Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

March 29, 2017

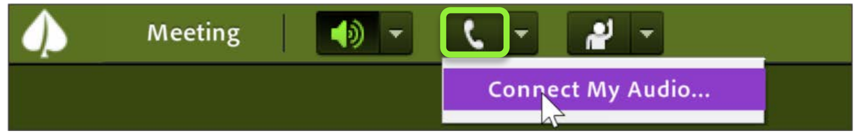
WEBINAR

Meeting Agenda

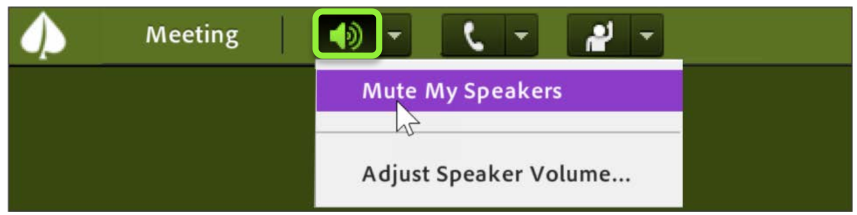
Time	Topic	Presenter
9:00 – 9:15	Introduction	Kelly Cunningham (PG&E)
9:25 – 10:40	Proposals Based on ASHRAE 90.1-2016 – Part 2 of 2: • Equipment Efficiency • Transfer Air • DCV • Occupant Sensor Ventilation	Ken Takahashi (Integral Group) Stefan Gracik (Integral Group) Matt Dahlhausen (Integral Group) Jared Landsman (Integral Group) Jeff Stein (Taylor Engineering)
10:40 – 11:55	Proposal Based on ASHRAE 90.1-2016: • Fan System Power • Exhaust Air Energy Recovery	Ken Takahashi (Integral Group)
11:55 – 12:00	Review and wrap-up, next steps	Kelly Cunningham (PG&E)

Hear and Be Heard!

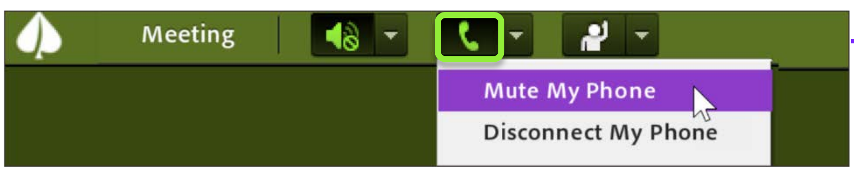
- Click the phone icon at the top of your screen, then follow the prompts



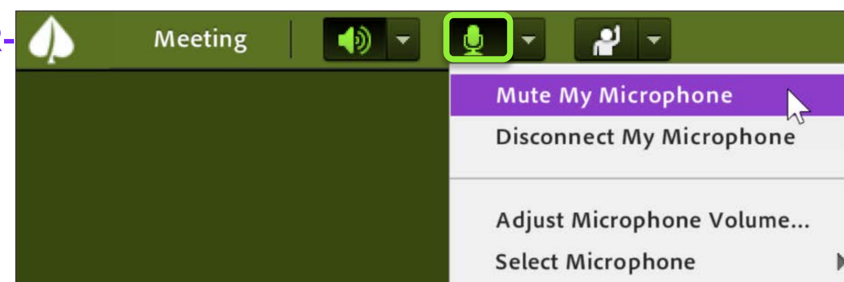
- If you connect via phone, mute your PC speakers to avoid feedback



- Mute your phone or microphone to avoid contributing unwanted background noise — unmute yourself when you want to talk



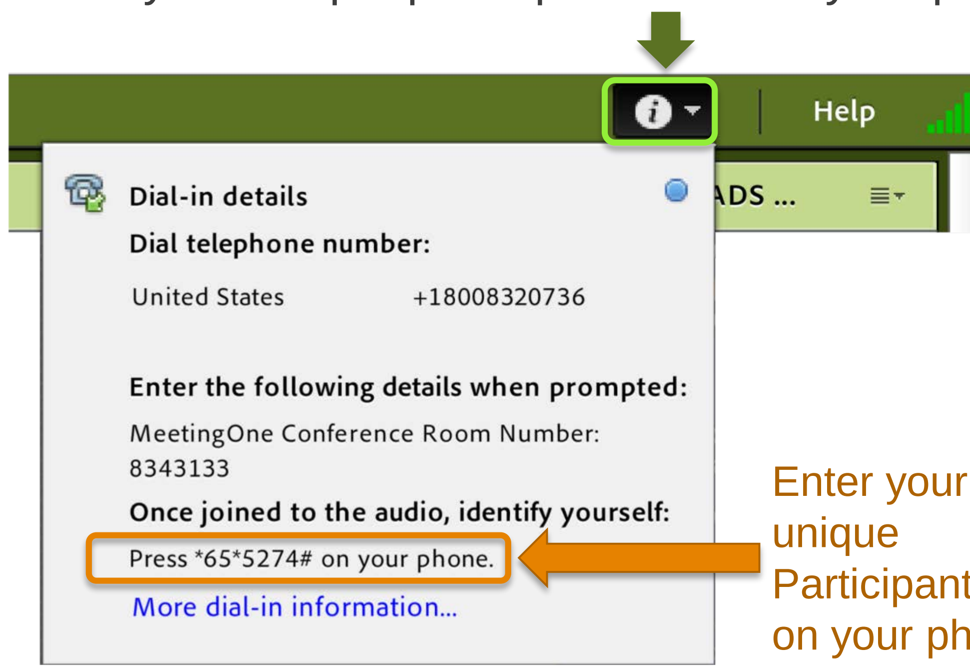
-OR-



Join your ears and eyes if you dialed in

If you dialed in and did not enter a participant code, please do so now.

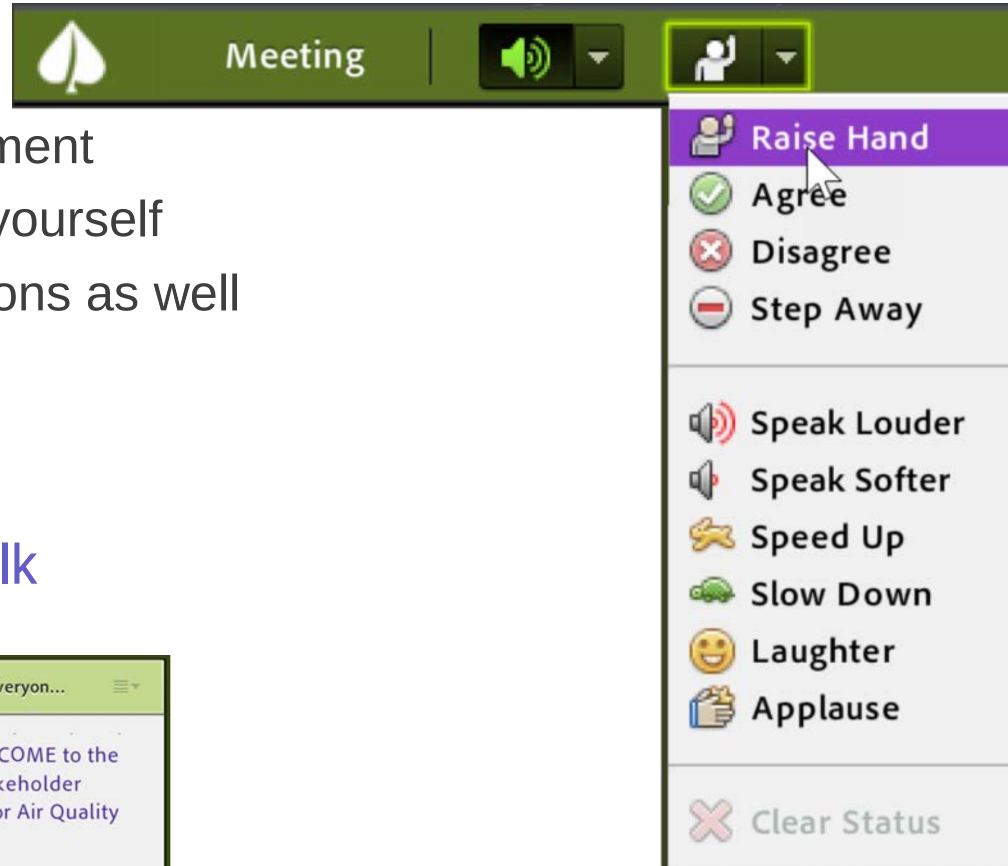
- Click the information button on the right side of the main menu bar
- Enter your unique participant code on your phone



