Worth, *Energy Solutions*

Benny Zank, *Energy Solutions*

November 5, 2019

Agenda

1	Overview of Air Distribution Measures	*5 min*
2	High Performance Ducts/Updates to Fan Power Limits	*20 min*
3	Fan Energy Index (FEI)	*20 min*
4	Expand Duct Leakage Testing	*20 min*
5	Discussion and Next Steps	*10 min*

Code Change Proposal – Summary

Submeasure	Building Types	System Type	Type of Change	Software Updates Required
High Performance Ducts/Updates to Fan Power Limits	Nonresidential	HVAC	Prescriptive	Yes
Fan Energy Index (FEI)	Nonresidential	HVAC	Prescriptive	Yes
Expand Duct Leakage Testing	Nonresidential	HVAC	Prescriptive	Yes

- Updates fan power limits to push for better fan system (including ducts) design
- Select high fans close to peak efficiency
- Reduce ductwork leakage

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Air Distribution

Submeasure A: High Performance Ducts/Updates to Fan Power Limits

Chad Worth, *Energy Solutions*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Revise fan power limitations and adopt best practices for duct design to reduce static pressure in air duct systems

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	HVAC	Prescriptive	Yes

Context and History

- **Why are we proposing this measure?**
  - Fans for air circulation and ventilation account for 28% of HVAC energy consumption
  - ASHRAE Research Paper-1651 shows that lower static pressure in air ducts can reduce fan energy consumption
  - Opportunity to clarify and improve existing Title 24 Part 6 has fan power limitations to drive better duct design and fan system efficiency

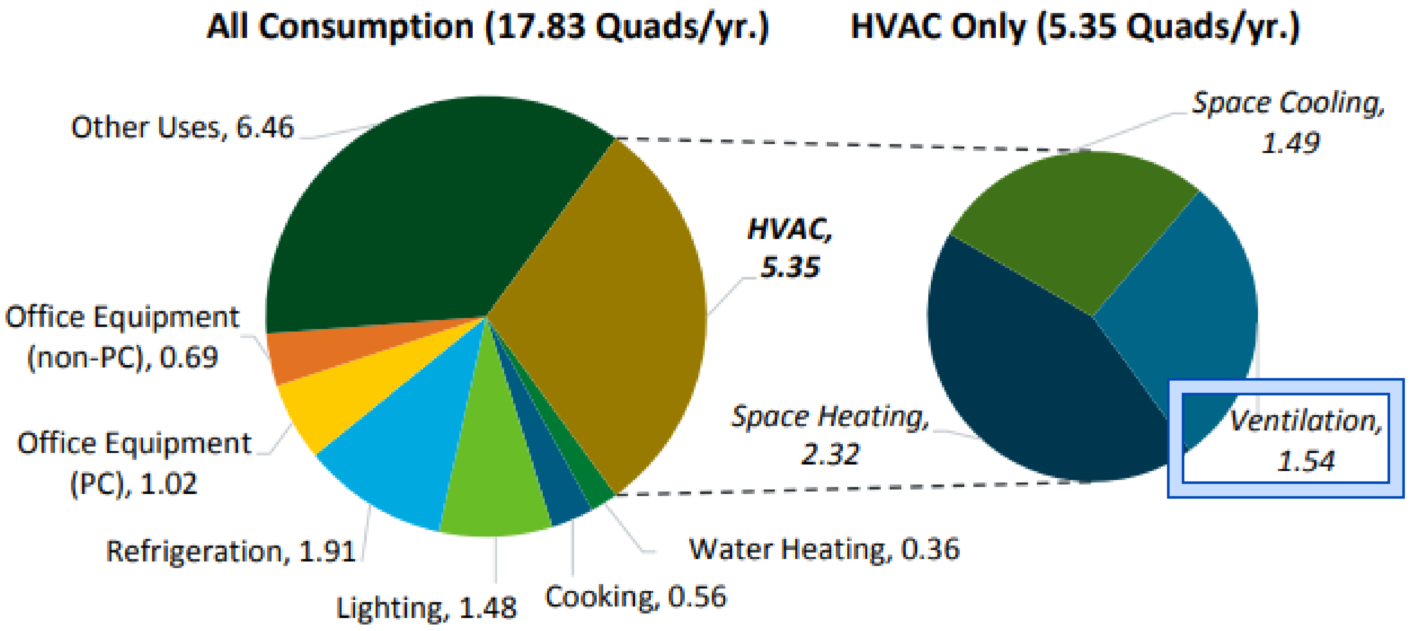


Figure 4: Commercial primary energy consumption by end use, Quads/yr. (2017)

Source: EIA AEO (2017)[11]

2019 Code Requirements

Title 24, Part 6- 2019	Nonresidential ACM - 2019	ASHRAE 90.1 (2019)
Section 140.4 • Allowable fan system power for a total fan system motor nameplate exceeding 5 hp • Fan power limitation pressure drop adjustment • No deductions for systems without coils	**Section 5.7.3.2** • Supply fan brake horsepower requirement • Minimum nominal efficiency for electrical motors	**Section 6.5.3.1** • Allowable fan system power for a total fan system with motor nameplate exceeding 5 hp • Fan power limitation pressure drop adjustment • Deductions for systems without coils

2019 Code Requirements

- 2019 Requirements in Title 24 Part 6
  - Section 140.4 – Prescriptive Requirements For Space Conditioning Systems

TABLE 140.4 - A Fan Power Limitation

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate hp	Allowable motor nameplate hp	$hp \leq cfm_s \times 0.0011$	$hp \leq cfm_s \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \leq cfm_s \times 0.00094 + A$	$bhp \leq cfm_s \times 0.0013 + A$

[1]cfm_s = maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute

hp = maximum combined motor nameplate horsepower for all fans in the system

bhp = maximum combined fan-brake horsepower for all fans in the system

A = sum of (PD x cfm_D/4131)

PD = each applicable pressure drop adjustment from Table 140.4 – B, in inches of water

cfm_D = the design airflow through each applicable device from Table 140.4 – B, in cubic feet per minute

TABLE 140.4-B – Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment Credits
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	0.5 in. of water
Return and/or exhaust airflow control devices	0.5 in. of water
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2 x clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	For each airstream [(2.2 x Energy Recovery Effectiveness) – 0.5] in. of water
Coil runaround loop	0.6 in. of water for each airstream
Exhaust systems serving fume hoods	0.35 in. of water

Source: Title 24 Part 6- 2019

Context and History

- Issues with *existing* Title 24, Part 6 Fan Power Limitations
  - Does not define fan systems well
    - What happens when multiple systems support one space?
    - Not clear with cases where one system feeds another (e.g. Constant volume dedicated outside air system (DOAS) unit feeds local variable air volume (VAV) air-handler units)
  - Does not differentiate between VAV systems that often run below design point and those that do not.
    - E.g. Many constant air volume systems have VFD’s, so users often believe they fall under VAV
  - Does not consider belt or motor efficiency, or correct for air density
  - Does not drive efficiency on smaller unit or those with short duct runs
  - Motor nameplate power limit method is too generous for most systems

Energy Savings in Fan Systems

- Low ductwork pressure loss and fan power can reduce fan energy consumption, fan heat gain, and supply air temperature rise.

$$bhp = \frac{CFM \times \boxed{SP}}{6356 \times \boxed{Fan\ Efficiency}}$$

1. Reduce static pressure
2. Increase fan efficiency

Proposed Code Change Overview

- Draft code language for this submeasure is available in the **resources tab**
- Summary of proposed changes

1. Redefine fan systems including supply, return, exhaust, transfer systems
2. Propose new calculation method based on maximum allowed electrical power input, inclusive of belt and motor efficiencies and air density to create fan power budgets for each fan system
3. Add/ modify pressure drop deductions

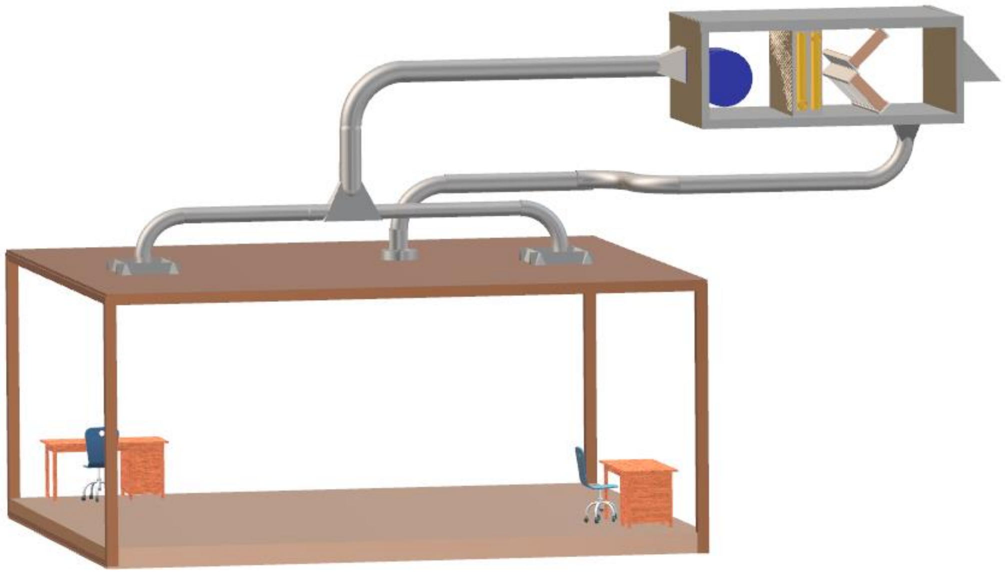


Image Source: Statewide IOU CASE Team

Market Overview

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

Market Overview and Analysis

- Current Market
  - Designers and manufacturers are very familiar with fan power limits, been in place since 1992
  - 2019 Nonresidential Alternative Calculation Method (ACM) reference manual uses fan power limitation for baseline prototype building
- Market Trends
  - New focus on fan energy efficiency in CA and ASHRAE
    - Fan Energy Index in ASHRAE Addendum AO (the next measure) is moving forward, as wire-to-air metric based on AMCA 208 rating method
    - Fan standards also being considered in CA Title 20 as an appliance standard
- Market Barriers
  - New standards may lead to larger/ more efficient ducts, and more efficient fan selections
  - Changes to long-standing fan power limits will take new training and education
- **Do you agree with this description? What else should we know?**

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Designers will need:
  - Training to fully understand the new calculation method for Fan Power Limits
  - Tools need to be developed to help and guide engineers conduct the calculation
  - Best practices for duct design to reduce pressure loss along ductwork and/or make better fan selections

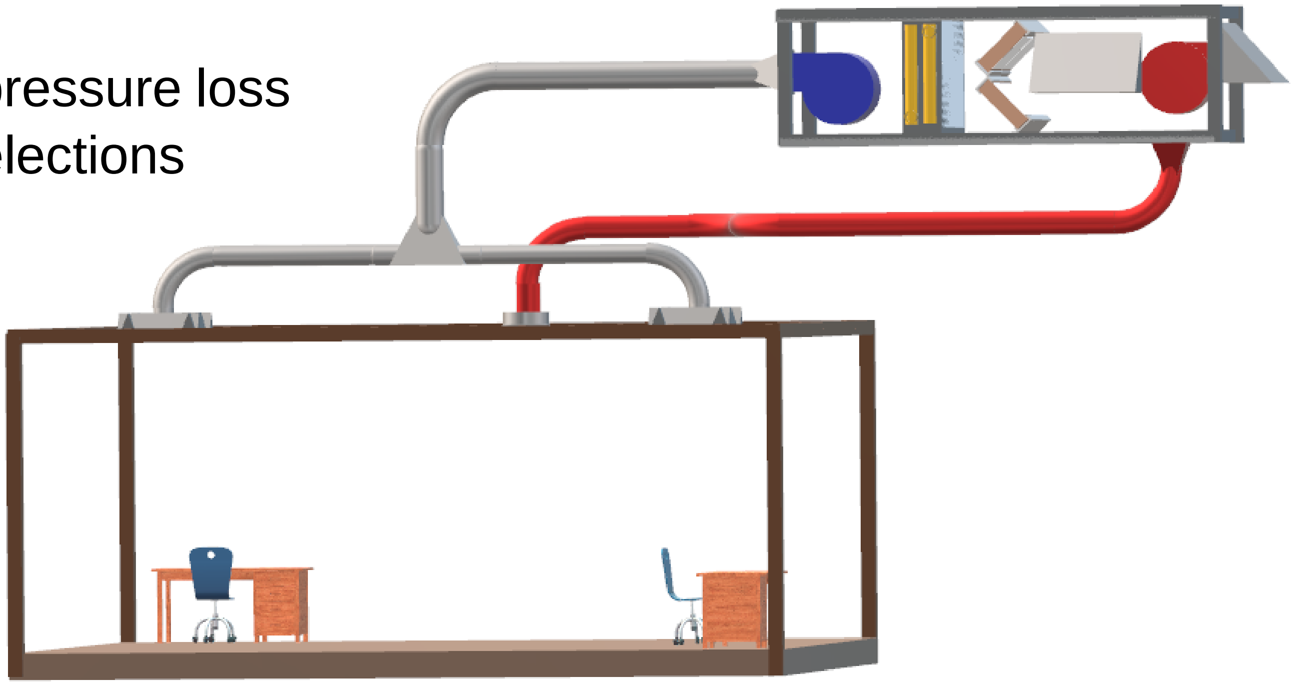


Image Source: Statewide IOU CASE Team

Energy and Cost Impacts

Methodology and Assumptions

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

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
High Performance ducts/Updates to Fan Power Limits	TBD	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Fan power minimally compliant with 2019 code
- 8,760 hrs/yr simulation period
- Period of evaluation: 15 years

Proposed Conditions

- Fan power: AMCA reference electrical fan power input
  - Fan Energy Index Budget: 1.0 for return and exhaust/ relief systems, and 1.2 for all other systems (explained later)
- 8,760 hrs/yr simulation period
- Period of evaluation: 15 years

Incremental Cost Information

- **How we collected costs of base case technology and proposed technology**
  - There are two ways to comply with fan power budget
    1. Fan improvements (reduced fan power)
    2. **Duct improvements (pressure reduction)**
       - Cost-effectiveness will be pursued through the duct improvement path
       - Incremental costs will include accounting for larger ducts, new fittings, etc.
- How we will further collect cost information?
  - Seeking data/ interviews from manufacturers, construction cost estimators, mechanical design firms, etc.
  - T-method, etc.
- **What other incremental cost sources did we leave out?**

Incremental Per Unit Cost

Over 15 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	TBD	Equipment Replacement	TBD
Installation	TBD	Annual Maintenance	TBD
Commissioning	TBD	Changes in filters	TBD
Other	TBD		
Total	TBD	**Total**	TBD

Statewide CASE Team still working on cost estimates for this measure

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Project Team:
  - Identifies if project triggers requirements based on fan system input power (1 kW)
  - Use new fan power limitations to design ductwork and size fan
  - Ensures design includes equipment that will meet fan limitations

2. Permit Application Phase

- Project team:
  - Submits design documents that identify fan power specs and are supported by the compliance documents.