Enter your unique Participant code on your phone

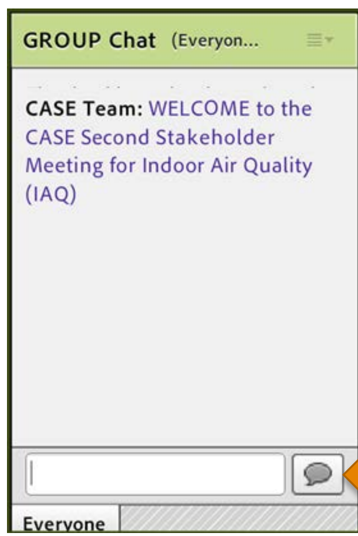
Communicate with icons

- Raise your hand
  - We'll call on you in a moment
  - Don't forget to "unmute" yourself
- Feel free to use the other icons as well



Use Chat if you don't want to talk

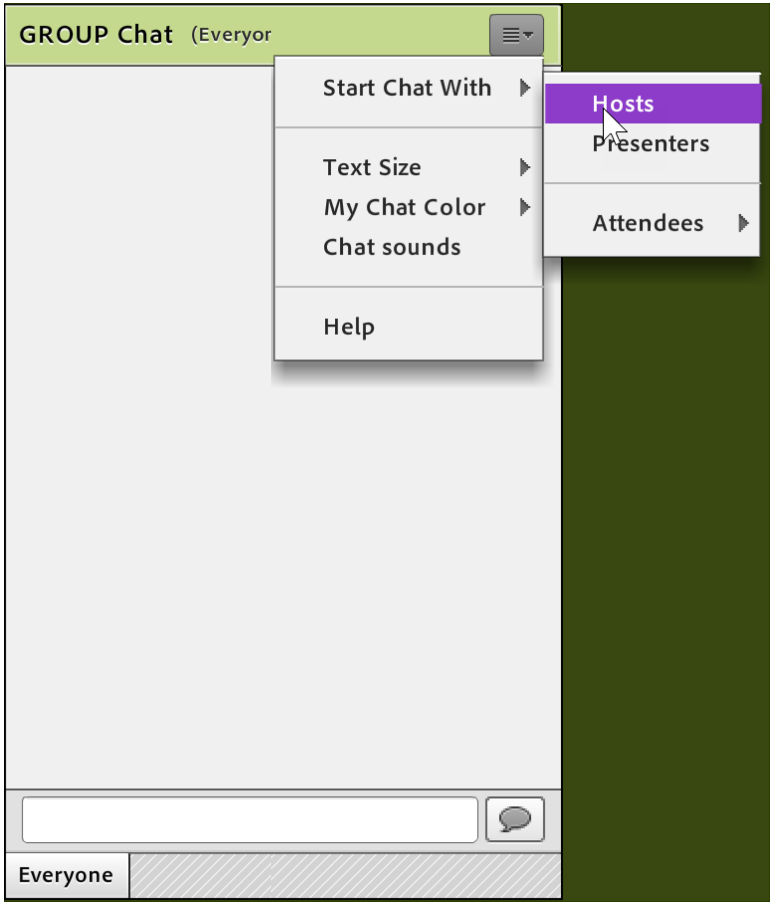
- The Chat pod is consistently found in the lower left of your screen



Type here and press Enter on your keyboard

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Technical Support for the Meeting Room



Tech support is standing by

- Use “Chat” (lower left of your screen)
- Direct your question or comment to “Hosts”
- Give us a moment to chat back

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

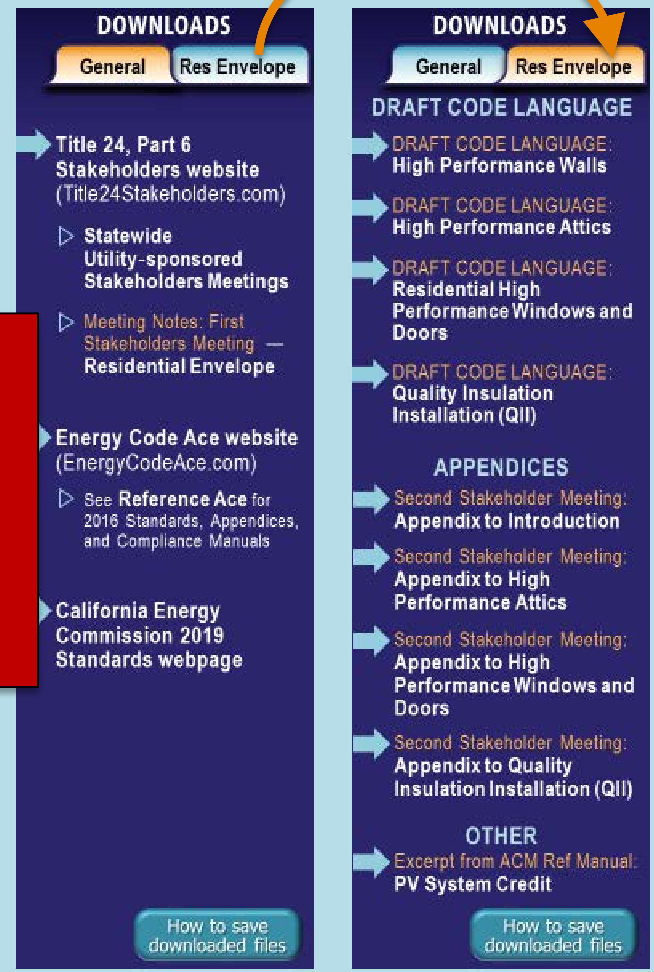
Supporting Resources

- Click on links in the Downloads pod
- Use “tabs” to switch between general downloads and topic-specific downloads

REPLACE

Click on a “tab” to switch between views

(It changes your view, but not others’)



CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Statewide Utility Team Title 24, Part 6 Advocacy Support

- The Utilities support the California Energy Commission by proposing changes to the Building Energy Efficiency Standards that are:

Feasible | Cost effective | Enforceable | Non-proprietary

Statewide Utility Team Title 24, Part 6 Advocacy Support

- For information on the Energy Commissions' rulemaking process, visit: http://www.energy.ca.gov/title24/2019standards

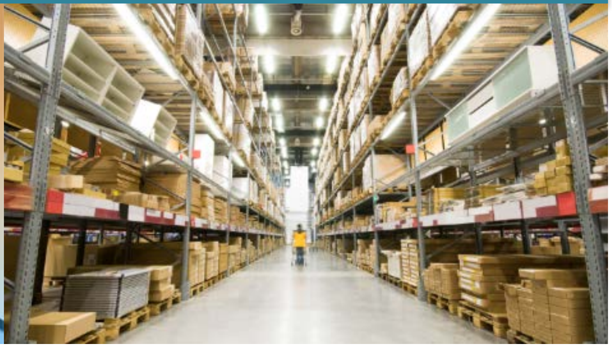
Objectives of Today's Discussion

Discuss and get input on:

- Code change proposals
- Technical and market feasibility
- Compliance and enforcement
- Cost effectiveness results (preliminary)
- Energy savings analysis (preliminary)

YOUR PARTICIPATION WILL INFORM THE CODE CHANGE PROPOSALS!





Invitation to Participate

We want to hear from you:

- Supporting and opposing viewpoints are welcome
- We may not be able to reach resolutions today
- There are no stupid questions
- Mute your phone, but do not place us on 'hold'
- Clearly state your name and affiliation prior to speaking
- Speak loudly (without shouting)

NOTES & PRESENTATION MATERIALS: www.Title24Stakeholders.com

Invitation to Participate

Participate in today's discussion by:

- Answering polls
- Use chat function
- Speak up and ask questions

Continue the discussion:

- Email or call CASE Authors
- Email info@title24stakeholders.com
- Contact California Energy Commission staff

NOTES & PRESENTATION MATERIALS: www.Title24Stakeholders.com

Utility-Sponsored Stakeholder Meetings, March 2017

#	Date	Time	Meeting Group	Measures in Group
1	March 07, 2017	9:00 - 12:00	Laboratory Spaces	1. Induction Exhaust Fans 2. Fume Hood Sash Closures
2	March 14, 2017	9:00 - 12:00	Residential Envelope	1. Residential High Performance Walls 2. Residential High Performance Attics 3. Residential Improved Fenestration Products 4. Residential Quality Insulation Installation (QII)
3	March 15, 2017	9:00 - 12:00	Nonresidential HVAC 1	1. Proposal Based on ASHRAE 90.1-2016 a. (1 of 7) Water Side Economize 2. Cooling Tower Minimum Efficiency 3. Fault Detection Diagnostics (FDD) for Built-up Systems
4	March 16, 2017	9:00 - 12:00	• Residential IAQ • Nonresidential IAQ	1. Residential Quality HVAC 2. Residential Indoor Air Quality (IAQ) 3. Nonresidential Indoor Air Quality (IAQ)
5	March 21, 2017	9:00 - 12:00	Warehouses	1. Hybrid Condensers 2. Loading Dock Seals

MEETING SCHEDULE ALSO AVAILABLE AT: www.Title24Stakeholders.com

Stakeholder Meetings in March 2017 (continued)