Compliance Verification Process

3. Construction phase

- Mechanical Contractor:
  - Ensures compliant equipment is installed documenting with compliance documentation

4. Inspection Phase

- Building Inspector:
  - Verifies compliance documentation has been submitted and document compliance
- Acceptance Testing Technician:
  - Conducts applicable acceptance tests

Market Actors

Market actors involved in implementing this measure include:

- Mechanical Designers/ Contractors
- Fan manufacturers
- Energy Consultants
- Mechanical Contractors
- Plans Examiners
- Building Inspectors
- Distributors
- Building Owners

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Are there specific concerns about meeting the fan power limitation requirements?**

Proposed Fan System Definitions

Fan system: All the fans that contribute to the movement of air through a point of a common duct or plenum.

- Fan system, supply: A fan system that exclusively provides ventilation and/or recirculated air to conditioned spaces.
- Fan system, exhaust/relief: A fan system dedicated to the removal of air from conditioned or semi-conditioned spaces to the outdoors.
- Fan system, return: A fan system dedicated to removing air from conditioned or semi-conditioned spaces where some or all the air is to be recirculated except during 100% economizer operation.
- Fan system, transfer: A fan system that exclusively moves air from one occupied space to another.

Define Multi-Zone VAV System

In order to use the budget duct, plenum and inlet/outlet losses (pressure losses) for a Multi-Zone VAV system, the fan system must meet the following requirements:

- Fan system must serve three or more HVAC zones and airflow to each must be individually controlled based on heating, cooling and/or ventilation requirements.
- Sum of the minimum airflows for each HVAC Zone must be 40% or less of the fan system design conditions. The fan system meets the requirements of section 140.4 (m).

Scope of Proposal

Fan system input power at *fan system design conditions* shall not exceed the budget power input calculated for *each* fan system.

- All air flows will be converted to *standard airflow*.
- When exhaust/relief fans or return fans are present, the values for supply fan systems, exhaust/relief fan systems and return air systems shall be calculated separately.

Exceptions:

- Fan systems serving a single HVAC zone with a *fan system input power* of **1 kW** or less.

Calculate Budget Power Input

Step 1: Calculate the budget *fan brake horsepower* (bhp_{budget})

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

Where

bhp_{budget} = Budget *Fan system brake horsepower (hp)*

Q_i = ***Actual airflow** at **fan system design conditions (acfm)***

Q_o = 250 acfm

P_{budget} = **The sum of the budgeted fan system pressure losses from table 140.4-B (in. H_2O)**

P_o = 0.4 in. H_2O

C_A = **Altitude density correction from Table 140.4-A**

FEI_{budget} = **1.0 for return and exhaust/relief systems, and 1.2 for all other systems**

Table 140.4-A Correction Air Density by Altitude

Altitude (ft)	Correct factor
0	1.000
500	0.982
1,000	0.964
1,500	0.947
2,000	0.930
2,500	0.913
3,000	0.896

Table 140.4-B Budget Pressure Fan System Pressure Losses for Calculating BHP_{budget}

Budget Pressure Loss Components	**Multi-Zone VAV System[1]**	**Other Systems**
Select one of the following:		
Supply fan system duct, plenum and outlet	2.75	1.75
Exhaust/relief and return iinlet, plenum and duct	1.00	0.5
Particle filtration[2,3]		
Filter up to MERV 12	0.50	
Filter up to MERV 13 to MERV 16	0.90	
HEPA Filter	1.50	

(Note: Tables are incomplete for display purposes)

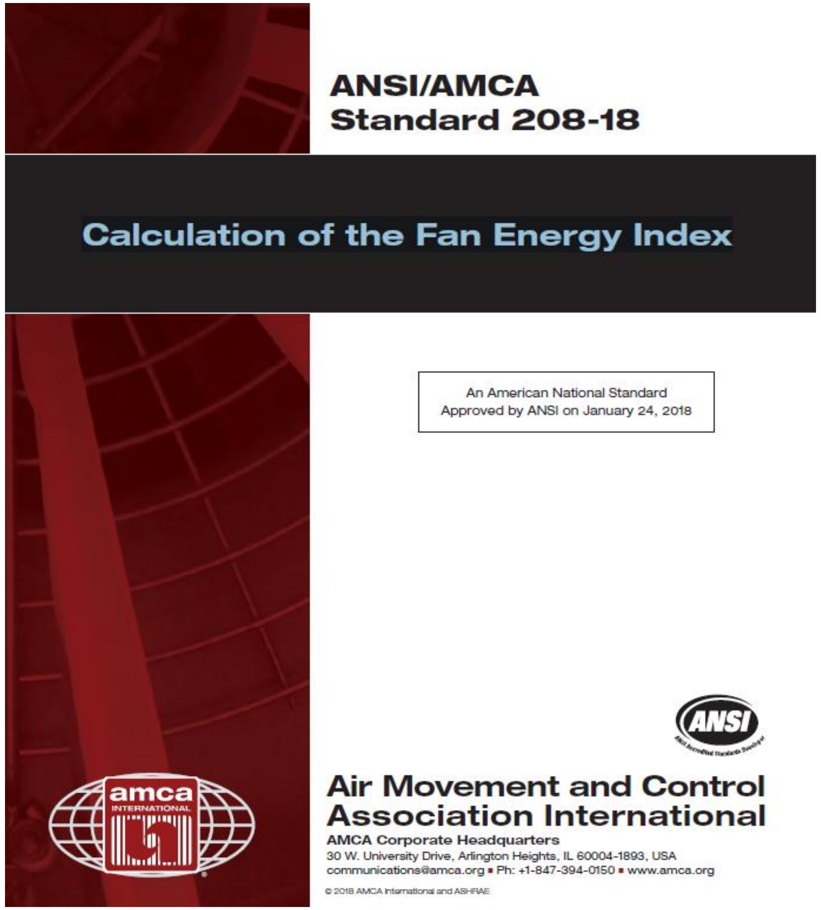
Calculate Budget Power Input (continued)

Step 2: Calculate the belt-drive transmission efficiency ($\eta_{trans,budget}$)

- Inputs: bhp_{budget}

Step 3: Calculate the budget reference transmission horsepower input ($H_{t,budget}$)

- Inputs: ($\eta_{trans,budget}$), bhp_{budget}



Calculate Budget Power Input (continued)

Step 4: Calculate the budget motor efficiency ($\eta_{mtr,budget}$)

- Inputs: $H_{t,budget,}$ Motor efficiency constants, to represent at DOE compliant motor

Step 5: Calculate the budget fan system electrical power input (W_{budget})

- Inputs: $H_{t,budget,}$ $\eta_{mtr,budget}$

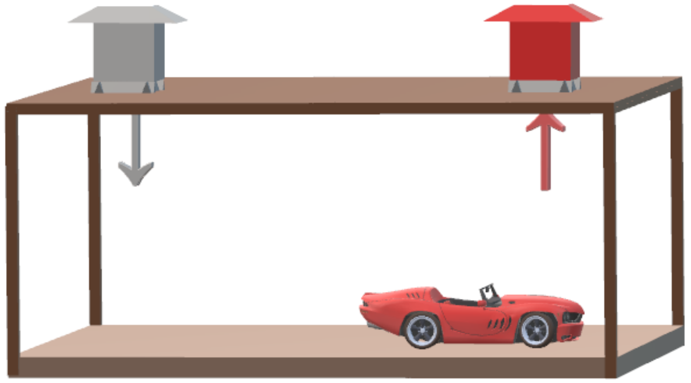


Image Source: Statewide IOU CASE Team

In Summary: Compare Budget Power Input

***Fan system input power* at *fan system design conditions* shall not exceed W_{budget}.**

- All air flows will be converted to *standard airflow*.
- When exhaust/relief fans or return fans are present, the values for supply fan systems, exhaust/relief fan systems and return air systems shall be calculated separately.
- The pressure loss values in Table 140.4-B are only to be used to calculate this value.

Software Updates

- Current modeling capabilities
  - CBECC-COM can calculate the baseline fan power based on 2019 ACM
- Proposed modeling capabilities
  - Revise calculation method for CBECC-COM baseline fan power in 2022 ACM

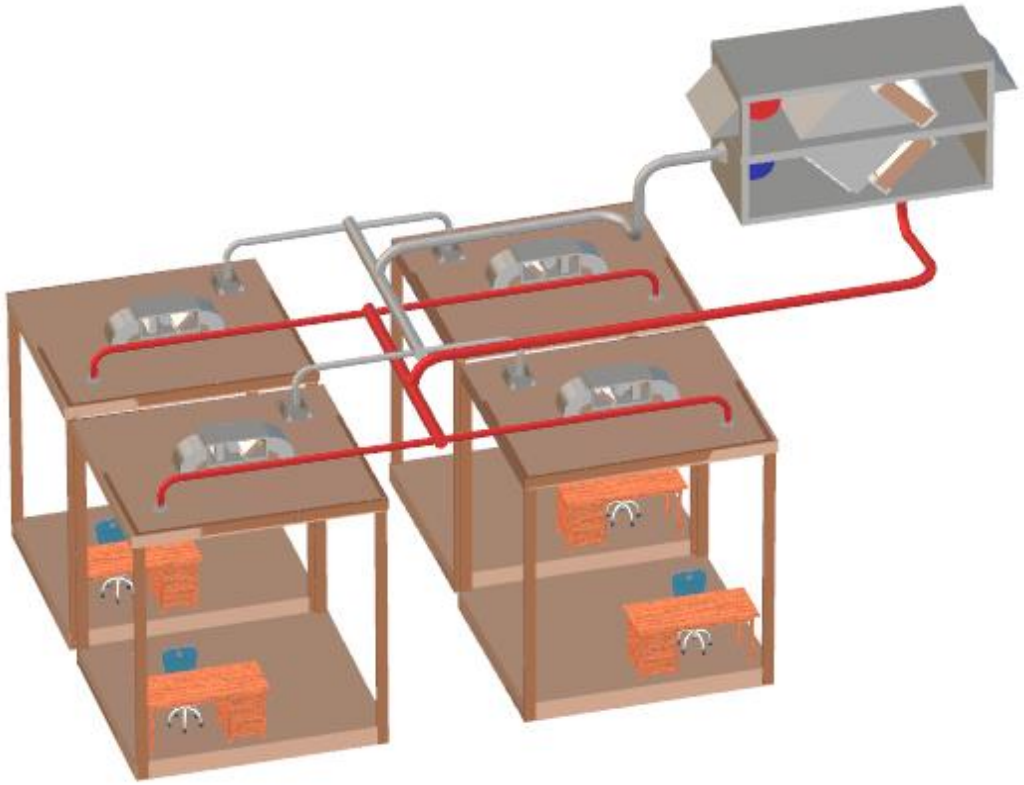


Image Source: Statewide IOU CASE Team

In Summary…

Proposed measure will:

- Make significant changes to the existing fan power limits
  - Update definitions and clarify what is a "fan system"
  - Add/ modify pressure drop adjustments
  - Address belt losses, motor losses and air density corrections
  - Create a new fan budgeting calculation method rooted in calculation of reference fan electrical input power FEP_{ref} (methodology from AMCA 208)
  - All fan systems will be allowed a "fan power budget" and must be designed to be under the budget value
- In the future, fan power limits can be further adjusted by modifying the target FEI_{budget} values, or add new system types with different target FEI values

Discussion and Next Steps

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Air Distribution

Submeasure B: Fan Energy Index (FEI)

Chad Worth, *Energy Solutions*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Background

– Fan Energy Index (FEI) evolved from DOE equipment efficiency rulemaking for commercial and industrial fans and blowers

– FEI adopted by ASHRAE 90.1 Addendum AO in August 2019

- FEI encourages more efficient fan selections

– CA also pursuing FEI as an appliance standard through Title 20 rulemaking process, with potentially broader scope

Code Change Proposal – Summary

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Air Distribution	Prescriptive	TBD

Types of Nonresidential Building Impacted

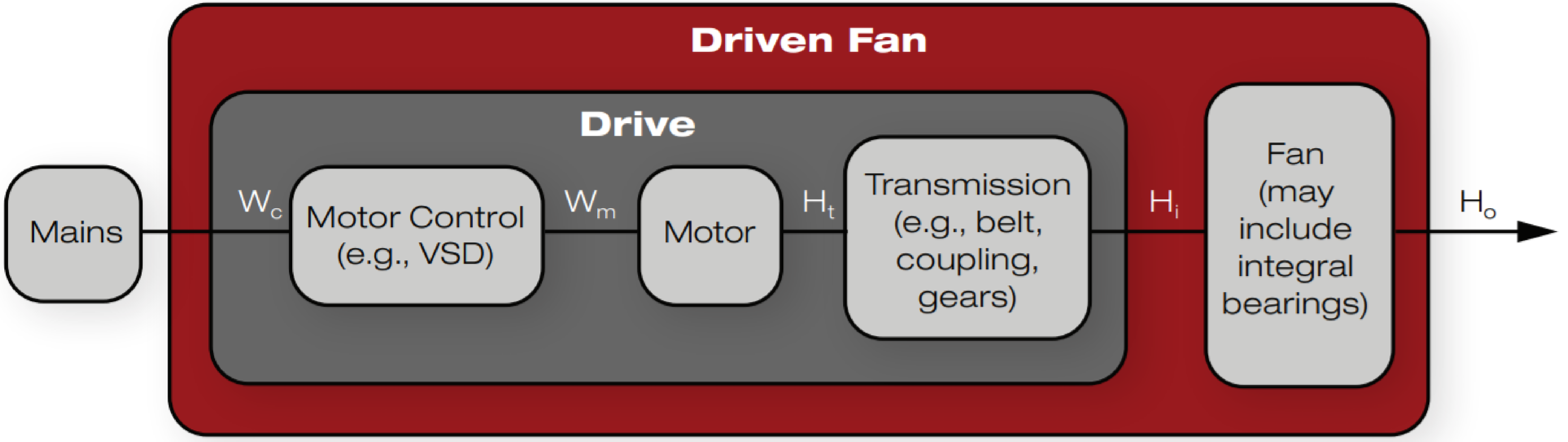
- Schools
- Large Office
- Restaurants
- Small Offices
- Etc.