#	Date	Time	Meeting Group	Measures in Group
6	March 22, 2017	9:00 - 12:00	Nonresidential Lighting 1	1. Nonresidential Indoor Lighting Sources 2. Nonresidential Indoor Light Controls 3. Nonresidential Lighting Alterations
7	March 23, 2017	9:00 - 12:00	Residential Water Heating	1. Residential Compact Hot Water Distribution Design 2. Residential Drain Water Heat Recovery
8	March 28, 2017	10:00 - 12:00	• Residential HVAC • Demand Response	1. Residential Quality HVAC 2. Demand Response Clean Up
9	March 29, 2017	9:00 - 12:00	Nonresidential HVAC 2	1. Proposal Based on ASHRAE 90.1-2016 a. (2 of 7) Fan System Power b. (3 of 7) Exhaust Air Energy Recovery c. (4 of 7) Equipment Efficiency d. (5 of 7) Transfer Air for Exhaust Air Makeup e. (6 of 7) Demand Control Ventilation for Classrooms f. (7 of 7) Occupant Sensor Ventilation
10	March 30, 2017	9:00 - 12:00	Nonresidential Lighting 2	1. Nonresidential Outdoor Lighting Sources 2. Nonresidential Outdoor Lighting Controls 3. Nonresidential Advanced Daylighting Design

Tentative Schedule for 2019 Code Development Cycle

Milestone	Date(s)
Utility-Sponsored Stakeholder Meetings	March 2017
Utility Team Submits Draft CASE Reports	April 2017
CEC Pre-rulemaking Workshops	May 2017 – June 2017
Utility Team Submits Final CASE Reports	June - July 2017
CEC Rulemaking	Nov 2017 – May 2018
2019 Standards Adopted	May 2018
2019 ACM Reference Manuals and Compliance Manuals Approved	Nov 2018
2019 Standards Effective	January 1, 2020

Let's move on to…

Residential High Performance Walls

- **Kelly Cunningham**
  KACV@pge.com

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Equipment Efficiency

March 29, 2017

Jared Landsman
jlandsman@integralgroup.com

1. Background

Introduction to Equipment Efficiency

- Mandatory equipment efficiency requirements exist in Title 24, Part 6 for:
  - Air conditioners
  - Heat pumps
  - Water chillers
  - Packaged Terminal Air Conditioners & Heat Pumps
  - Single Package Vertical Air Conditioners & Heat Pumps
  - Heat exchangers
  - Cooling towers
  - Condensers
  - Variable Refrigerant Flow (VRF) Air Conditioners & Heat Pumps
  - Furnaces
  - Boilers

Relevant Code History

- Federal law requires the US Department of Energy (DOE) to review ASHRAE 90.1 equipment efficiency updates
- DOE typically adopts ASHRAE's equipment efficiency levels and they become mandatory minimum federal requirements
- States have the opportunity to adopt equipment efficiency values in 90.1 using a simplified process before they become federally required
- Cost effectiveness analysis is not required

2. Proposed Code Changes

Proposed Code Change

- Mandatory code change to include:
  - **Single Package Vertical Air Conditioners (SPVAC):** increase EER and COP for weatherized units <65,000 Btu/h
  - **Single Package Vertical Heat Pumps (SPVHP):** increase EER and COP for weatherized units <65,000 Btu/h
  - **Propeller or axial fan closed-circuit Cooling Towers:** increase gpm/hp
  - **Variable Refrigerant Flow Air Conditioners (air-cooled):** increase IEER
  - **Variable Refrigerant Flow Heat Pumps (air-cooled, cooling mode):** increase IEER
  - **Variable Refrigerant Flow Heat Pumps (water-source, cooling mode):** increase IEER and add EER and IEER requirements for ≥ 240,000 Btu/h size category
  - **Variable Refrigerant Flow Heat Pumps (water-source, heating mode):** increase COP and add COP requirements for <65,000 Btu/h and ≥ 240,000 Btu/h size categories

Proposed Code Change

- Mandatory code change to include addition of new requirements:
  - **Air Conditioners and Condensing Units Serving Computer Rooms:** set minimum COP for air-cooled, water-cooled, and glycerol-cooled units

- Consideration of including the following requirements:
  - **Vapor Compression Based Indoor Pool Dehumidifiers:** set minimum MRE for single package and split system units
  - **Electrically Operated DX-DOAS Units:** set ISMRE and ISCOP for units with and without heat recovery

Why Are We Proposing This Code Change

- Support ZNE goals
- Achieve significant energy savings
- Align with model codes
- Keep up with ASHRAE 90.1 as required by federal statues

What about pool dehumidification and DX-DOAS?

3. Technical and Market Barriers

Technical and Market Barriers

- No technical or market barriers are identified
- Manufacturers and industry professionals settled on these updated efficiencies based on available products
- We do not anticipate any barriers to designers, suppliers, or manufacturers in adopting these updates

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - No change from current requirements
  - Design teams will still need to ensure that equipment they are specifying meets mandatory equipment efficiency requirements

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - – No change from current requirements

Compliance Process

Construction Phase

- What happens in construction phase?
  - No change from current requirements

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - No change from current requirements

Compliance and Enforcement Barriers

- Compliance or enforcement barrier #1
  - Manufacturers selling equipment that does not comply with the standard
  - Resolution is to ensure designers, engineers, and plan checkers are familiar with the code updates

What do you think? (Discussion)

- Did we capture technical and market barriers?
- Did we capture compliance and enforcement barriers?
- Are there other barriers — or solutions — we haven’t discussed?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Model Assumptions

- Prototype modeling for SPVAC & SPVHC in schools and small offices
- Prototype modeling for closed circuit cooling towers in high rise residential
- No verified modeling technique for VRF (not currently modeled)
- Single zone computer room modeling for computer room air conditioning

Baseline Conditions

- Minimally compliant with 2016 Standards or industry standard practice

Proposed Conditions

- Compliant with prescriptive equipment efficiency

Cost-Effectiveness Analysis

Incremental Costs

- Cost effectiveness analysis is not required by the California Energy Commission to adopt mandatory equipment efficiency updates

Annual Energy Savings Per Square Foot

Climate Zone	TDV Energy Savings (TDV kBtu/yr)	15/30 Year TDV Energy Cost Savings ($2020)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Annual Energy Savings calculations in progress, but all savings will be positive across all climate zones

Annual Energy Savings Per Square Foot

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (kWh/yr)	Peak Electric Demand Reduction (kW)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Annual Energy Savings calculations in progress, but all savings will be positive across all climate zones

Let's move on to…

Transfer Air for Exhaust Air Make-up

- **Jared Landsman**
  (jlandsman@integralgroup.com)

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Transfer Air for Exhaust Air Make-up

March 29, 2017

Jeff Stein
JStein@taylor-engineering.com

Stefan Gracik
sgracik@integralgroup.com

Matt Dahlhausen
mdahlhausen@integralgroup.com

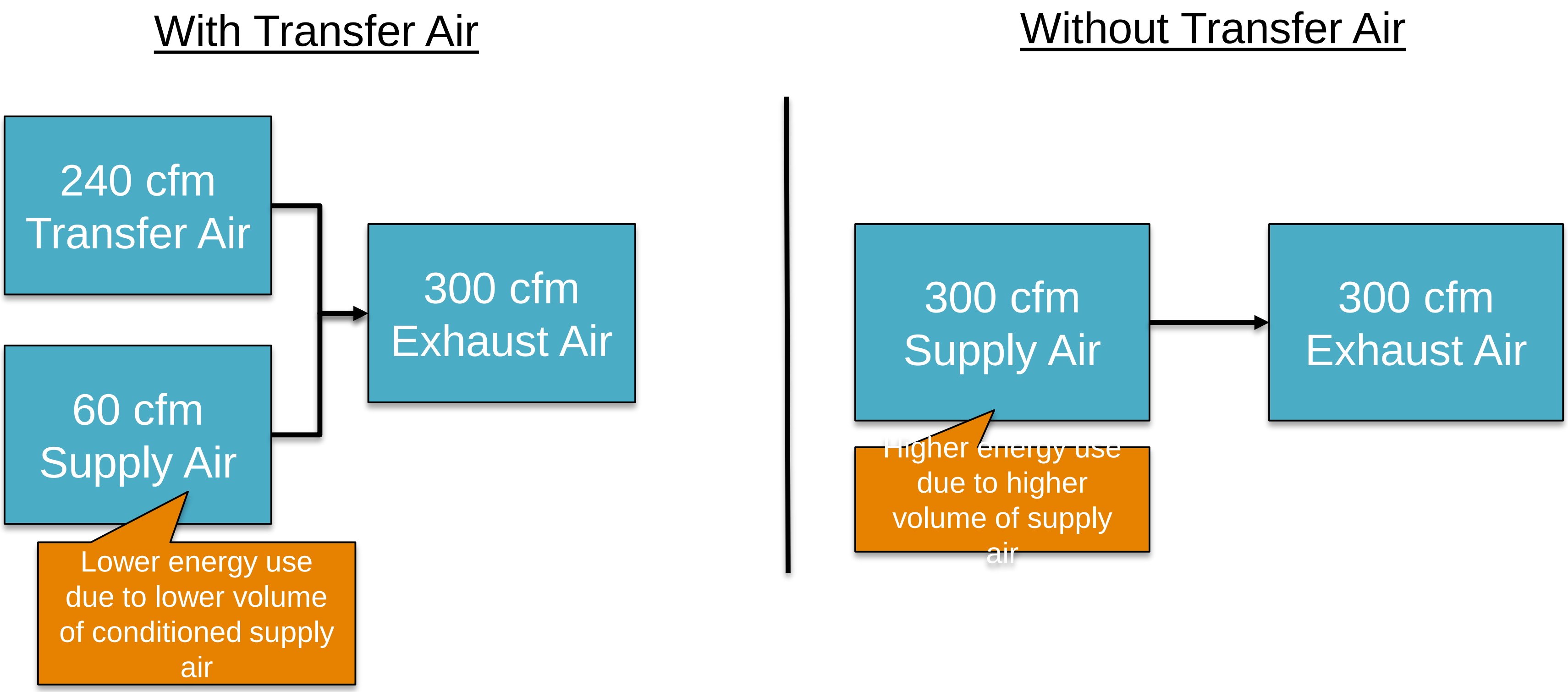
1. Background

Introduction to Transfer Air for Exhaust Air Makeup

- Many space types have mandatory exhaust air requirements, set by the California Mechanical Code
  - e.g. restrooms, copy rooms, kitchens, art classrooms
  - Rates vary from 0.25 to 1.5 cfm/ft2
- Ventilation requirements for these space types are often much lower
  - Typically 0.15 cfm/ft2
- Supply air required to condition the space is usually lower than the exhaust makeup requirement
- Many designers simply match the supply flow to the exhaust flow which results in excessive reheating of the supply flow
- It is much more efficient to limit the supply flow to that needed for the space heating/cooling load and then use transfer air for the balance of the exhaust makeup.

Introduction to Transfer Air for Exhaust Air Makeup

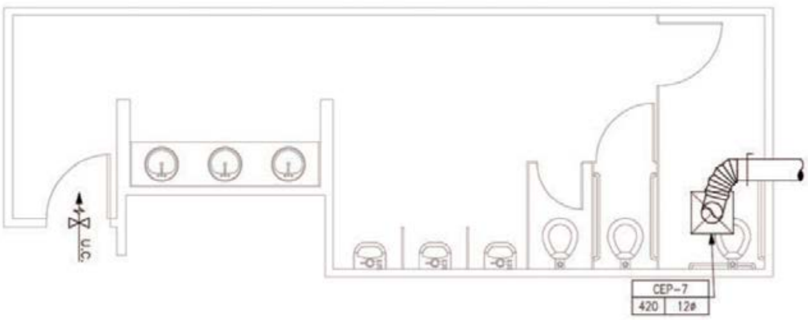
- Example of transfer air for Toilet exhaust makeup:



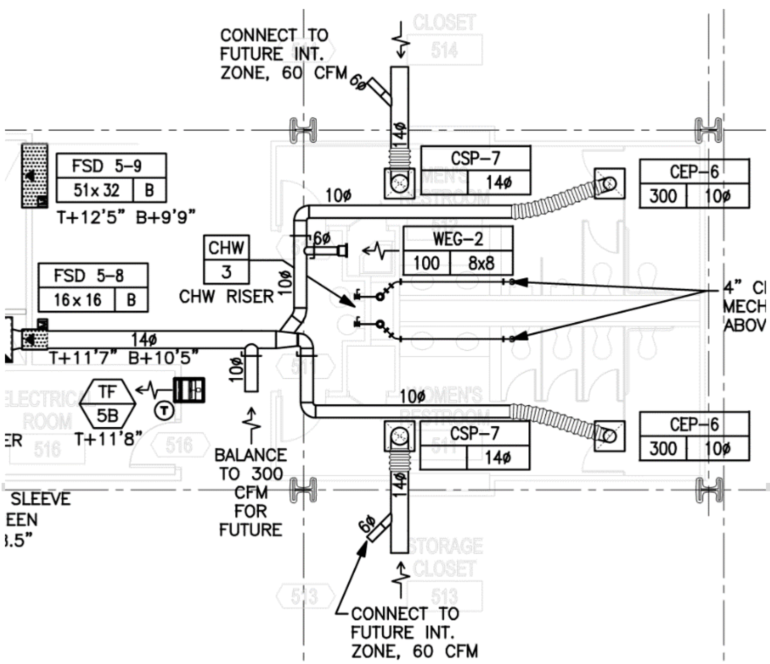
Introduction to Transfer Air for Exhaust Air Makeup

- Example of transfer air for Toilet exhaust makeup:

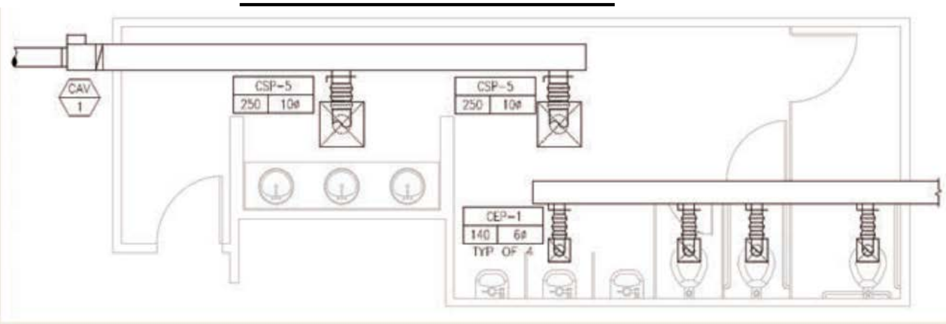
<u>With 100% Transfer Air</u>



<u>With 80% Transfer Air</u>



<u>Without Transfer Air</u>



Relevant Code History

- There are existing requirements in Title 24, Part 6
  - Title 24 Section 140.9
  - Applies to Kitchen exhaust only
- Other Relevant Code Requirements
  - ASHRAE 90.1-2016 includes exact same transfer air requirements being proposed here

2. Proposed Code Changes

Proposed Code Change

- Prescriptive code change applies to:
  - Spaces that have process exhaust airflow higher than:
    - Airflow required for heating or cooling
    - Airflow required for ventilation
  - That are adjacent to spaces that do not have high exhaust requirements
- In this situation, the code change requires transfer air
- Several exceptions including BSL3, Vivariums, and “class of air” recirculation limits.
- Revision to existing requirement
- All nonresidential buildings impacted
- Applies to additions but not to alterations and repairs
- Aligns with ASHRAE 90.1

Proposed Code Change

(o) **Exhaust System Transfer Air.** Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of

1. the supply flow required to meet the space heating or cooling load
2. the ventilation rate required by the authority having jurisdiction, the facility Environmental Health and Safety department, or by Section 120.1
3. the mechanical exhaust flow minus the available transfer air from conditioned spaces or return air plenums on the same floor, not in different smoke or fire compartments, and that at their closest point are within 15 feet of each other. Available transfer air is that portion of outdoor ventilation air that

   A. is not required to satisfy other exhaust needs,

   B. is not required to maintain pressurization of other spaces, and

   C. is transferable according to applicable codes and standards and to the class of air recirculation limitations in the California Mechanical Code

EXCEPTION 1 to Section 140.4(o): Biosafety level classified laboratories 3 or higher.

EXCEPTION 2 to Section 140.4(o): Vivarium spaces.

EXCEPTION 3 to Section 140.4(o): Spaces that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.

EXCEPTION 4 to Section 140.4(o): Spaces where the highest amount of transfer air that could be used for exhaust makeup may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.

Proposed Code Change - ACM

- Expand the following kitchen modeling rules to all spaces:
  - – Proposed Model - All exhaust systems and associated makeup air systems shall be explicitly modeled in the proposed case — e.g., toilet rooms must be modeled.
  - – Baseline Model – Software shall calculate the heat/cool load and available transfer air each hour and shall maximize the use of transfer air while meeting the heat/cool load.

Why Are We Proposing This Code Change

- Eliminate the practice of provide 100% supply or 100% outside air to spaces to make up air for high exhaust rates
- Support ZNE goals
- Achieve significant energy savings
- Reduces first costs
- Align with model codes
- Keep up with ASHRAE 90.1

What do you think? (Discussion)

- What are your thoughts on the proposed code changes?
- Any questions or concerns?

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

3. Technical and Market Barriers

Technical and Market Barriers

- Ensuring design engineers understand how to properly implement this code requirements
- Proposed solution is to include training and classes on code changes

What do you think? (Discussion)

- Did we capture technical and market barriers?
- Are there other barriers — or solutions — we haven't discussed?