Source: https://www.greenheck.com/products/air-movement/fans/vane-axial-fans

Context and History

- Why are we proposing this measure?
  - Fan power limits have been the primary mechanism to encourage efficient fans for decades
  - ASHRAE 90.1 recently adopted FEI and there is a desire to harmonize with Title 24
  - Significant savings opportunity, to ensure most fans (not in packaged equipment) are selected closer to their peak efficiency
- FEI encourages more efficient fan selection
  - FEI is a wire-to-air metric that encapsulates motor, transmission loses and is a function of airflow (CFM) and pressure (in wg)
  - FEI is the ratio of Fan Electrical Power (FEP) of an actual fan, compared to that of a reference fan at the same duty point.
  - The higher the FEI the more energy efficient
    - For example, a fan that has an FEI of 1.1 is 10% more efficient than a fan with an FEI of 1.0

FEI: A Wire to Air Metric



W shall designate electrical input power, the product of voltage and current, and, in the case of an AC circuit, power factor

H shall designate mechanical power, the product of torque and shaft speed when considering input power

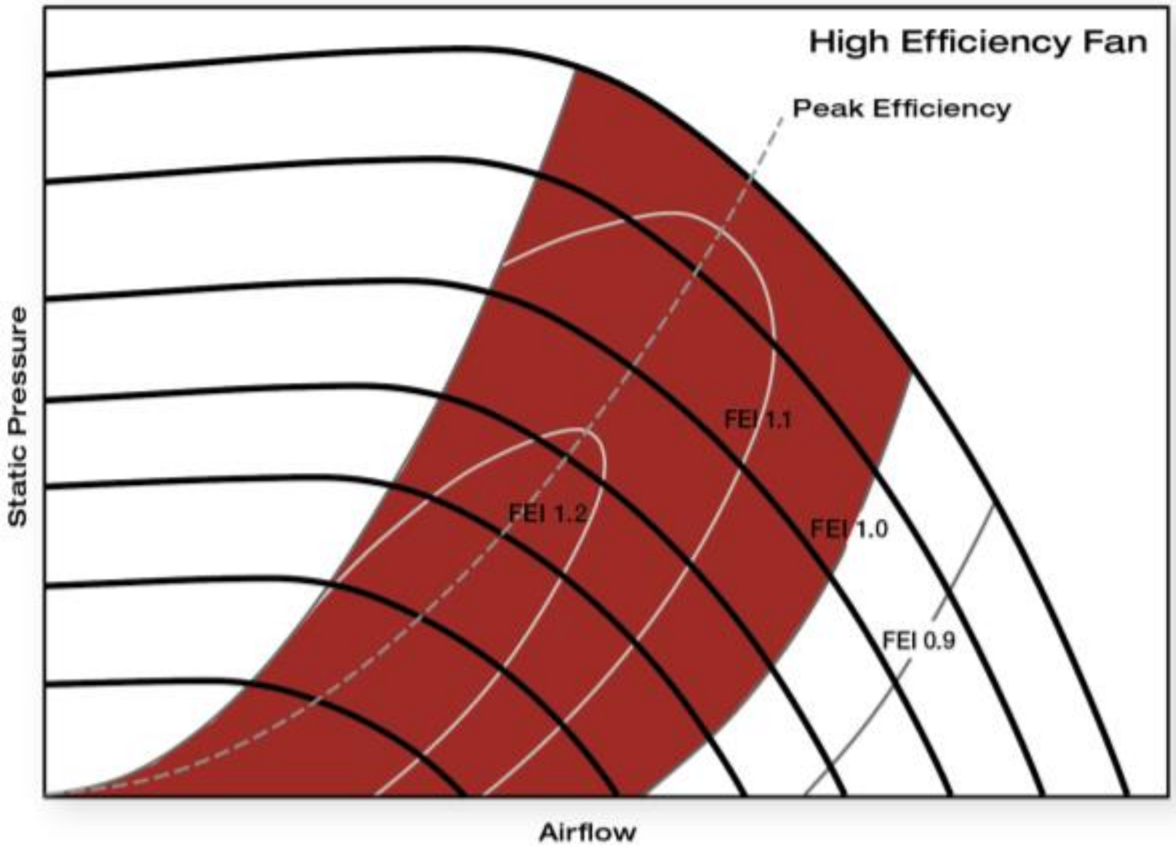
Source: https://www.amca.org/assets/resources/public/documents/Introducing%20the%20Fan%20Energy%20Index%20Metric.pdf

Fan Energy Index

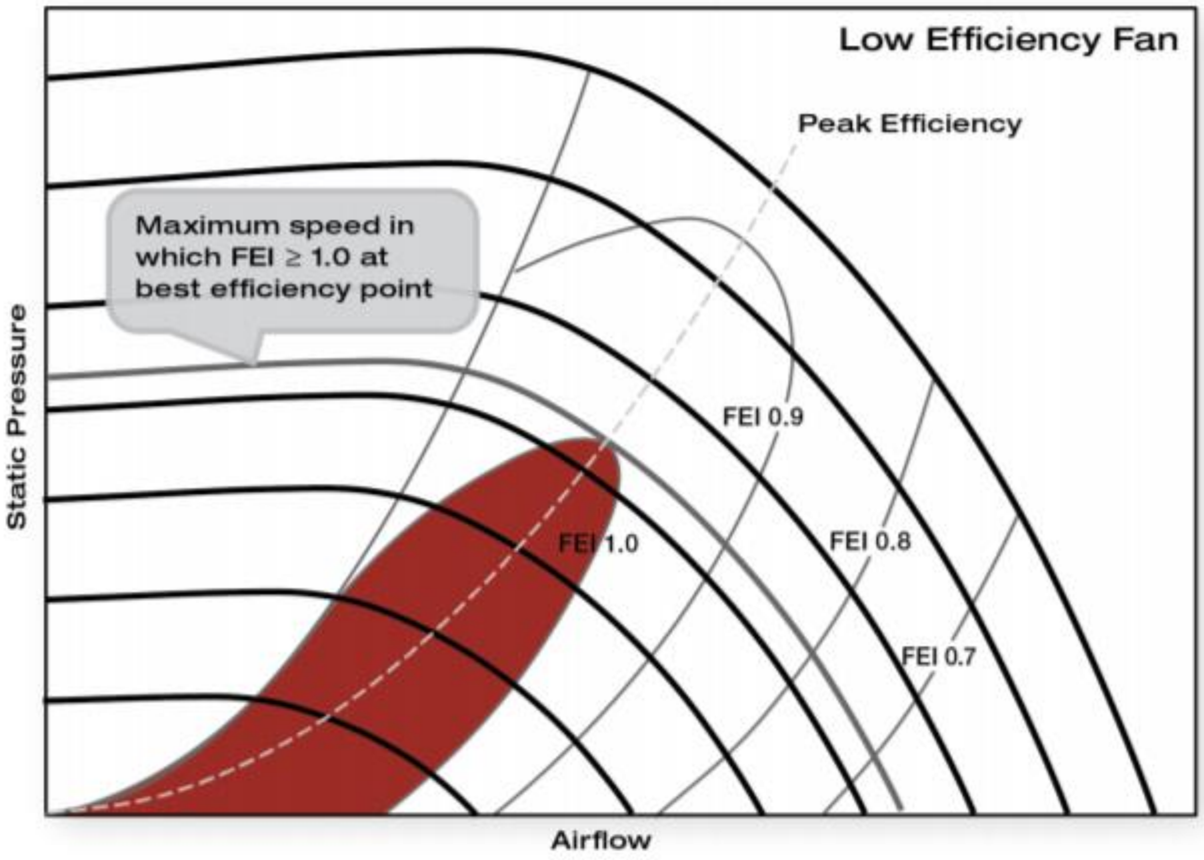
$$\text{FEI} = \frac{\text{Baseline Fan Electrical Input Power}}{\text{Fan Electrical Input Power}}$$

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

About FEI "Bubbles"



EFFICIENT FAN



INEFFICIENT FAN

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

FEI and Fan Tables

CFM	1 in. wg			2 in. wg			3 in. wg			4 in. wg			5 in. wg			6 in. wg		
	RPM	BHP	FEI	RPM	BHP	FEI	RPM	BHP	FEI	RPM	BHP	FEI	RPM	BHP	FEI	RPM	BHP	FEI
6000	830	1.39	1.65	1051	2.79	1.41												
7000	900	1.72	1.55	1092	3.18	1.44	1267	4.83	1.34									
8000	979	2.14	1.41	1142	3.64	1.43	1306	5.41	1.36	1458	7.34	1.30						
9000	1064	2.66	1.28	1209	4.28	1.36	1358	6.13	1.35	1499	8.15	1.31	1633	10.3	1.27			
10000	1152	3.28	1.15	1280	4.95	1.30	1411	6.86	1.34	1550	9.11	1.30	1674	11.3	1.28	1798	13.8	1.25
11000	1242	3.98	1.04	1359	5.79	1.22	1479	7.84	1.28	1597	10.0	1.31	1722	12.5	1.28	1835	14.9	1.27
12000	1336	4.82	0.94	1441	6.73	1.15	1549	8.82	1.24	1660	11.1	1.27	1770	13.6	1.28	1883	16.3	1.26
13000	1431	5.80	0.84	1528	7.86	1.06	1627	10.1	1.18	1728	12.4	1.23	1828	14.9	1.26	1932	17.6	1.26
14000	1527	6.94	0.76	1617	9.09	0.99	1707	11.3	1.12	1799	13.8	1.19	1897	16.6	1.22	1987	19.1	1.25
15000	1625	8.23	0.68	1706	10.4	0.92	1791	12.8	1.06	1878	15.5	1.14	1964	18.1	1.20	2054	21.1	1.21
16000	1724	9.68	0.62	1798	12.0	0.86	1879	14.6	1.00	1957	17.2	1.09	2038	20.0	1.16			
17000	1823	11.3	0.56	1892	13.7	0.80	1967	16.4	0.94	2041	19.1	1.04						
18000	1923	13.1	0.51	1986	15.6	0.74	2056	18.4	0.89									

Selections highlighted in gray indicate FEI ≥ 1.0

Non-highlighted selections indicate FEI < 1.0

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

More on FEI

- Encourages better fan selection closer to a fan's peak efficiency.
  - Higher FEI values can often be achieved with more efficient fan designs, or selecting a larger diameter fans at a slower speed
- Designers must size and select fans such that the nominal design point is greater than the minimum FEI requirement in Title 24 Part 6.
  - Manufacturers' software will display FEI at given operating conditions (airflow, pressure, air density)
  - AMCA Certified Ratings Program is currently certifying catalogs and software selection tools
- Few fan models will be eliminated from market
  - Fans with larger compliance bubbles will have broader applications, and achieve more market share.

Current Code Requirements

Title 24, Part 6	Fan Appliance Standards	ASHRAE
Section 140.4 • Fan power limits for fan systems greater than 5 HP Fan Power Limits have been primary energy saving mechanism to limit fan power, though it has its limitations. (See previous measure)	**Title 20** • Proposal at the Energy Commission to regulate commercial and industrial fans and blowers **Department of Energy** • Started exploring fan standards in 2011, though work paused after the publication of the Notice of Data Availability III in 2016	**90.1 Addendum AO** • Adopted FEI 1.0, except FEI of 0.95 for VAV fans **189.1 Proposal** • FEI of 1.1, except FEI of 1.05 for VAV fans

Proposed Code Change Overview

- The Statewide CASE team is considering similar proposal to ASHRAE Addendum AO in 90.1 and 189.1 with the following potential modifications:
  - A widening of the scope to cover more fans
    - Such as including certain air handlers
  - Higher/different FEI levels for fans of different applications
    - Considering ASHRAE Standard 189.1 proposal of FEI of 1.1
    - Or even higher, with an FEI of 1.2?

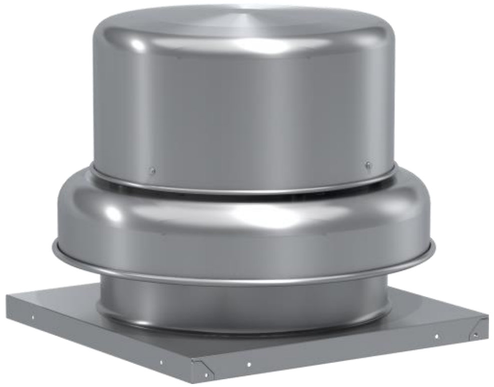


Image Source: https://www.greenheck.com/products/air-movement/fans/centrifugal-downblast-exhaust-fans

Code Change Proposal – Summary

Building Types	Nonresidential
System Type	Air distribution
Type of Change	Prescriptive
Software Updates Required	TBD

All in-scope fans required to have an FEI >1.X, or X.X for VAV fans.