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - Designers will need to be aware of code changes and apply them correctly to their designs.
  - Design teams that do not collaborate will now need to

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - No change in the process for the permit application phase
  - Added complexity for plan checker to check for compliance

Compliance Process

Construction Phase

- What happens in construction phase?
  - No change in the process for the permit application phase
  - Added need for coordination between disciplines

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - No change in the process for the permitting

Compliance and Enforcement Barriers

Barrier 1

- Enforcement of this requirement is difficult, and calculations will need to be done to determine if adequate transfer air is being used
- Possible solutions includes training for permit officials

Barrier 2

- Designers could avoid compliance by claiming higher than actual heating/cooling loads or claiming exceptions that do not apply
- Possible solutions includes training for permit officials and designers on the ease of complying and intent behind this measure

What about compliance and enforcement barriers?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2016 Standards or industry standard practice
- Mixed office and laboratory prototype building
- No transfer air to make up laboratory exhaust air

Proposed Conditions

- Compliant with proposed code change
- List key assumptions
- Mixed office and laboratory prototype building
- Transfer air to make up laboratory exhaust air

Cost-Effectiveness Analysis

Incremental Costs

- Incremental First Cost
  - Zero incremental first cost is anticipated
- Incremental Maintenance Costs over 15-year period of analysis
  - Zero maintenance cost is anticipated

- **Total Incremental Cost over 15-year period of analysis = $0.00**

Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15/30-year period of analysis
  - **Total Energy Cost Savings = range of $x,xxx to $y,yyy depending on climate zone**
  - *Energy cost savings explained in more detail in following slides.*
- **Total Incremental Cost Savings (Benefit) over 15/30-year period of analysis = $x,xxx**

Annual Energy Savings calculations in progress, but all savings will be positive across all climate zones

Benefit-to-Cost Ratio

Climate Zone	Benefit to Cost
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Cost-Effective in All Climate Zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings Per [unit]

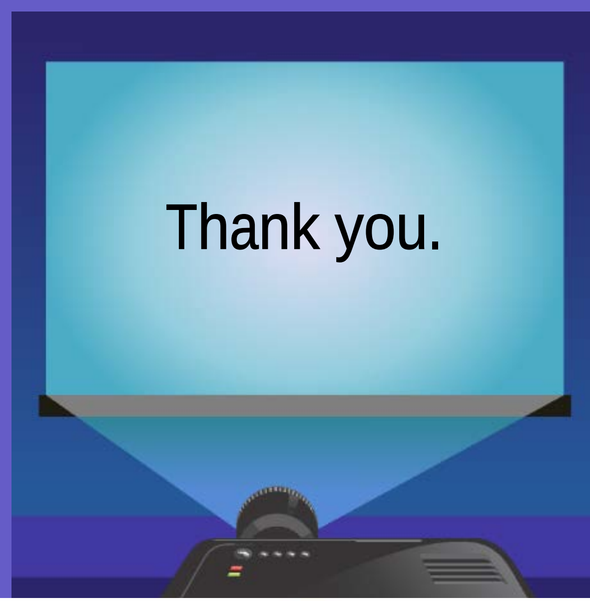
Climate Zone	TDV Energy Savings (TDV kBtu/yr)	15/30 Year TDV Energy Cost Savings ($2020)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Annual Energy Savings Per [unit]

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (kWh/yr)	Peak Electric Demand Reduction (kW)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Let's move on to…

Demand Controlled Ventilation for Classrooms



- **Jeff Stein**
  JStein@taylor-engineering.com
- **Stefan Gracik**
  sgracik@integralgroup.com
- **Matt Dahlhausen**
  mdahlhausen@integralgroup.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Demand Controlled Ventilation for Classrooms

March 29, 2017

Jeff Stein
JStein@taylor-engineering.com)

Stefan Gracik
sgracik@integralgroup.com

Matt Dahlhausen
mdahlhausen@integralgroup.com

1. Background

Introduction to Demand Controlled Ventilation

- Demand controlled ventilation (DCV) resets the minimum airflow setpoint in most high density spaces based on the number of occupants in the space
- It uses CO_2 levels to estimate the number of occupants

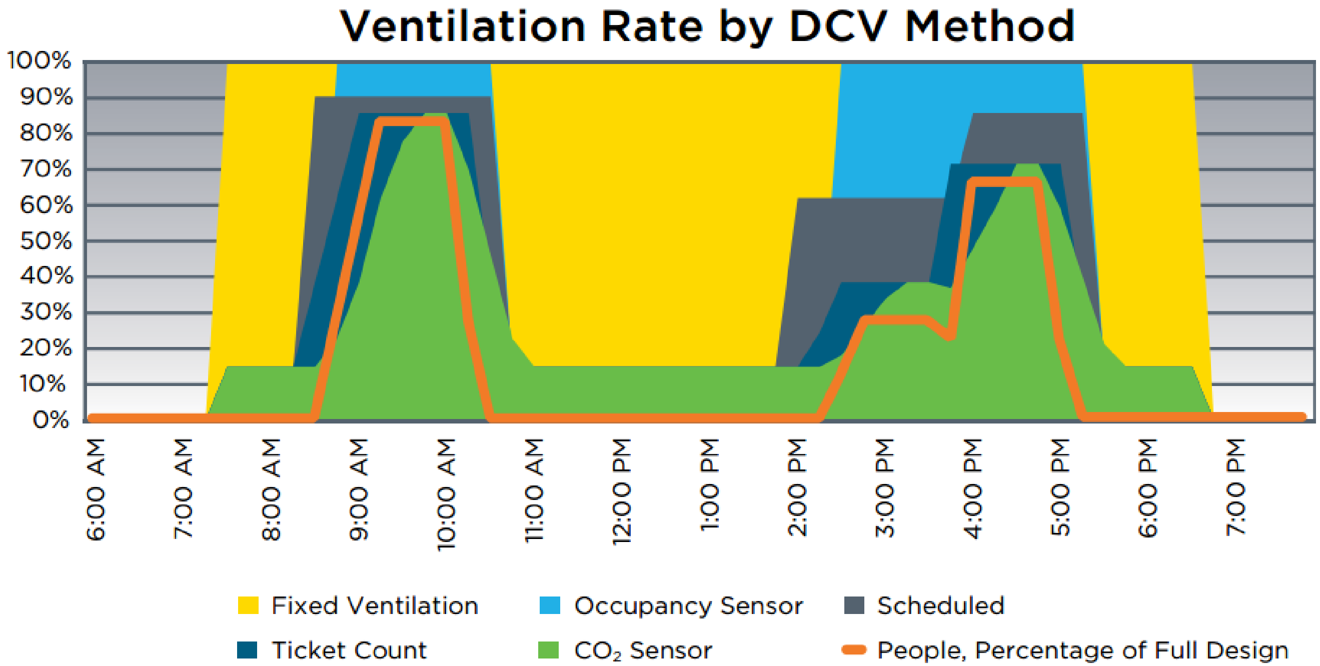


Figure 1. Ventilation rates provided with fixed ventilation and DCV alternatives

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Relevant Code History

- There are existing requirements in Title 24, Part 6
  - DCV has been allowed in high density spaces since 1992
  - DCV has been mandatory in most densely occupied spaces since 2001 including: conference rooms, break rooms, auditoria, dining rooms, lobbies, religious worship, mall common areas, sports arena seating, museums, courtrooms, health clubs, casinos.
  - Section 120.1(c) outlines the requirement, including accuracy, factory calibration, failsafe controls, etc.
- Other Relevant Code Requirements
  - DCV has been mandatory in ASHRAE 90.1 since 1999 for most high density spaces, including classrooms

2. Proposed Code Changes

Proposed Code Change

- Update Section 120.1(c)3 to:
  - Require DCV in the same high density spaces covered by 90.1, including classrooms
    - Exceptions: correctional cells, daycare sickrooms, science labs, barber shops, beauty and nail salons, and bowling alley seating
  - Require DCV only when the system includes:
    - Air economizer, or
    - Modulating outdoor air control, or
    - Design outdoor air flow rate > 3,000 cfm
  - Remove exception for Occupant Sensor Ventilation Controls
- Mandatory measure
- Impacts all nonresidential buildings with high density spaces
- Applies to newly installed HVAC systems in additions
- Does not apply to alterations

Proposed Code Change

3. **Required Demand Control Ventilation.** Demand ventilation controls complying with 120.1(c)4 is required for a spaces with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person) if the system serving the space has one or more of the following:

   A. an air economizer

   B. modulating outside air control

   C. design outdoor airflow rate > 3000 cfm

   EXCEPTION 1 to Section 120.1(c)3: ~~Classrooms, call centers, office spaces served by multiple zone systems that are continuously occupied during normal business hours with occupant density greater than 25 people per 1000 ft² as specified by Section 120.1(b)2B, healthcare facilities and medical buildings, and public areas of social services buildings are not required to have demand control ventilation.~~ Spaces with one of the following occupancy categories as defined in the California Mechanical Code: correctional cells, daycare sickrooms, science labs, barber shops, beauty and nail salons, and bowling alley seating.

   EXCEPTION 2 to Section 120.1(c)3: Where space exhaust is greater than the design ventilation rate specified in Section 120.1(b)2B minus 0.2 cfm per ft² of conditioned area.

   EXCEPTION 3 to Section 120.1(c)3: Spaces that have processes or operations that generate dusts, fumes, mists, vapors, or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons shall not install demand control ventilation.

   EXCEPTION 4 to Section 120.1(c)3: Spaces with an area of less than 150 square feet, or a design occupancy of less than 10 people as specified by Section 120.1(b)2B.

   ~~**EXCEPTION 5 to Section 120.1(c)3:** Spaces with an area of less than 1,500 square feet complying with Section 120.1(c)5.~~

Why Are We Proposing This Code Change

- Support ZNE goals
- Achieve significant energy savings
  - Occupant sensor ventilation controls no longer required for classrooms
- Insure adequate ventilation is provided at all times
  - Airside economizers often fail in the position of not supplying any outside air at all (or manually disabled, or poorly calibrated)
  - Without DCV controls this condition can persist undetected for years.
  - Title 24 requires failsafe controls and requires CO_2 sensor readings to be displayed continuously and trended.
- Align with model codes
- Keep up with ASHRAE 90.1

What do you think? (Discussion)

- What are your thoughts on the proposed code changes?
- Any questions or concerns?

3. Technical and Market Barriers

Technical and Market Barriers

- There are no anticipated technical or market barriers
  - Demand controlled ventilation is an already common practice and CO_2 sensors are widely available and inexpensive
  - There will be a small increase to the number of spaces covered

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase?
  - There are no anticipated design phase changes
  - Designers are used to implementing existing DCV requirements and this only adds a small number of spaces

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - There are no anticipated permit application phase changes
  - Plan checkers are used to DCV and know what to look for

Compliance Process

Construction Phase

- What happens in construction phase?
  - There are no anticipated construction phase changes

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - There are no anticipated permitting phase changes

Compliance and Enforcement Barriers

There are no anticipated compliance or enforcement barriers

What do you think? (Discussion)

- Did we capture technical and market barriers?
- Did we capture compliance and enforcement barriers?
- Are there other barriers — or solutions — we haven't discussed?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2016 Standards or industry standard practice
- Large classroom prototype building
- No DCV in classroom spaces
- Constant ventilation during occupied hours

Proposed Conditions

- Compliant with proposed code change
- Large classroom prototype building
- DCV added in classroom spaces
- Ventilation volume changes based on CO_2 concentration and occupant schedule

Cost-Effectiveness Analysis

Incremental Costs

- Incremental First Cost
  - CO_2 Sensor ($260/room)
  - **Total Incremental First Cost ($260/room)**
- Zero Additional Maintenance Costs over 15-year period of analysis
- **Prototype Models (assumes 60% classrooms, 1000 sf each)**
  - **Small School (24,000 sf): 15 classrooms $3,800 $0.21/sf**
  - **Large School (210,000 sf): 128 classrooms $33,300 $0.21/sf**

Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of $x,xxx to $y,yyy depending on climate zone**
  - *Energy cost savings explained in more detail in following slides.*
- **Total Incremental Cost Savings (Benefit) over 15/30-year period of analysis = $x,xxx**

Annual Energy Savings calculations in progress, but all savings will be positive across all climate zones

Benefit-to-Cost Ratio

Climate Zone	Benefit to Cost
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Cost-Effective in All Climate Zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings Per [unit]

Climate Zone	TDV Energy Savings (TDV kBtu/yr)	15/30 Year TDV Energy Cost Savings ($2020)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Annual Energy Savings Per [unit]

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (kWh/yr)	Peak Electric Demand Reduction (kW)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

No layout change

Let's move on to…

Occupant Sensor Ventilation Requirements

- **Jeff Stein**
  JStein@taylor-engineering.com
- **Stefan Gracik**
  sgracik@integralgroup.com
- **Matt Dahlhausen**
  mdahlhausen@integralgroup.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Occupant Sensor Ventilation Requirements

March 29, 2017

Jeff Stein
JStein@taylor-engineering.com

Stefan Gracik
sgracik@integralgroup.com

Matt Dahlhausen
mdahlhausen@integralgroup.com

1. Background

Introduction to Occupant Sensor Ventilation

- Occupant sensor ventilation involves using occupant sensors to shut-off ventilation air when a space is unoccupied
- Can be tied into lighting occupancy sensors

Relevant Code History

- There are existing requirements in Title 24, Part 6
  - Section 120.2(e)3 includes current requirements for spaces where occupant sensor ventilation controls are required, including:
    - Multipurpose rooms < 1000 ft^2
    - Classrooms > 750 ft^2
    - Conference rooms > 750 ft^2
  - Section 120.1(c)5 includes current requirements for occupant sensor ventilation control devices
    - When unoccupied first shut off supply air then cycle it to average 25% of ventilation rate over 2 hours
- Other Relevant Code Requirements
  - This is the same proposal that ASHRAE 90.1 approved for publication public review at the January 2017 ASHRAE meeting in Las Vegas

2. Proposed Code Changes

Proposed Code Change

- Updates to Section 120.1
  - Mandatory changes to clean up and simplify ventilation control devices requirements: when unoccupied and temperature is satisfied then shut off ventilation.
- Updates to Section 120.2
  - Mandatory changes to modify space types required to implement occupied standby controls to spaces:
    - required to have lighting controls, and
    - Where occupied standby is allowed by CBC and ASHRAE 62.1

Proposed Code Change

- Mandatory For:
  - enclosed offices < 250 ft^2
  - conference rooms
  - multipurpose/assembly rooms < 1000 ft^2
  - corridors
  - lobbies
  - lecture classrooms
  - hotel guestrooms

- NOT Mandatory For:
  - K-12 classrooms
  - office copy/print rooms
  - break rooms
  - computer rooms
  - penitentiary
  - laboratories
  - food (kitchens, dining rooms)
  - gambling
  - sports arenas
  - healthcare
  - multipurpose/assembly rooms > 1000 ft^2
  - enclosed offices > 250 ft^2
  - open plan offices
  - museums
  - courtrooms
  - religious worship
  - auditorium
  - supermarkets
  - sports arena spectator areas

Not Allowed (K-12 classrooms through healthcare)

Allowed (Optional) (multipurpose/assembly rooms > 1000 ft^2 through sports arena spectator areas)

Proposed Code Change

occupied-standby mode: when a zone is scheduled to be occupied and an occupant sensor indicates zero population within the zone.

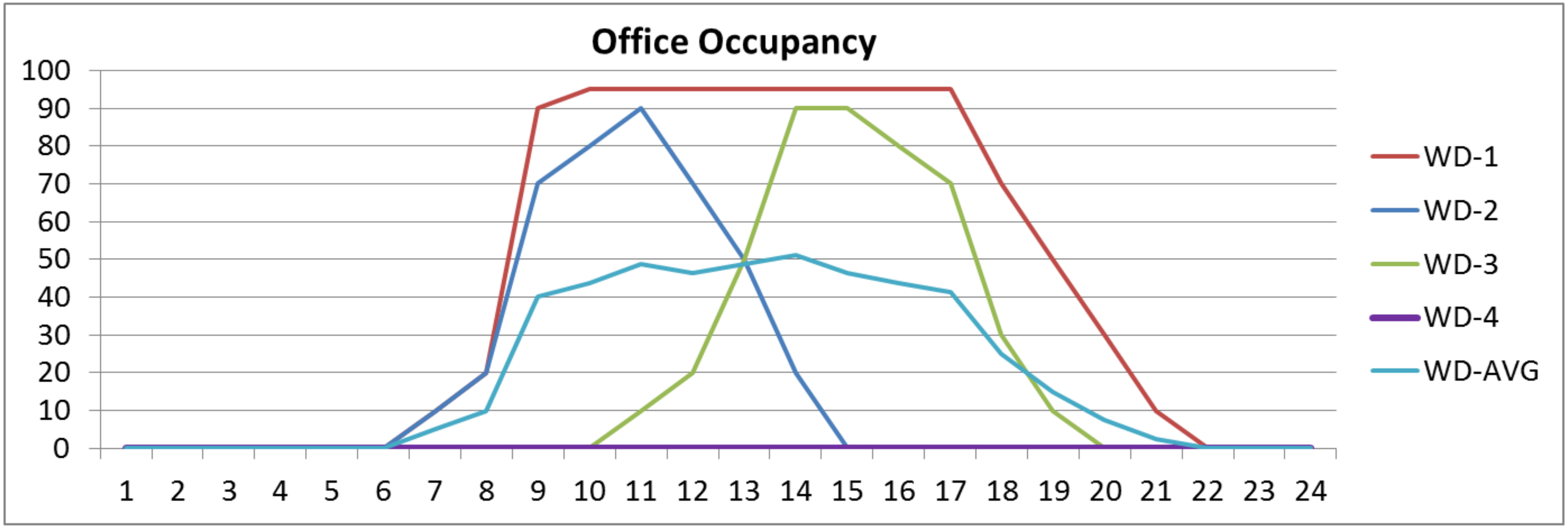
120.2(e)3 - Occupied Standby Controls. Zones serving only room(s) that are required to have occupant sensing lighting controls per sections 130.1(c)5 to 130.1(c)8, and where the ASHRAE Standard 62.1 occupancy category permits ventilation air to be reduced to zero when the space is in occupied-standby mode, shall meet the following within 5 minutes of all room(s) in that zone entering occupied-standby mode.