Market Overview

- Current Market
- Trends
- Barriers

Market Overview and Analysis

- Current Market
  - ~55,000 fan products are sold per year in CA (new construction and replacement) under 90.1 scope according to DOE rulemaking data
  - Fan industry is a mature market and the distribution channels are well established
    - Energy saving opportunity lies in better selection and application of fans, not aerodynamic efficiency
  - There have not been utility programs/ incentives for commercial and industrial fans
- Market Trends
  - Based on preliminary research and modeling, many fans in new buildings have FEI >1.0 due to existing fan power limit standard in the building code, so this measure will especially drive efficiency where duct-runs are short. (e.g. exhaust fans)
- Market barriers
  - New metric, new education needed for plan examiners, designers and mechanical contractors
  - In certain case larger fans could needed, requiring more mechanical room space or larger roof footprints
- **Do you agree with this description? What else should we know?**

History of fan regulations

- Fan power limits have been in building code since the early 1990s
  - Regulates fan brake horsepower/nameplate horsepower as a function of airflow w/ pressure adjustments
  - Limits can be met with more efficient fan, or better duct design with lower pressure losses
- Fan Efficiency Grade (FEG)
  - The Fan Efficiency Grade was adopted by ASHRAE 90.1 in 2016, adopted in 17 states
  - This metric relates peak fan efficiency to impeller diameter, but industry has moved on and since removed FEG from ASHRAE 90.1, replacing it with FEI metric to drive more energy savings.
- DOE Rulemaking -> FEI
  - DOE started in 2011, led to a formal negotiated rulemaking, but stalled in 2016
  - Final document was the "Notice of Data Availability III" published in November 2016
- Energy Commission Title 20 Appliance Rulemaking
  - CA is picking up where DOE left off, exploring a rulemaking for FEI
  - Latest staff report published in July 2018

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental Costs
  - Energy Cost savings

Incremental Cost Information

- Proposal is to leverage DOE rulemaking data from 2016 from the Notice of Data Availability (NODA) III if possible
- This same data has been proposed to be used for CEC Title 20 rulemaking
- DOE incremental costs were inclusive of total installed costs
- We found the costs to be reasonable
  - DOE found simple paybacks to be 3 years or less at the FEI = 1.0 level (ASHRAE Addendum AO)
- **Do you find this approach to costs to be reasonable?**

Assumptions for Energy Impacts Analysis

- Key assumptions
  - Energy savings will be calculated for 15 years for all buildings
  - FEI not currently included in CBECC-Com, may be added, TBD
    - FEI was added to Energy Plus in 2019, providing the ability to calculated FEI for fan systems for different CEC prototype buildings, though the CASE team has identified some potential issues, leading to misrepresentations (i.e. higher FEI levels)
- DOE NODA 3 analysis unit energy savings (UES) may be used for the energy savings for different fan types
  - IOU Statewide CASE team has slightly modified and docketed these DOE values for Title 20 rulemaking

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

Methodology for Energy Impacts Analysis

- Methodology for energy and demand impacts
  - DOE NODA III data will be used to determine baseline FEI values of prototype buildings and also to model the energy savings at different FEI levels
  - The Statewide CASE Team proposes to model the following prototype buildings
    - Large office, medium office, small office, restaurant, and retail
  - Key part of analysis will be to determine which fans already have compliant FEI levels from fan power limit changes (previous measure)

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
FEI	*424 kWh/ fan**	EnergyPlus/ Spreadsheet	TBD	• All climate zones • All prototype buildings

- 424 kWh/ unit is a placeholder value based on DOE NODA III analysis for the national fan market achieving an FEI of 1.0, to give scale only, not inclusive of already compliant fans.
- Actual energy savings will differ and likely be less due to fan power limit changes.

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

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Fan sizes are minimally compliant with 2019 Code, specifically the existing Fan Power Limit requirement
- Other data sources show many fans FEI < 1.0, namely exhaust fans
- Only in-scope fans with input power >1 kW included

Proposed Conditions

- Minimally compliant with 2019 Code, specifically the existing Fan Power Limits
- Fans will meet the minimum FEI requirement at the design point, not exceed it

Initial Data and Findings

- FEI Values
  - Relief/ return/ exhaust fans have the highest savings potential according to DOE analysis
  - Fans in baseline prototype buildings, mainly VAV systems, all have FEI values greater ranging from 1.05 to 1.8 according to EnergyPlus though the CASE team believes FEI is being calculated improperly, inflating values.
  - Other fans, not included in prototype buildings, but are common, such as power roof ventilators, have lower FEI values
  - The CASE team is still considering which FEI level to propose, but is considering ASHRAE Standard 189.1 levels of FEI 1.1, maybe higher.
- DOE NODA III data showed all levels considered were cost-effective

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

Preliminary Energy Savings Estimates

Preliminary Energy Savings Estimate				
Annual per Unit Electricity Savings* (kWh/yr)	Annual per Unit Natural Gas Savings* (Therms/yr)	First Year Statewide Electricity Savings (GWh/yr)	First Year Statewide Natural Gas Savings (Million Therms/yr)	Confidence Level (high, medium, low)
424		TBD		Medium

* Savings based on per fan, from DOE NODA 3 analysis at the FEI = 1.0 level, based on national market.

Incremental Per Unit Cost

Over 30 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

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

Compliance and Enforcement

– Design

– Permit Application

– Construction

– Inspection

FEI- Compliance Verification Process

1. Design Phase

- Mechanical designers specify fans that meet the minimum FEI requirements (e.g. FEI >1.0)
- Require use AMCA (or equal third party) certified catalogs or approved selection software to determine fan FEI

2. Permit Application Phase

- Designers include FEI *(and static pressure, outlet velocity, cfm, RPM)* on fan equipment schedule and Title 24 non-residential code compliance forms
- Plans examiners can request FEI calculation as needed

FEI- Compliance Verification Process

3. Construction phase

- Fans are installed according to plans, where FEI is compliant at design point
- When fan substitutions occur, the designer should ask the contractor for a revised FEI calc output as part of the submittal process.

4. Inspection Phase

- Plan reviewers compare installation certificates with plans
- Building inspectors verifies compliance documents and documents compliance

Market Actors

Market actors involved in implementing this measure include:

- Mechanical Designers/ Contractors
- Fan manufacturers
- Energy Consultants
- Mechanical Contractors
- Plans Examiners
- Building Inspectors
- 3rd Party Database Administrator (such as AMCA)

Proposed Code Changes

– Draft Code Change Language

– Proposed Software Updates

Draft Code Change Language

Standard 140.4- Prescriptive Requirements for Space Conditioning Systems

Each fan and *fan array at fan system design conditions* shall have a *fan energy index (FEI)* of **1.00/ 1.XX** or higher. Each fan and *fan array* used for a *variable-air-volume system* shall have an *FEI* of **0.95/ X.XX** or higher *at fan system design conditions*. The *FEI* for *fan arrays* shall be calculated in accordance with AMCA 208 Annex C.

All fans and associated FEI values shall be listed in the Air Movement and Controls (or equal third party) certified catalogs or approved selection software to determine fan FEI values.

Poll

What FEI levels should the Statewide CASE Team pursue for our proposal?

A. FEI of 1.0, align with ASHRAE 90.1

B. FEI of 1.1, align with ASHRAE 189.1

C. FEI of 1.2, go beyond ASHRAE codes

Draft Code Change Language

Below are the Exemptions to FEI in ASHRAE 90.1 the IOU Statewide CASE team is considering:

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.

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.

Embedded fans that are part of equipment listed under Section 110.2 (Mandatory Requirements for Space Conditioning Equipment)

Embedded fans included in equipment bearing a third-party-certified seal for air or energy performance of the equipment package.

Ceiling fans, i.e., nonportable devices suspended from a ceiling or overhead structure for circulating air via the rotation of fan blades.

Fans used for moving gases at temperatures above 482°F.

Fans used for operation in explosive atmospheres.

Reversible fans used for tunnel ventilation.

Fans outside the scope of AMCA 208.

Fans that are intended to only operate during emergency conditions.

- **Should the Statewide CASE Team pursue scope of coverage than ASHRAE 90.1? If so, which exemptions should be added/ deleted?**

Software Updates

- Current modeling capabilities
  - FEI is currently available in Energy Plus, not in CBECC-Com
    - Though Statewide CASE team is still verifying modeling accuracy within the CEC prototype buildings
- Proposed modeling capabilities
  - Considering adding FEI modeling capabilities to CBECC-Com
    - Pending issues are resolved with FEI in EnergyPlus/ CEC prototype buildings

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- 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

Comments on this measure are due by November 19, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Air Distribution

Submeasure C: Expand Duct Leakage Testing

Benny Zank, *Energy Solutions*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

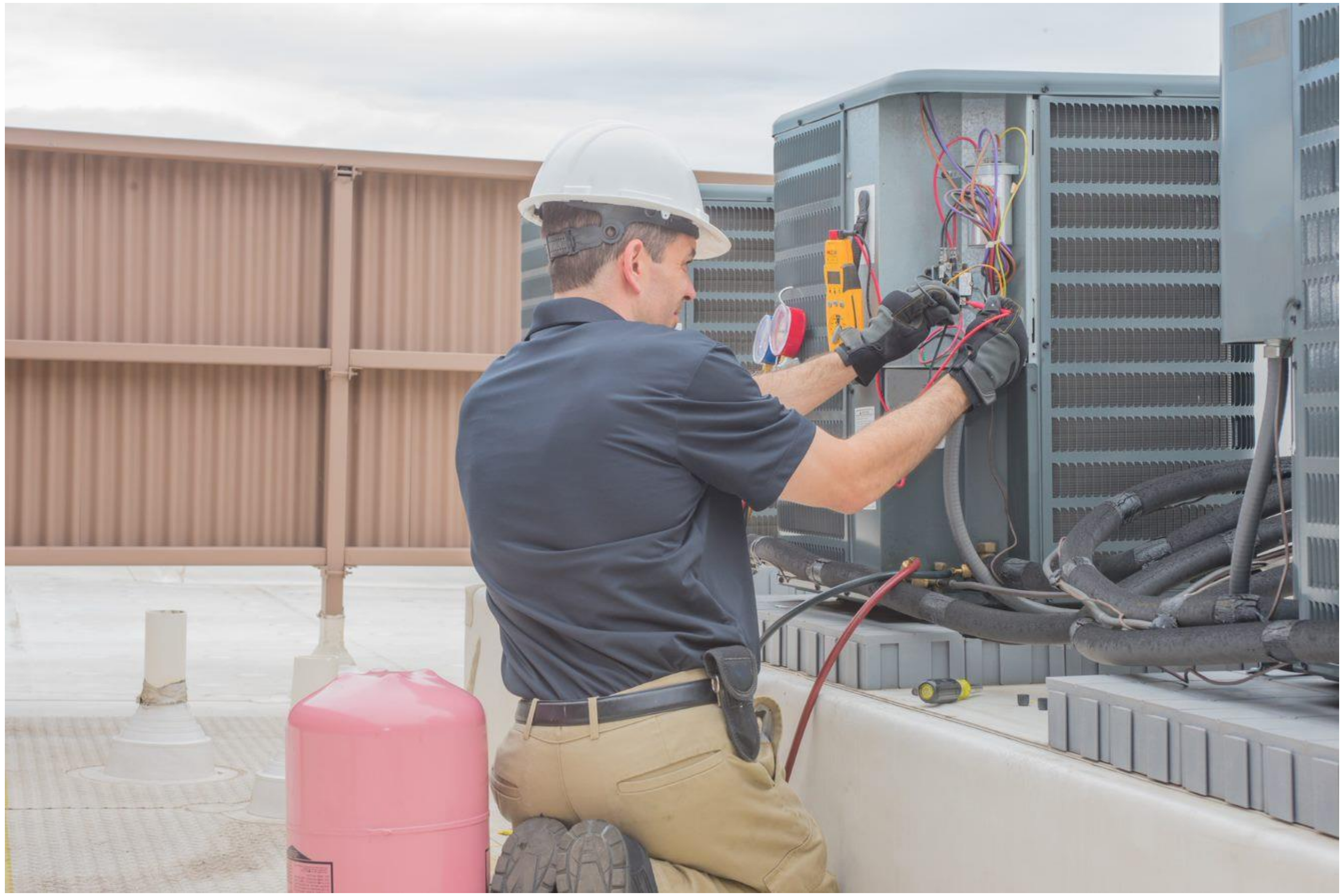
Code Change Proposal – Summary

Building Types	Construction Type	System Type	Type of Change	Software Updates Required	Compliance Updates Required
Nonresidential (all) *Duct system*	New, Additions, Alterations	HVAC	Prescriptive	Yes	Yes

- Expand maximum duct system leakage requirements to nonresidential buildings and hotels and motels with VAV supply-air systems, toilet exhaust systems, and/or general exhaust systems

Context and History

- Duct system testing requirements in Title 24, Part 6 are limited to nonresidential buildings <5000 ft^2
- The 2018 and 2021 Uniform Mechanical Code (UMC) require duct testing, as well as system Test and Balance (TAB) for all nonresidential buildings
- There is now a published standard, ASHRAE 215, and a draft standard, SMACNA System Air Leakage Test (SALT), available for review



Source: Energy Solutions

Motivation

- There are recent studies showing significant leakage downstream of VAV boxes, and significant variations in the level of leakage, supporting the need for testing
- In large commercial buildings, fans account for over 30-50% of HVAC energy use
- Fan energy use increases disproportionately with leakage, even when ducts are in semi-conditioned spaces
- In new construction there are numerous technologies and methodologies to create tight ducts

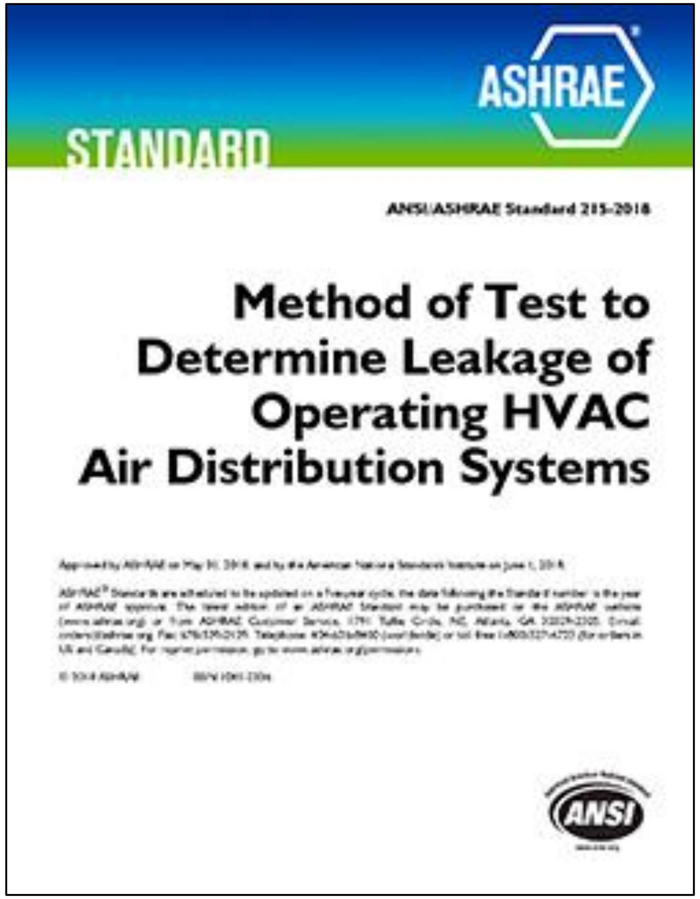
Source: Energy Solutions

Current Code Requirements

- Existing Requirements in Title 24, Part 6
  - Section 140.4(l) for new construction, Section 141.0(b)2D for alterations: Duct systems shall be sealed to a leakage rate not to exceed 6 percent of the nominal air handler airflow rate
    - Applies to constant volume, single-zone systems serving less than 5,000 ft^2 of conditioned floor area where more than 25 percent of ductwork is in unconditioned space.
- Existing Model Code Requirements
  - Duct testing (603.10.1) and TAB (407.3.1) are required for all non-residential buildings by the 2019 CA Mechanical Codes (CMC)

Overview of ASHRAE 215

- Method of test to determine leakage of operating HVAC systems
  - Measure supply or exhaust fan airflow
  - Measure flow at each supply or exhaust grille
  - Measure air temperature and relative humidity, and identify altitude
  - Use ASHRAE spreadsheet to calculate leakage



Overview of SMACNA SALT Manual

- Method of test to determine leakage of operating HVAC systems
  - Test subsystems and representative samples during construction process
  - Fan pressurization test
    - Install fan to section of ductwork
    - Temporarily seal all other intentional openings
    - Use the fan to pressurize system to test pressure
    - Measure cfm leakage/min, based on airflow needed to maintain test pressure
    - Isolated item test for inline equipment and accessories

Proposed Code Change Overview

- Draft code language for this sub-measure is available in the **resources tab**
  - Applies to: VAV supply-air systems with ceiling plenum returns; toilet and general exhaust systems
  - VAV systems shall leak no more than 4 percent upstream and 4 percent downstream of VAV boxes.
  - Exhaust systems shall leak no more than 6 percent
  - Seal Class A required for all ductwork
    - All transverse joints, longitudinal seams and duct wall penetrations to be sealed
  - For VAV systems: 100% testing by the SALT method during construction **or**
    - Testing according to California Mechanical Code during construction and ASHRAE Standard 215 at completion
  - For exhaust systems: SALT, SMACNA Air Duct Leakage Test (DALT) Manual, or ASTM E1554
  - The CASE Team is evaluating whether to develop test criteria for leakage in components for manufacturers and having the Energy Commission maintain a database
    - Manufacturer reported leakage
    - Verification of leakage for 20% of each type of equipment/accessory by isolated inline test

Poll

Which of the two testing methodologies would you use/prefer for VAV supply-air systems with ceiling plenum returns? Please elaborate in the chat.

A) 100% Testing by the SALT method during construction with isolated inline testing of at least 20% of accessories and equipment

B) Testing per the CMC during construction and using ASHRAE 215 at completion

C) Not sure

Market Overview

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

Market Overview and Analysis

- Current Market
  - Industry was active in developing ASHRAE Standard 215 and SMACNA SALT
  - Test, Adjust, and Balance (TAB) contractors test nonresidential duct systems
- Market Trends
  - Voluntary duct system leakage testing and sealing in existing buildings is being carried out, often through Energy Service Companies (ESCOs), as part of energy savings retro fit work
  - Duct leakage system testing will be required as of Jan. 1, 2020 by the 2019 CMC.
    - This will be done according to the 2019 SMACNA Air Duct Leakage Test (DALT)
      - Does not include equipment and accessories
- **Do you agree with this description? What else should we know?**

Market Barriers

- Duct construction contractors are not accustomed to sealing to below a maximum leakage after VAV boxes – Seal Class A is now commonly used for all ductwork regardless of pressure
- Cost of system testing – possibly conducted in conjunction with TAB. Any cost increases would be offset by energy savings from lower leakage rates.
- Training for testers – need to confirm that technicians and contractors can conduct test in a variety of buildings. ATTCP alternative to HERS for duct leakage testing already exists in NA1.9. TAB technicians already make most of these measurements.
- Enforcement by local building officials – officials are familiar with enforcing the requirement with commercial buildings where leakage testing is required

- **Do you agree with this description? What else should we know?**

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Sealing can be achieved with traditional construction and sealing technologies and methodologies (e.g. gasketed fittings, mastic sealants)
- Existing data shows that ducts in buildings larger than 5,000 ft^2 have significant leakage
- Designers and contractors will need to specify levels of allowed leakage for ducts and accessories and specify required testing and documentation
- Equipment and accessories will need to meet leakage specifications
- Value of sealing and cost of testing will vary between building types

Technical Barriers and Potential Solutions

  - Lack of familiarity and competence with new test procedures – active airflow measurements for ASHRAE 215 are already made by TAB technicians and the calculations are laid out in the standard. Technicians are familiar with fan pressurization testing. SALT is an extension of DALT and contractors should be familiar.

- **Do you agree with this description? What else should we know?**

Energy and Cost Impacts
Methodology and Assumptions

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

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
Expand Duct Leakage Testing	TBD	EnergyPlus and Spreadsheet	Yes	• All climate zones • All prototype buildings

Definition of Baseline and Proposed Conditions

Baseline Conditions

- 8,760 hrs/yr simulation period
- 10-12.5% leakage upstream of VAV
- 10-12.5% leakage downstream of VAV

Proposed Conditions

- 8,760 hrs/yr simulation period
- 4% leakage upstream
- 4% leakage downstream

Incremental Cost Information

- Incremental costs include installing tighter duct work, duct sealing, testing, and verification
- How will we collect costs?
  - RS Means
  - Interviews with HERS Raters, TABB, NEBB, AABC, ATTCP on the costs of testing
  - Interviews SMACNA, designers, contractors, sheet metal union, and inspection technicians on cost of installing tighter duct work and duct sealing
  - Costs will be reduced as project teams become familiar with testing procedures.
- **What components of costs did we leave out?**
- **Do you find these cost sources to be reasonable?**

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Project team develops details and specifications for tight ducts and accessories
- Required testing and documentation of results is specified

2. Permit Application Phase

- Project team submits design documents showing specifications and sealing materials
- Maximum leakage rates included in energy compliance documentation

Compliance Verification Process

3. Construction phase

- Tighter ducts are installed and duct sealing is carried out
- Tighter components are installed
- Installation and verification is documented with compliance documentation
- Duct pressurization testing occurs during construction and after the duct system and components are completely installed

4. Inspection Phase

- ATT or TAB technician conducts leakage test, verifies it does not exceed allowed limit
- Code official confirms leakage results are submitted and meet requirement

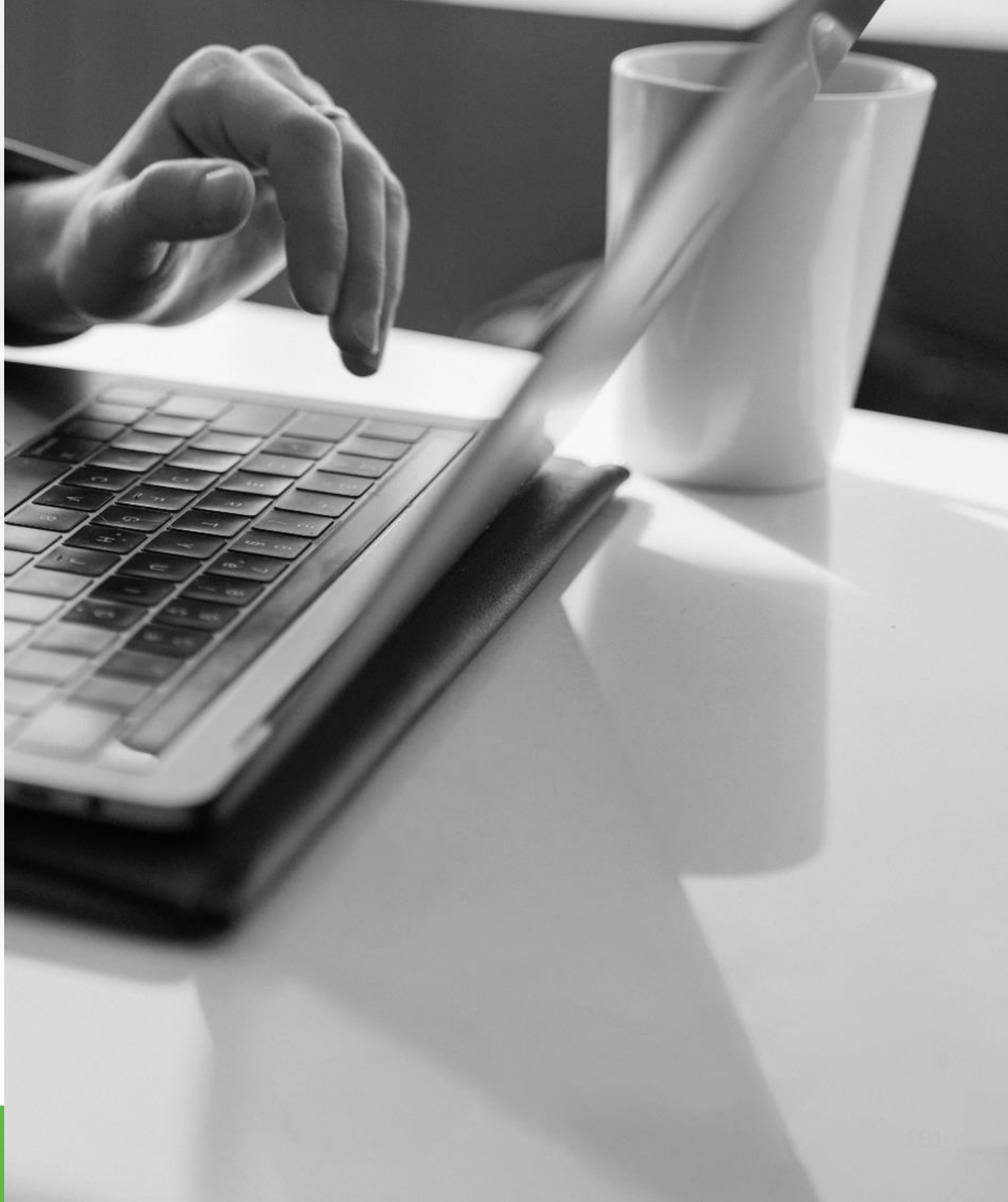
Market Actors

Market actors involved in implementing this measure include:

- Mechanical designers and contractors: develop and implement duct and component installation and sealing plan
- ATT, TAB contractor, HERS Rater, or other test entity: conducts sealing test
- Code official: reviews duct system air leakage test results

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**

- **How do stakeholders view this proposal?**

Software Updates

- Current modeling capabilities
  - Duct leakage cannot be modeled in CBECC-Com
- Proposed modeling capabilities
  - Energy losses from duct leakage, which are available in EnergyPlus, need to be added to CBECC-Com

Discussion and Next Steps

EnergyCode Ace™
Helping you play your cards right

Comply With Me

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

www.EnergyCodeAce.com

offers **No-Cost**

Tools ♠ Training ♠ Resources

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

SDGE — A Sempra Energy utility®
SoCalGas — A Sempra Energy utility®
Southern California EDISON® — An EDISON INTERNATIONAL® Company
PG&E — Pacific Gas and Electric Company®

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.

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- 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

Comments on this measure are due by November 19, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

Chad Worth, *Energy Solutions*
cworth@energy-solution.com

Benny Zank, Energy Solutions
bzank@energy-solution.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Extra Slides

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2019 Code Requirements

- 2019 Requirements in Title 24 Part 6 (Motor Nameplate Limit)
  - Section 140.4 – Prescriptive Requirements For Space Conditioning Systems

(c) **Fan Systems.** Each fan system having a total fan system motor nameplate horsepower exceeding 5 hp used for space conditioning shall meet the requirements of Items 1, 2, and 3 below. Total fan system power demand equals the sum of the power demand of 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.

1. **Fan Power Limitation.** At design conditions each fan system shall not exceed the allowable fan system power of option 1 or 2 as specified in Table 140.4-A

TABLE 140.4 - A Fan Power Limitation

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate hp	Allowable motor nameplate hp	$hp \le cfm_s \times 0.0011$	$hp \le cfm_s \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \le cfm_s \times 0.00094 + A$	$bhp \le cfm_s \times 0.0013 + A$

[1]cfm_s = maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute

hp = maximum combined motor nameplate horsepower for all fans in the system

bhp = maximum combined fan-brake horsepower for all fans in the system

A = sum of (PD x cfm_D/4131)

PD = each applicable pressure drop adjustment from Table 140.4 – B, in inches of water

cfm_D = the design airflow through each applicable device from Table 140.4 – B, in cubic feet per minute

- Motor nameplate option intended for simple compliance.
- Simple systems – no allowance for additional pressure drops for higher filtration, ducted return, etc.
- hp/cfm is higher than BHP method (option 2) to allow for belt loss and some motor oversizing.
- Generous to systems with no heating coil, air blender.

2019 Code Requirements

- 2019 Requirements in 2019 Nonresidential ACM
  - 5.7.3.2 Supply Fans – Supply Fan Brake Horsepower

For healthcare facilities, same as the Proposed Design.

For FPFC and heating and ventilation systems, not applicable.

For laboratory systems where the building lab design exhaust flow is greater than 10,000 cfm, a separate exhaust fan power allowance is given, and the entire fan power budget can be allocated to the supply fan:

VAV Supply Fan BHP = (0.0013 x cfmmax + A)

CAV Supply Fan BHP = (0.00094 x cfmmax + A)

For PVAV and built-up VAV systems:

Supply Fan BHP = (0.0013 x cfmmax + A) x Supply Fan Ratio,

For other systems,

Supply Fan BHP = (0.00094 x cfm + A) x SupplyFanRatio, where

cfm = the design supply air flow, and

A = the fan power adjustment (see separate building descriptor)

SupplyFanRatio is the ratio of supply fan brake horse power at design conditions to total system brake horsepower at design conditions

Table 11: Minimum Nominal Efficiency for Electric Motors (Percent)

Motor Horse Power	Efficiency (%)
1	85.5
1.5	86.5
2	86.5
3	89.5
5	89.5
7.5	91.7
10	91.7
15	92.4
20	93.0
25	93.6
30	93.6
40	94.1
50	94.5
60	95.0
75	95.4
100	95.4
125	95.4
150	95.8
200	96.2
250	96.2
300	96.2
350	96.2
400	96.2
450	96.2
500	96.2

Compare to 2016 ACM

Supply Fan Static Pressure	
Applicability	All fan systems using the static pressure method
Definition	The design static pressure for the supply fan. This is important for both fan electric energy usage and duct heat gain calculations.
Units	Inches of water column (in. H_20)
Input Restrictions	As designed The design static pressure for the supply fan does not need to be specified if the supply fan brake horsepower (bhp) is specified.
Standard Design	The standard design for all systems except four-pipe fan coil (FPFC) and PTAC is defined by the following table: (see table below) An additional pressure drop allowance is available for special filtration requirements only for specific processes such as clean rooms. See process and filtration pressure drop for details. Not applicable for the four-pipe fan coil system.