1. Active heating setpoint shall be setback at least 0.5ºF, and
2. Active cooling setpoint shall be setup at least 0.5ºF, and
3. All airflow supplied to the zone shall be shut-off whenever the space temperature is between the active heating and cooling setpoints

~~**EXCEPTION 5 to Sections 120.2(e)3:**. If Demand Control Ventilation is implemented as required by Section 120.1(c)3 and 120.1(c)(4).~~

Proposed Code Change - ACM

- New realistic schedules to incent occupied standby controls where it is optional (also needed to incent dual max controls and TAV)
- 4 separate weekday schedules randomly assigned to zones in the building on a daily basis. On the first weekday the first zone is assigned schedule WD-1, the second zone is assigned WD-2, etc. Each weekday each zone moves to the next schedule.



Why Are We Proposing This Code Change

- Support ZNE goals
- Achieve significant energy savings
- Align with model codes
- Keep up with ASHRAE 90.1
- Improve compliance with existing standards

What do you think? (Discussion)

- What are your thoughts on the proposed code changes?
- Any questions or concerns?

3. Technical and Market Barriers

Technical and Market Barriers

No technical or market barriers are anticipated

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - There are no anticipated design phase changes
  - Designers are used to implementing existing occupant sensor ventilation requirements and this is only expanding and simplifying those requirements

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - There are no anticipated permit application phase changes
  - Performance compliance modelers should know how to take credit for optional use of occupied standby
  - Plan checkers are used to occupant sensor ventilation and know what to look for, but need to check that ventilation is set to turn down to zero in control strategies

Compliance Process

Construction Phase

- What happens in construction phase?
  - There are no anticipated construction phase changes

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - There should be another acceptance test similar to "2016-NRCA-LTI-02-A-Lighting Control" and "2016-NRCA-MCH-06-A-Demand Control Ventilation" to functionally test Occupant Sensor Ventilation controls

Compliance and Enforcement Barriers

There are no anticipated compliance or enforcement barriers

What do you think? (Discussion)

- Did we capture technical and market barriers?
- Did we capture compliance and enforcement barriers?
- Are there other barriers — or solutions — we haven't discussed?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2016 Standards or industry standard practice
- Large office prototype building
- Occupant sensor ventilation included in spaces where it is currently required
- Ventilation air does not turn to zero when spaces are unoccupied

Proposed Conditions

- Compliant with proposed code change
- Large office prototype building
- Updated spaces that require occupancy sensor ventilation
- Added more complex controls to estimate amount of hours in a day spaces are unoccupied
- Turn down ventilation air to zero when spaces are unoccupied

Cost-Effectiveness Analysis

Incremental Costs

- Incremental First Cost
  - Upgraded Occupancy Sensor ($100/room)
  - **Total Incremental First Cost ($100/room)**
- Incremental Maintenance Costs over 15-year period of analysis
  - **Zero Incremental Maintenance Cost**

Small Hotel	**1 room**	**$100**	**$0.00/sf**
High-Rise	**1 room**	**$100**	**$0.00/sf**
Small office	**4.5 rooms**	**$450**	**$0.08/sf**

Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of $x,xxx to $y,yyy depending on climate zone**
  - *Energy cost savings explained in more detail in following slides.*
- **Total Incremental Cost Savings (Benefit) over 15/30-year period of analysis = $x,xxx**

Annual Energy Savings calculations in progress, but all savings will be positive across all climate zones

Benefit-to-Cost Ratio

Climate Zone	Benefit to Cost
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Cost-Effective in All Climate Zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings Per [unit]

Climate Zone	TDV Energy Savings (TDV kBtu/yr)	15/30 Year TDV Energy Cost Savings ($2020)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Annual Energy Savings Per [unit]

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (kWh/yr)	Peak Electric Demand Reduction (kW)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

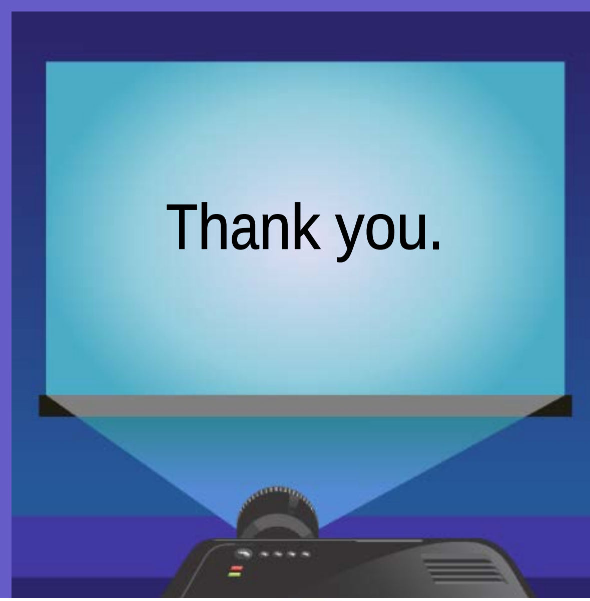
6. Next Steps

Next Steps

- Please send any additional feedback within 2 weeks to:
  - CASE Author (see contact info at end of this presentation)
  - Info@title24stakeholders.com
- Keep an eye on Title24Stakeholders.com for:
  - Presentations from today's meeting
  - Draft Code Change Language
  - Notes from today's meeting
  - Draft CASE Report (will be posted in April)

Let's move on to…

Fan System Power



- **Jeff Stein**
  JStein@taylor-engineering.com)
- **Stefan Gracik**
  sgracik@integralgroup.com)
- **Matt Dahlhausen**
  mdahlhausen@integralgroup.com

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Fan System Power

March 29, 2017

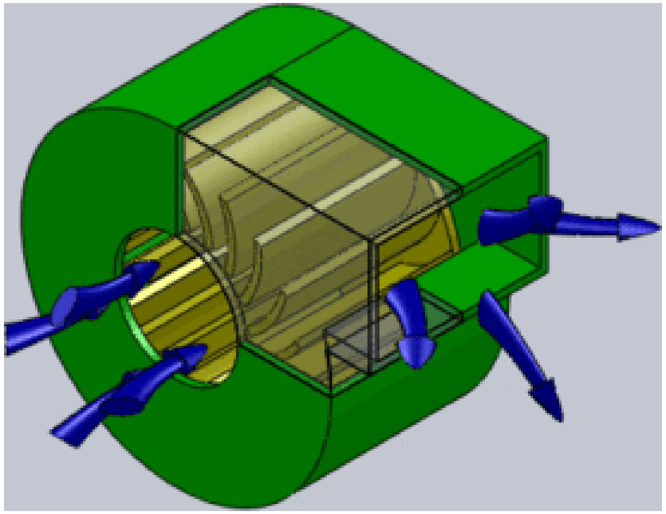
Ken Takahashi
510-663-2070
ktakahashi@integralgroup.com

Los Angeles Department of Water & Power · SMUD · SDG&E A Sempra Energy utility · SoCalGas A Sempra Energy utility · Southern California Edison An Edison International Company · Pacific Gas and Electric Company

1. Background

Introduction to Technology

- Fan
  - Creates airflow using rotational motion
  - Uses an electric motor to move the fan



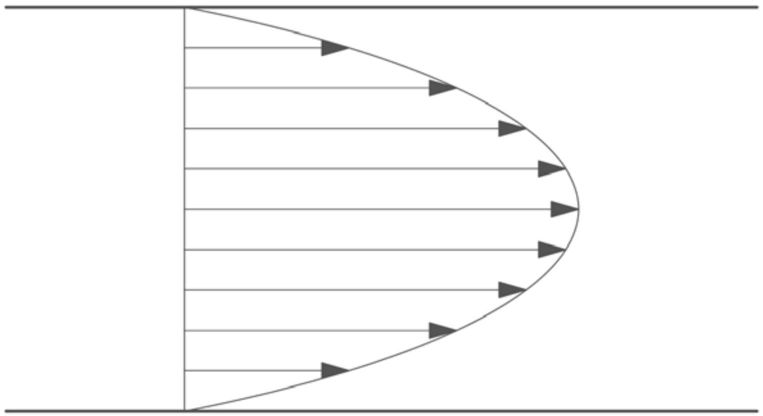
- Power measured in horsepower (hp) or watts (W)