Airflow	Single zone, six stories or less	Multiple zone, less than six stories	Multiple zone, greater than six stories
<2000 cfm	2.5"	3.0"	3.5"
2000 cfm – 10,000 cfm	3.0"	3.5"	4.0"
>10,000 cfm	3.5"	4.0"	4.5"

- 2016 ACM had stricter base pressure drop basis than the current prescriptive limits
- No allowance for additional pressure drops for MERV-13 filters, energy recovery, etc
- This table was removed in the 2019 version
- 2019 was a step forward in prescriptive and a step back in the ACM

2019 Code Requirements

- Existing Requirements in ASHRAE 90.1-2016
  - 6.5.3.1 Fan System Power and Efficiency

6.5.3 Air System Design and Control

6.5.3.1 Fan System Power and Efficiency

6.5.3.1.1

Each *HVAC system* having a total *fan system motor nameplate horsepower* exceeding 5 hp at *fan system design conditions* shall not exceed the allowable *fan system motor nameplate horsepower* (Option 1) or fan *system* bhp (Option 2) as shown in Table 6.5.3.1-1. This includes supply fans, return/relief fans, exhaust fans, and fan-powered *terminal* units associated with *systems* providing heating or cooling capability that operate at *fan system design conditions*. Single-zone *VAV systems* shall comply with the constant-volume fan power limitation.

Exceptions to 6.5.3.1.1

1. Hospital, vivarium, and laboratory *systems* that use flow *control devices* on exhaust and/or return to maintain *space* pressure relationships necessary for occupant health and safety or environmental *control* may use variable-volume fan power limitation.
2. Individual exhaust fans with motor *nameplate horsepower* of 1 hp or less.

2019 Code Requirements

- Existing Requirements in ASHRAE 90.1-2016
  - 6.5.3.1 Fan System Power and Efficiency

Table 6.5.3.1-1 Fan Power Limitation[a]

	Limit	Constant Volume	Variable Volume
Option 1: Fan *system* motor nameplate hp	Allowable *motor nameplate hp*	$hp \leq cfm_S \times 0.0011$	$hp \leq cfm_S \times 0.0015$
Option 2: Fan *system* bhp	Allowable fan *system* bhp	$bhp \leq cfm_S \times 0.00094 + A$	$bhp \leq cfm_S \times 0.0013 + A$

a. where

cfm_S = maximum design supply airflow rate to *conditioned spaces* served by the *system* in cubic feet per minute
hp = maximum combined motor *nameplate horsepower*
bhp = maximum combined fan-brake horsepower
A = sum of $(PD \times cfm_D/4131)$
where
PD = each applicable pressure drop adjustment from Table 6.5.3.1-2 in in. of water
cfm_D = the design airflow through each applicable device from Table 6.5.3.1-2 in cubic feet per minute

2019 Code Requirements

- Existing Requirements in ASHRAE 90.1-2016
  - 6.5.3.1 Fan System Power and Efficiency

Table 6.5.3.1-2 Fan Power Limitation Pressure Drop Adjustment

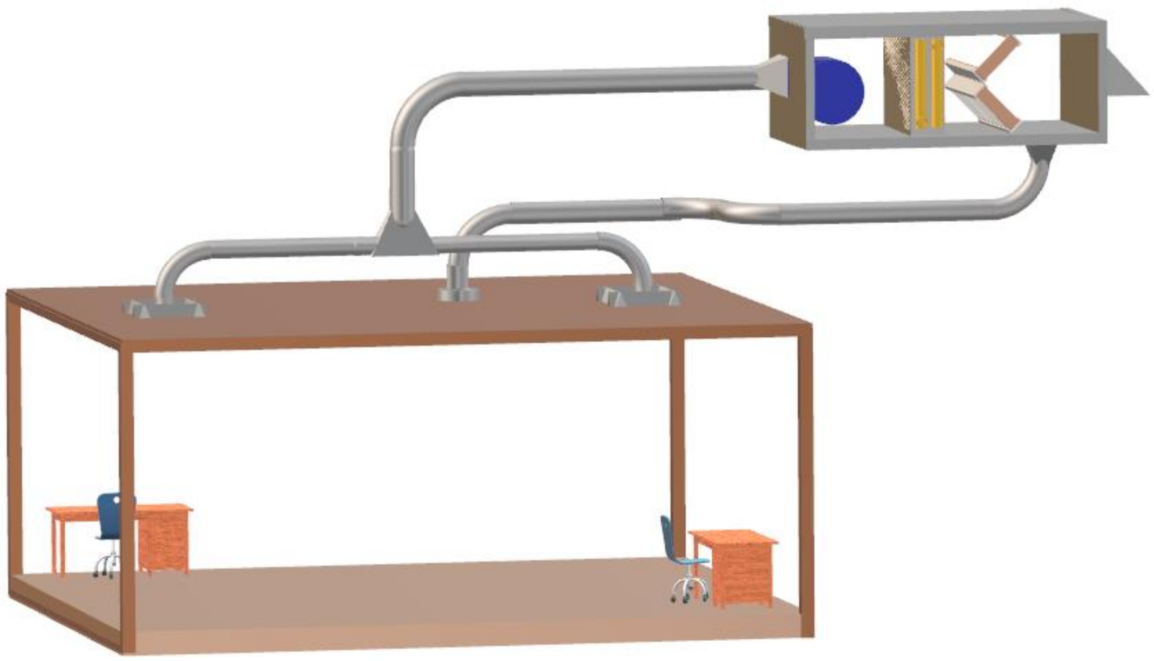
Device	Adjustment
Credits	
Return or exhaust *systems* required by code or accreditation standards to be fully ducted, or *systems* required to maintain air pressure differentials between adjacent rooms.	0.5 in. of water (2.15 in. of water for laboratory and vivarium *systems*)
Return and/or exhaust airflow *control devices*	0.5 in. of water
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at *fan system design condition*
Particulate Filtration Credit: MERV 9 through 12	0.5 in. of water
Particulate Filtration Credit: MERV 13 through 15	0.9 in. of water
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at *fan system design condition*
Carbon and other gas-phase air cleaners	Clean filter pressure drop at *fan system design condition*
Biosafety cabinet	Pressure drop of device at *fan system design condition*
Energy recovery device, other than coil runaround loop	For each airstream [(2.2 × *Enthalpy Recovery Ratio*) – 0.5] in. of water
Coil runaround loop	0.6 in. of water for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at *fan system design condition*
Sound attenuation section (fans serving *spaces* with design background noise goals below NC35)	0.15 in. of water
Exhaust *system* serving fume hoods	0.35 in. of water
Laboratory and vivarium exhaust *systems* in high-rise *buildings*	0.25 in. of water/100 ft of vertical duct exceeding 75 ft
Deductions	
Systems without central cooling device	–0.6 in. of water
Systems without central heating device	–0.3 in. of water
Systems with central *electric resistance* heat	–0.2 in. of water

Table G3.9.1 *Performance Rating Method* Motor *Efficiency* Requirements

Motor Horsepower	Minimum Nominal Full-Load *Efficiency*, %
1.0	82.5
1.5	84.0
2.0	84.0
3.0	87.5
5.0	87.5
7.5	89.5
10.0	89.5
15.0	91.0
20.0	91.0
25.0	92.4
30.0	92.4
40.0	93.0
50.0	93.0
60.0	93.6
75.0	94.1
100.0	94.5
125.0	94.5
150.0	95.0
200.0	95.0

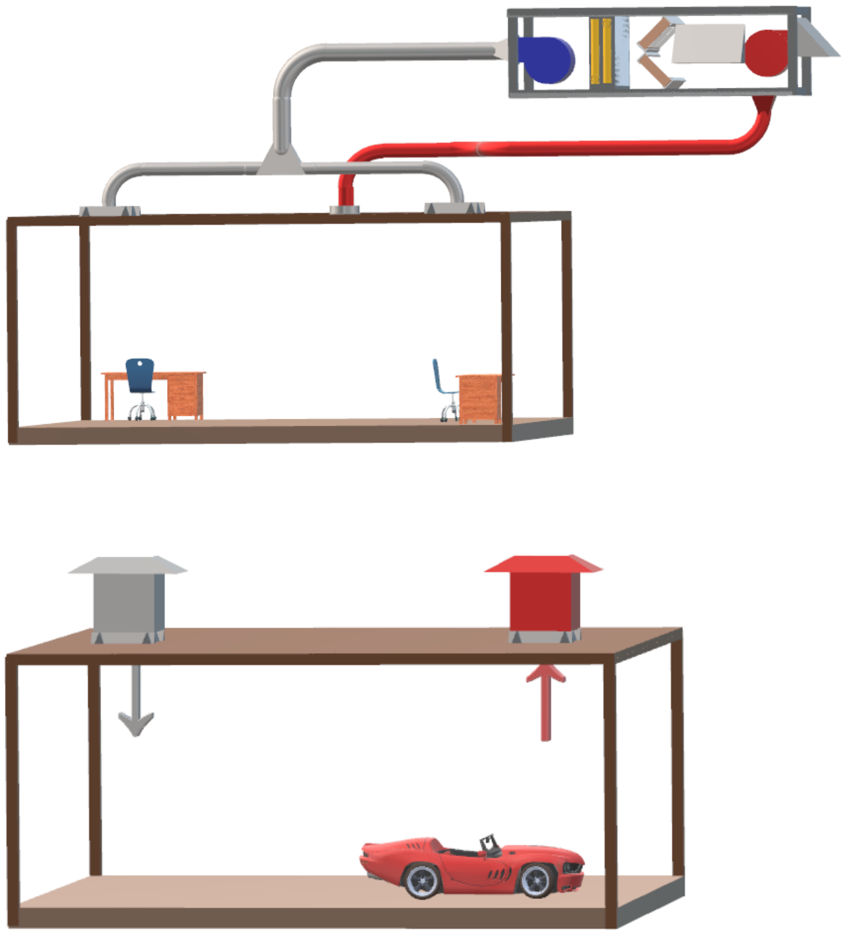
Example of Proposed Fan System – Single Fan

- Single fan or fan array to provide both supply air and recirculates the same air.
  - Credit for both supply and return duct loss.
  - Credit for only one AHU entry loss.
  - If there is no return air path, then only the supply pressure credits would apply.
  - Other systems in the same category
    - RTU with non-powered economizer.
    - Recirculation-only systems (e.g. fan coil, VRF indoor unit, zone WSHP)



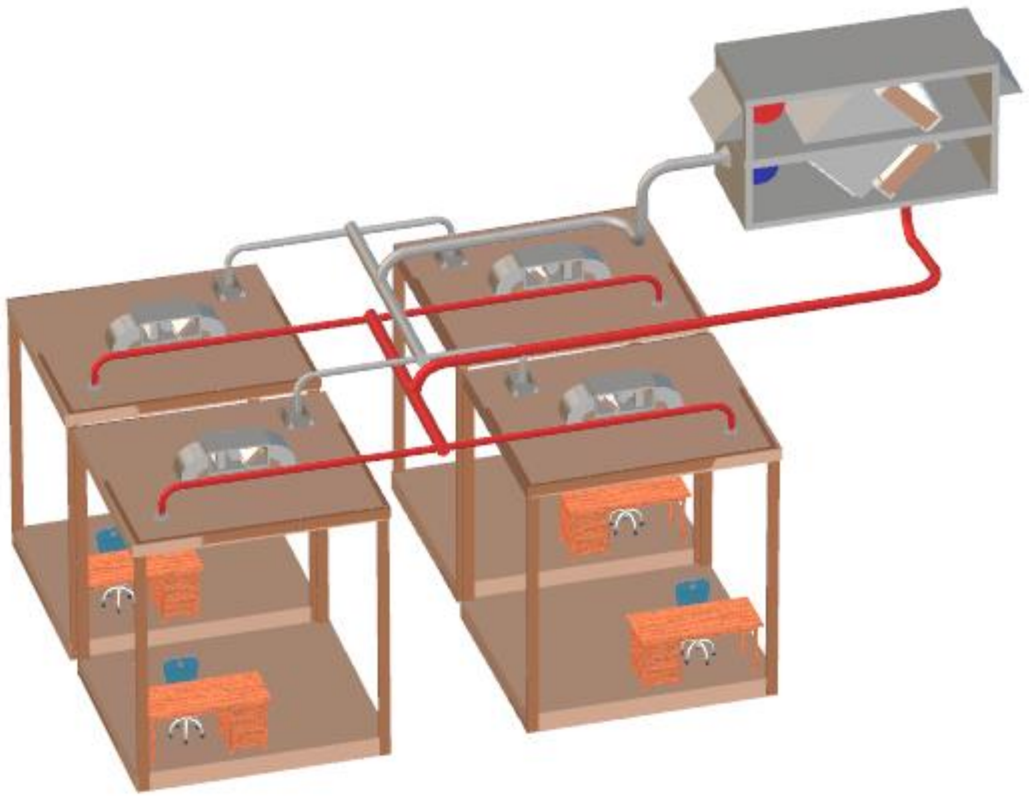
Examples of Fan Systems – Separate Supply and Exhaust

- Separate supply and exhaust air streams – fan power budget is separately calculated for each airstream.
  - Supply fan gets credit for supply duct loss, coil, filters.
  - Exhaust fan gets credit for return duct, AHU entry. If economizer, based on economizer airflow.
  - Other systems where supply and exhaust is calculated separately.
    - Units with air-to-air energy recovery.
    - Supply PRV and Exhaust PRV.
    - Kitchen make-up air unit and exhaust hood.



Example of Fan System – Multiple Units Serving Same Zone

- In this example, the zone is served by a fan coil and a DOAS unit. They do not share a common duct at any point.
  - The DOAS system will be treated as two separate fan systems – supply and exhaust - just like the previous example.
  - Each fan coil is an individual supply/return system.
  - If active chilled beams were used instead of fan coils, they would not be treated as fan systems. The power required to induce airflow is credited to the DOAS.



2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Reduced Infiltration

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Envelope

Alamelu Brooks, *Energy Solutions*

November 5, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

1	Background of Reduced Infiltration	*5 min*
2	Market Overview and Analysis	*10 min*
3	Technical Feasibility	*10 min*
4	Cost and Energy Methodology	*10 min*
5	Compliance and Enforcement	*5 min*
6	Proposed Code Changes	*5 min*
7	Discussion and Next Steps	*15 min*

Submeasure A: Air Leakage

Submeasure B: Vestibule Infiltration

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Building Types	Construction Type	System Type	Type of Change	Software Updates Required
Nonresidential buildings *Air leakage testing*	New construction, Additions	Envelope	Prescriptive	Yes

Whole building air-leakage testing will be required for nonresidential buildings and hotels and motels.

Maximum whole building air leakage is limited to 0.3 cfm/sq. ft.; no changes in the material or assembly leakage

Performance credit will be available for buildings that achieve leakage below 0.22 cfm/sq. ft.

Context and History

- There is currently no testing or verification of whole building air-leakage rates required, although it is one of three prescriptive options
- There are existing requirements for the Washington State energy code
  - In 2020 buildings in Washington State will need have less than 0.25 cfm/sq. ft.
- U.S. Army Corps of Engineers has had leakage requirements of 0.25 cfm/sq. ft. for their buildings for over 10 years
- GSA federal buildings: Tier 1 – 0.25 cfm/sq. ft., Tier 2 – 0.15 cfm/sq. ft., Tier 3 – 0.10 cfm/sq. ft.
- IECC 2021 has a mandatory testing requirement in CE97.19

https://archive.airbarrier.org/conference/ASHRAE%201478%20-%20Wagdy%20Anis.pdf?v=2014-04-10_01-18

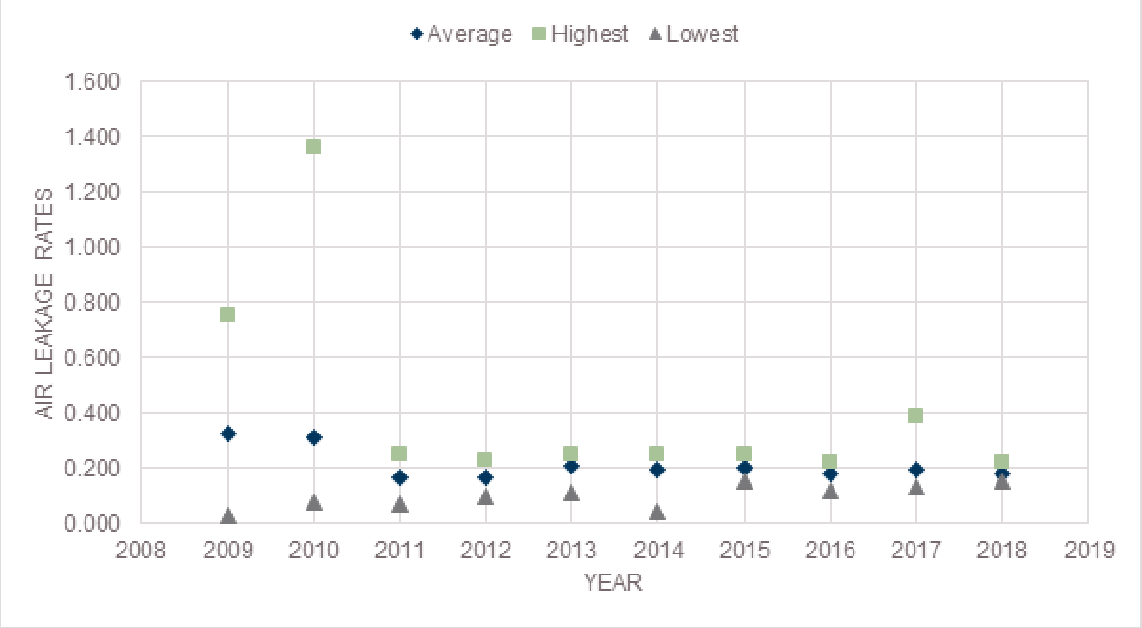
Why test?

- Studies have shown leakage rates above the allowed maximum when testing is not required
- The only way to know how much buildings are leaking is to test them. Currently there are qualitative methods to determine air leakage but they do not quantify if the building leakage measured is consistent with modeler assumptions.
- It is already common practice to test and verify the air leakage of single family homes
- The building is pressurized and then the rate at which air flows out is measured. The same test can be performed under depressurization, of which the amount of air infiltration is measured.
- Testing the whole building leakage will identify leaks to seal, and can confirm that performance is in line with assumptions.
- A tighter building is easier to heat and cool and has fewer moisture issues

Test Data From Morrison Hershfield

- Test data starting 2009 indicates that since the implementation of air leakage testing requirements, MH has observed a significant decrease in envelope air leakage of buildings

Year	AVG	Highest	Lowest
2009	0.326	0.756	0.032
2010	0.311	1.361	0.075
2011	0.163	0.250	0.070
2012	0.165	0.230	0.100
2013	0.208	0.250	0.110
2014	0.194	0.250	0.040
2015	0.202	0.250	0.150
2016	0.178	0.220	0.120
2017	0.192	0.390	0.130
2018	0.183	0.220	0.150



*data from testing of buildings tested in Washington area and Military buildings

Current Code Requirements

Title 24, Part 6	2018 Washington State Energy Code	ASHRAE 90.1 - 2019
Section 140.3(a) 9 A: Materials have an air permeance not exceeding 0.004 cfm/sq ft at 0.3 iwc or B: Assemblies have an average air leakage not exceeding 0.04 cfm/sq ft at 0.3 iwc or C: The entire building has an air leakage rate not exceeding 0.40 cfm/sq ft at 0.3 iwc	**C402.5.1.2 Building test.** The completed building shall be tested and the air leakage rate of the *building envelope* shall not exceed 0.25 cfm/ft2 at a pressure differential of 0.3 inches water gauge (2.0 L/s x m2 at 75 Pa) at the upper 95 percent confidence interval in accordance with ASTM E 779 or an equivalent method approved by the *code official*. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the building owner and the *code official*.	**5.4.3.1.1 Whole-Building Air Leakage** Whole-building pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air leakage rate of the building envelope shall not exceed 0.40 cfm/ft2 under a pressure differential of 0.3 in. of water, with this air leakage rate normalized by the sum of the above-grade and below-grade building envelope areas of the conditioned space and semiheated space.

Current Code Requirements - Failure

2018 Washington Energy Code	ASHRAE 90.1-2019
If the tested rate exceeds that defined here by up to 0.15 cfm/ft2, a visual inspection of the air barrier shall be conducted and any leaks noted shall be sealed to the extent practicable. An additional report identifying the corrective actions taken to seal air leaks shall be submitted to the building owner and the Code Official and any further requirement to meet the leakage air rate will be waived.	Where the measured air leakage rate exceeds 0.40 cfm/ft2 but does not exceed 0.60 cfm/ft2,a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the building is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner and shall be deemed to satisfy the requirements of this section.

Poll

Which air barrier compliance option is common in California?

A. Materials

B. Assembly

C. Whole building testing

D. I do not know

Poll

Did you come across any nonresidential new construction project that failed an air barrier requirement?

A. No
B. Yes
C. There is no way of knowing it
D. I do not know

Proposed Code Change Overview

- Draft code language for this submeasure is available in the **resources tab**
- Description of change (use succinct language)
  - Section 140.3(a)9 – The tested whole building leakage rate shall not exceed 0.3 cfm/sq. ft. In addition, it shall meet Option A or Option B.
  - If the tested rate exceeds 0.3 cfm/ft2 but does not exceed 0.60 cfm/ft2:
    - Diagnostic testing and visual inspection
    - Seal leaks where possible
    - Additional report on corrective action to building owner and code official

Market Overview

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

Market Overview and Analysis

- Current Market
  - Air-leakage testing is carried out for single family homes and all military buildings.
  - Local technicians have the capacity to carry out the testing and provide consulting and training to contractors.
  - It is assumed that the building air barrier material and assembly is installed exactly as required.
- Market Trends
  - Third party entities test the leakage rate of elements and assemblies but the leakage rate of the whole building is not being verified.
- **Do you agree with this description? What else should we know?**
- **Are there building certification programs that verify air leakage rates?**

Market Barriers

- Availability of testing technicians – local technicians have been performing whole building air leakage tests for the army corps of engineers buildings. A market study will help confirm availability of technicians
- Cost of testing – the test will become more affordable as it becomes a standard practice, and as testing agencies become more competitive in their estimates for deliverables.
- Cost of preparing the building – this will become more affordable as contractors become familiar with the practice
- Potential delays/overtime costs in order to accommodate scheduling of test.
- Availability of equipment – it can be rented from manufacturers to start.

- **Do you agree with this description? What else should we know?**

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

Design

- Designers should clearly identify the whole building air leakage testing requirements in plans and a checklist for envelope elements that need to be sealed
  - Contractors may not readily be able to identify envelope elements. Currently Washington state code requires that construction documents include (but are not limited to) "Air barrier details including all air barrier boundaries and associated square foot calculations on all sides of the air barrier as applicable“.
  - Designers should provide building envelope areas for the testing agency to use for air barrier calculations.

- **Do you agree with this description? What else should we know?**

Technical Considerations

Testing

- Pre-test meeting – a meeting early in construction so that contractors are aware of requirements for the testing and help coordinate preparatory work. Pre-test walks to review the progress of preparatory work also benefit the team.
- During testing – access to envelope assemblies provided to the testing agency so that qualitative review is possible.
  - This would include access via exterior boom lifts, terraces, and roofs. Testing agencies should review data to determine if leakage measured is representative given building envelope assembly type and area. If excessive leakage is observed, testing agency and construction team should review building to verify preparatory work.
- The testing should coordinated such that it is performed before interior drywall is hung so that leaks can be easily identified and repaired.

- **Do you agree with this description? What else should we know?**

Technical Barriers and Potential Solutions

Buildings may not pass the requirement the first time – it is important that there are resources to help them pass and that leaks be identified before testing.

- In-situ testing of sample sizes of wall assemblies can be performed to verify that progress installation meets the desired performance requirements. A third party consultant and testing agency can assist with construction quality control.
- Code officials should consider alternative options for post construction remediations if air leakage rate cannot be met.

- **Do you agree with this description? What else should we know?**

Energy and Cost Impacts

Methodology and Assumptions

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

Methodology for Energy Impacts Analysis

- Impacts will be characterized as the differences between the Baseline and Proposed conditions
- Using existing literature and data we will estimate a baseline infiltration rate that is more realistic
  - The baseline leakage rates of 0.6 – 0.8 cfm/ft^2 are under consideration

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- 0.60-0.80 cfm/sq ft at 0.3 iwc

Proposed Conditions

- 0.3 cfm/sq ft at 0.3 iwc

Incremental Cost Information

- Cost of testing from Seattle
  - High rise buildings in Seattle (40 stories) the cost ranges 25,000 to 40,000.
  - Mid rise buildings in Seattle (10-20 stores) the cost ranges from 15,000 to 25,000.
  - Low rise building in Seattle (3-5 stories) the cost ranges from 5,000 to 12,000.
- We are still collecting costs to prepare the building
  - Through interviews with contractors
  - Does not include coordination or other overhead cost
- **What components of costs did we leave out?**
- **Do you find these costs to be reasonable?**

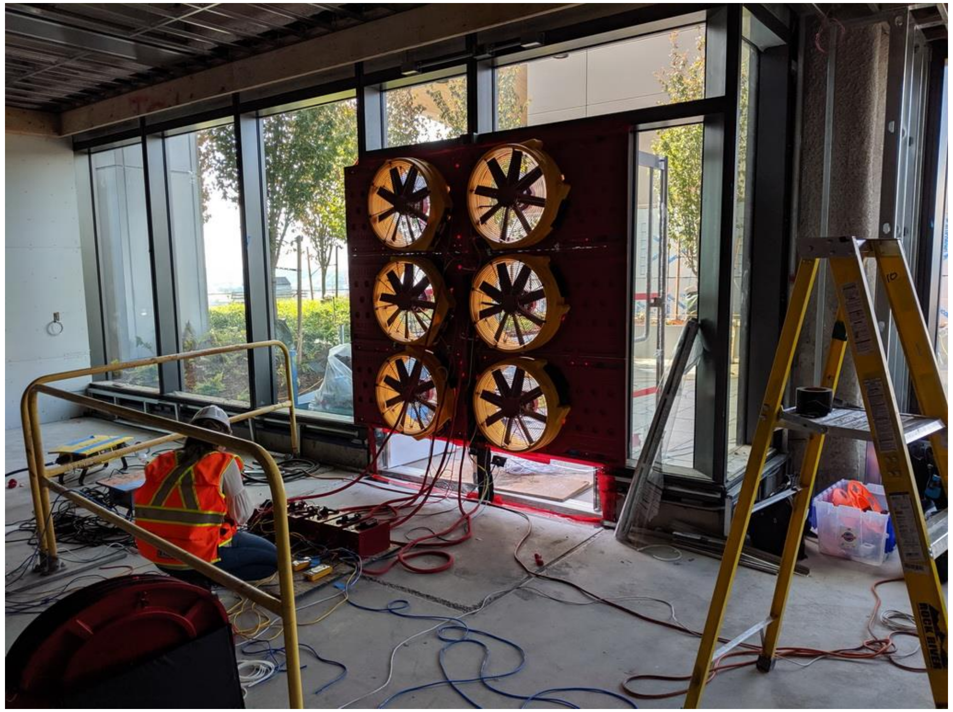
Source: Morrison Hershfield

Cost of testing in Seattle explored

Key Components of costs from testing agency include;

1) Equipment setup – assuming building envelope achieves air tightness of 0.4 CFM per square foot, one fan would be required per 7,500 square foot of building envelope area to accurately perform the test. Additional air barrier zones (retail, penthouse spaces, etc.) require additional fans.

2) Pre-test memos, meetings and walkthroughs – testing agency needs to meet with general contractor to review building preparation, and then perform walkthroughs to verify preparation is in accordance with test guidelines.

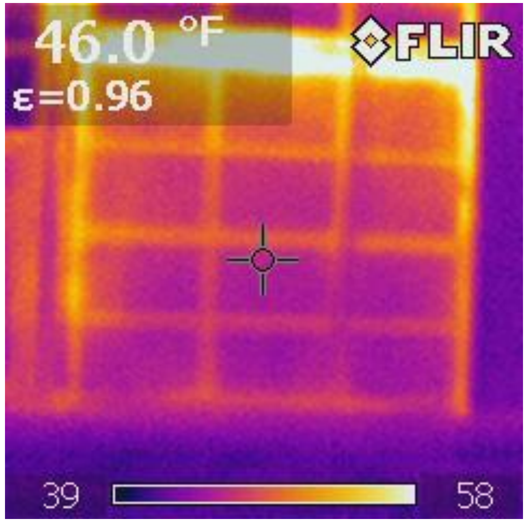


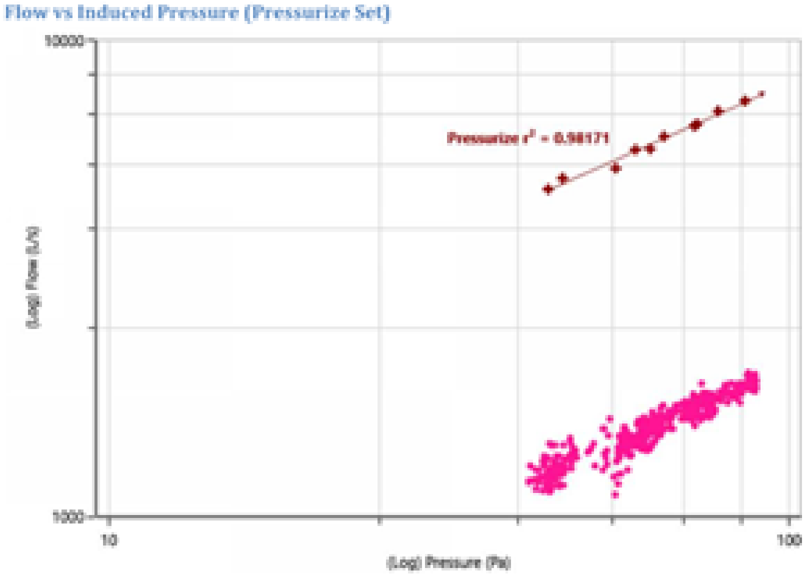
Source: Morrison Hershfield

Cost of testing in Seattle explored (continued)

3) Labor in performing qualitative review of building envelope to determine paths of air infiltration during test. This can be conducted via infrared thermography and smoke pens.

4) Compiling report to present findings on quantitative test results, as well as verified paths of air leakage observed.





Source: Morrison Hershfield

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Building designer selects approved envelope assemblies to meet the leakage requirements and documents them in the plan

2. Permit Application Phase

- Continuous air barrier plan identified in architectural drawings

Compliance Verification Process

3. Construction phase

- Air barrier is installed as specified with proper sealants and caulking
- Third party observation to confirm air barrier system is being installed as designed
- Best practice:
  - Field mockups to confirm acceptance of installation methods
  - In situ tests on selected portions of the wall to confirm progress compliance

4. Inspection Phase

- Whole building leakage test is performed according to chosen standard
- Documentation gathered and submitted to demonstrate the building passing
- Supervision to verify compliance with the air leakage testing requirements

Poll

What should happen if a building fails the whole-building leakage test?

A. Mitigate and retest
B. Document mitigation but do not retest
C. Document failure
D. Other (please specify)

Construction Phase Best Practice Explored

Field Mockup

In-Situ Air Testing

Market Actors

Market actors involved in implementing this measure include:

- Architects need to clearly document the air barrier assembly
- Mechanical designers need to account for a tighter envelope
- Energy consultants will help to specify the necessary elements to meet requirements
- Installers need to closely follow the specifications and seal leaks
- Plans examiners will need to ensure the envelope is clearly detailed and meets requirements
- Building inspectors and ATT will have to ensure that the proper test is performed and documents filed to show that the building passed
- Envelope Commissioning Professionals

Poll

Is there enough information readily available in the construction documents or in the field for air barrier verification?

A. No
B. Yes
C. In the documents only
D. In the field only

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Discussion and Next Steps

Submeasure A: Air Leakage

Submeasure B: Vestibule Infiltration

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Context and History

- Why are we proposing this measure?
  - For over a decade, ASHRAE has required vestibules to a be a part of building entrances, with some exceptions, in order to realize significant energy savings
  - Vestibules reduce the air infiltration through doors and create a tighter seal of the building envelope
  - A vestibule is a building entrance that is used to separate the conditioned interior of a building with the exterior
  - Vestibules can lead to energy savings in many climates, particularly cooler ones
  - Vestibules are also used for increased security measures in buildings with sensitive materials such as data centers

Image Credit: https://www.clearviewindustriesinc.com/entry-vestibule-installation

2019 Title 24 requirements

- Title 24 Part 6 Section 110.6(a)1
  - Exterior doors shall not have air infiltration rates exceeding 0.3 cfm/ft^2 of the door area for nonresidential single doors and 1.0 cfm/ft^2 for nonresidential double doors.

There are no requirements for vestibules, revolving doors, or air curtains in the current building envelope code

Poll

Are you involved in any design or building projects in CA state that included Vestibule, revolving door or air curtains?

A. Yes
B. No
C. No, but visited many buildings that included any one of them
D. Proposed, but the building owners rejected the recommendation.

Other Code Requirements

- **ASHRAE 90.1 5.4.3.3** and **IECC Section 402.5.7** require the installation of enclosed vestibules for primary building entrances.

- ASHRAE 90.1 2019
  - Location – Vestibule, Revolving doors or both
  - Equipped with self-closing devices
  - Vestibule size – Vestibule floor area of 50 ft^2 or 25 of the gross conditioned area
  - Minimum distance between the doors – 7 ft (or 16 ft for gross conditioned areas with that building level >40000 ft^2)
  - Vestibule envelope – Shall meet with the continuous air barrier requirement

https://www.energycodes.gov/sites/default/files/documents/cn_commercial_vestibules.pdf

ASHRAE 90.1 2019 Exceptions

Notable Exceptions include:

- Doors opening into semiheated spaces.
- Enclosed elevator lobbies for building entrances directly from parking garages.
- Building entrances in buildings that are located in Climate Zone 3, where the building is less than four stories above grade and less than 10,000 ft in gross conditioned floor area.
- Building entrances in buildings that are located in Climate Zone 0, 4, 5, 6, 7, or 8, where the building is less than 1000 ft in gross conditioned floor area.
- Doors that open directly from a space that is less than 3000 ft in area and is separate from the building entrance.
- Self-closing doors in buildings in Climate Zones 0, 3, and 4 that have an air curtain complying with Section 10.4.5.
- Self-closing doors in buildings 15 stories or less in Climate Zones 5 through 8 that have an air curtain complying with Section 10.4.5.

Poll

Which one do you recommend for California?

A. Vestibule

B. Air Curtain

C. Revolving Doors

D. A combination of two or more

Poll

Should air curtains be an exception for vestibule installation in California?

A. Strongly in favor of exception
B. Somewhat in favor of exception
C. Unsure
D. Somewhat opposed to exception
E. Very opposed to exception

Code Change Proposal – Summary

- A new prescriptive requirement to reduce infiltration rate through exterior doors
  - Vestibule
  - Revolving door
  - Air curtain

- This proposal will only impact newly constructed nonresidential buildings

Submeasure	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Forms Updated
Vestibule infiltration	Prescriptive	Yes	140.3	Yes

Proposed Code Change Overview

- Draft code language for this submeasure is available in the **resources tab**

- This proposed code change will require entrances to include enclosed vestibules designed with self-closing devices.
  - Exclusions for the proposal currently include:
    - Revolving doors
    - Doors with air curtains
    - Doors not intended to be used as a public entrance
    - Doors that lead to a space smaller than 3000 square feet
    - Doors that open directly from a dwelling unit

Market Overview

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

Market Overview and Analysis

- Current Market
  - Based on the Energy Commission's 2023 new construction forecast and a high-level analysis of vestibule applicability, an estimated 71 million square feet of buildings will be required to comply with this proposal
  - The vestibule market is fairly mature, and vestibules are primarily found in buildings where many individuals walk from the outside into a conditioned space
- Market Trends
  - Vestibules have increasingly become a part of model code over the past decade
  - There is much ongoing debate on the effectiveness of vestibules compared to revolving doors and air curtains

- **Do you agree with this description? What else should we know?**

Market Barriers

Market Barriers	Solutions
Building developers may not be comfortable with vestibule requirements for certain climate zones.	The Statewide CASE Team will use long-standing IECC and ASHRAE 90.1 Building Code Requirements to demonstrate the value of a vestibule requirement in commercial buildings for various climates.
There may be confusion over when the vestibule requirement applies.	The applicable definitions of spaces that trigger vestibule requirements will be discussed with building developers in order to best align with ASHRAE and IECC.
Disagreement over vestibule exceptions	The Statewide CASE Team will conduct rigorous energy savings analysis to ensure only the proper climate zones are included and will consult with ASHRAE and IECC members to better understand why certain exceptions exist and their applicability to California.

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Technical Considerations
  - Distance between the exterior and interior doors of the vestibule
  - Envelope of the vestibule
  - Sizing that triggers a vestibule installation
  - Benefits of air infiltration in certain climates

Technical Barriers

Technical Barriers	Solutions
Vestibules will take up too much space in the building entrance.	The Statewide CASE Team will talk with building designers and owners to find the most practical sizing dimensions for vestibules to ensure productive commercial activity can still take place.
There may be confusion as to technical definitions of spacing requirements that trigger a vestibule.	The Statewide CASE Team will analyze how IECC and ASHRAE handle specific scenarios and use them as examples.
Potential disputes may arise over savings from air curtains compared to vestibules.	The most up-to-date literature will be leveraged along with interviews from professional organizations so that the proper exceptions are included.

Energy and Cost Impacts

Methodology and Assumptions

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

Methodology for Energy Impacts Analysis

- We will analyze reports that have estimated the energy benefits of vestibule installation and see how they apply to California
- Modeling analysis for all qualified nonresidential buildings and climate zones
- Use energy savings impact reports of model code vestibule requirements as guidance

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 code without vestibules

Proposed Conditions

- Minimally compliant with 2019 code with vestibules leading into spaces 3000ft^2 or larger

Incremental Cost Information

- How we will collect costs of base case technology and proposed technology
  - Interviews with building developers, contractors, and professional organization members will be conducted to estimate overall vestibule installation costs
  - Costs will include added labor expenses and installation costs associated with vestibule inclusion
  - Costs may also include a decrease in sales from a reduction in commercial space
  - We will also gather totals for increases in maintenance costs
- What components of costs did we leave out?

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Building designer specifies proper vestibule or other compliant entryways in building plans

2. Permit Application Phase

- No significant changes apart from including the vestibule specifications

Compliance Verification Process

3. Construction phase

- Vestibules constructed according to specification

4. Inspection Phase

- Acceptance and/or field verification tests for vestibules will be created

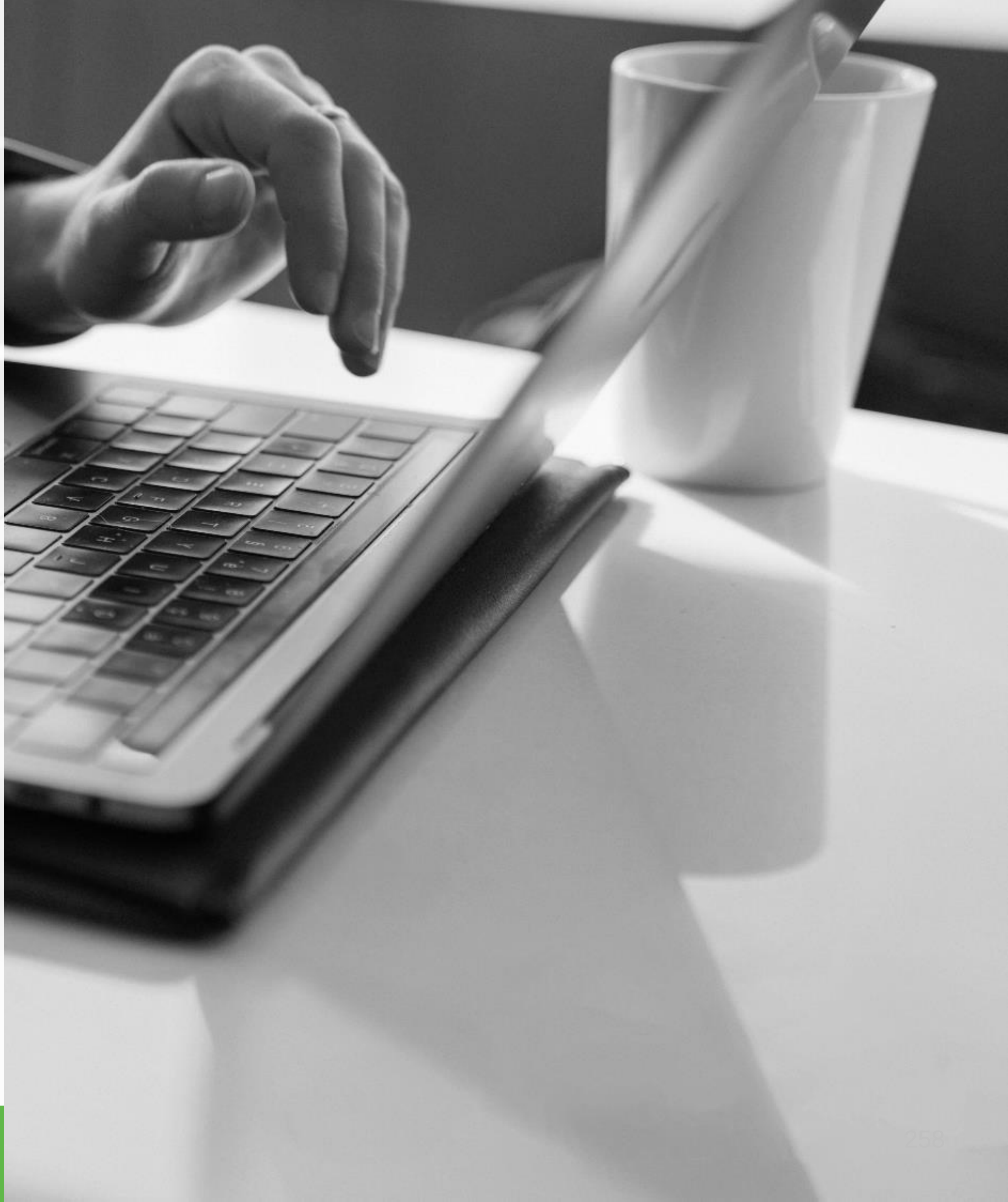
Market Actors

Market actors involved in implementing this measure include:

- Building designers
- Building contractors
- Building code experts
- Researchers
- Developers and building owners

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language

- Draft code language available for review in the **resources tab**

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- 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

Comments on this measure are due by November 19, 2019, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

Alamelu Brooks, *Energy Solutions*
abrooks@energy-solution.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Thank you for your participation today

Shaojie Wang, *Energy Solutions*
swang@energy-solution.com

Ben Brannon, *Arup*
ben.brannon@arup.com

Chad Worth, *Energy Solutions*
cworth@energy-solution.com

Benny Zank, *Energy Solutions*
bzank@energy-solution.com

Alamelu Brooks, *Energy Solutions*
abrooks@energy-solution.com

Please complete the closing polls below

Upcoming Meetings

Meeting Topic	Building Type	Date
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019