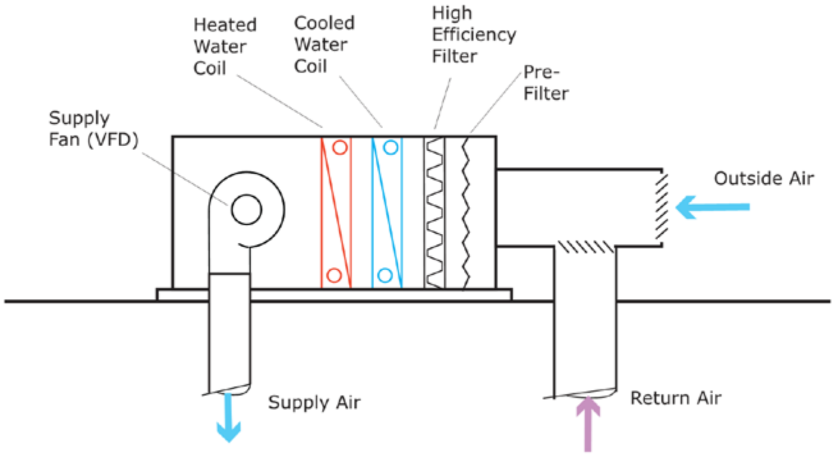
- Amount of airflow measured in cubic feet per minute (CFM)

Introduction to Technology

- Static Pressure is the resistance to air flow
  - Affected by ductwork, filters, coils, or other air-side equipment
  - Units of measurement: inch water column (in. w.c.)
  - Higher static pressure = More fan power

- Proposed measure aims to reduce static pressure allowances

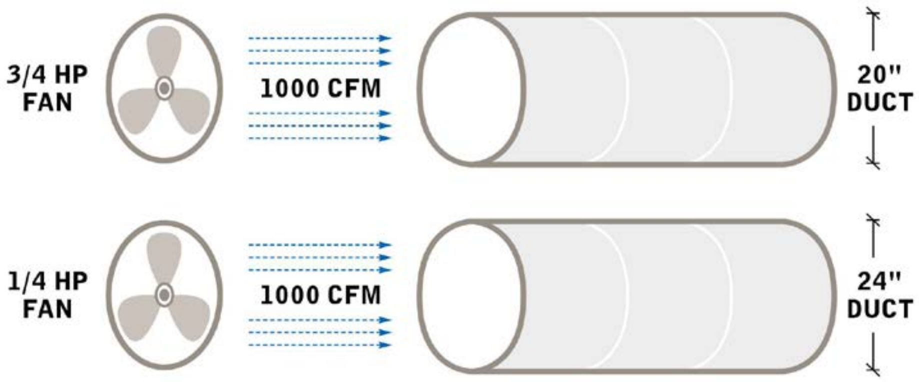




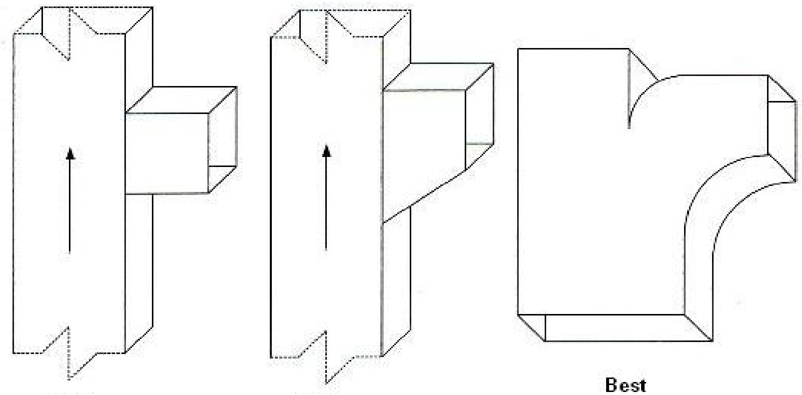
Introduction to Technology

Ways to reduce external static pressure

Larger Ducts



Smoother bends



Relevant Code History

- There are existing requirements in Title 24, Part 6
  - Prescriptive requirement for power consumption of fans (added 1992)
    - 0.8 W/cfm for constant volume systems
    - 1.25 W/cfm for variable volume systems

- Other Relevant Code Requirements
  - Nonresidential Alternate Compliance Method Reference Manual
    - Sets fan power for limit for the baseline for performance compliance
  - ASHRAE 90.1
    - Limits fan horsepower based on airflow
  - DOE 10 CFR 431
    - Establishes motor efficiencies

What do you think? (Discussion)

- Do you understand the technology / building system and how it saves energy?
- Any questions or concerns?

2. Proposed Code Changes

Proposed Code Change

- High-level description of the proposed code change include:
  - Revisions to the existing prescriptive code
  - Affects all building complying under prescriptive compliance path
  - Affects space conditioning fan systems with a total power of 5 hp or greater
    - Sum of fans including supply, return/relief, exhaust, fan-powered boxes.
  - Calculation method based on ASHRAE 90.1 2016 6.5.3.1 and aligning with NR ACM requirements
  - Adopt ASHRAE 90.1 2016 adjustment factors tied to process loads
    - Include filters, air treatment, and heat recovery devices*
    - Exclude sound attenuators, evaporative humidifier/coolers, and return/exhaust systems

**Heat recovery device credit can only be taken when required by code.*

Why Are We Proposing This Code Change

- Update fan power compliance method introduced in 1992
- Regulate more fans (minimum of 5 hp down from 25 hp)
- Keep up with ASHRAE 90.1 as required by federal statues
- Make fan power calculation more transparent to designers
  - Allow designer to calculate based on what is actually designed
- Allow State of California to limit pressure drops through various devices that affect fan power including future devices
- Alignment with NR ACM requirements

Why Are We Proposing This Code Change

Nonresidential Alternate Compliance Method Requirements

- Standard Design in the NR ACM should represent the prescriptive requirements of Title 24, Part 6
  - Allows for proposed design to have tradeoffs between prescriptive codes
- Discrepancy between Title 24, Part 6 and NR ACM
  - NR ACM is much more stringent than prescriptive standard

	Motor Size	Total Static Pressure	W/cfm
Title 24 Part 6	25 hp	6.2”	1.25
NR ACM	25 hp	4.5”	0.91

Proposed Code Change

- Proposed fan system total static pressure.

Total Static Pressure	Constant Volume	Variable Volume
Title 24 Part 6	3.96”	6.18”
ASHRAE 90.1	3.85”	5.35”
Proposed (NR ACM)	3.50”	4.50”

Note: ASHRAE assumes 65% fan efficiency, NR ACM assumes 62% fan efficiency.

3. Technical and Market Barriers

Technical and Market Barriers

- Lower Static Pressure Duct Design
  - Changes in design practices for duct layout
    - No major changes anticipated. Typical practices don't reach above 6" of total static pressure without additional filter or process equipment.
  - More space taken up by ducts
    - Coordinate early with structural engineers and architects to allocate more space.
  - Increased sheet metal
  - If larger ductwork is not an available option,
    - Specify a more efficient or larger fan
      - less power for same airflow
    - Adjustment factors for process equipment

Feedback on the Proposed Code Change

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - Mechanical designer lays out ductwork.
  - Mechanical designer specifies fan system.
  - Coordination with structural engineer and architect to achieve static pressure target.

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - Mechanical designer or energy consultant compares proposed fan brake horsepower with allowed fan brake horsepower
  - Changes to compliance form to reflect new requirements (NRCC-MCH-07-E)

Compliance Process

Construction Phase

- What happens in construction phase?
  - Sheet Metal subcontractor installs ductwork and HVAC system
  - No changes to current practices

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - Inspector check for correct fan installation
  - No changes to current practices
  - No field verification or acceptance test

What do you think? (Discussion)

Since there are no changes to the technology or major changes to design practices, we do not anticipate any compliance and enforcement barriers…

- Do you agree?
- Any questions, concerns, or suggestions?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - Complaint with prescriptive code
  - 1.25 W/cfm
  - Static pressure varies from 5.9" w.c. to 6.3" w.c. based on motor efficiency
  - 62% fan efficiency

- **Proposed Conditions**
  - Compliant with NR ACM manual
  - 4.5" w.c. of static pressure
  - W/cfm varies from 0.95 W/cfm - 0.88 W/cfm based on motor efficiencies
  - 62% fan efficiency

Cost-Effectiveness Analysis

Incremental Costs

- Incremental First Cost
  - Increased sheet metal ($0.30-$0.48/ft²$ depending on climate zone)
  - **Total Incremental First Cost ($0.30-$0.48/ft²)**
- Incremental Maintenance Costs over 15-year period of analysis
  - None anticipated ($0)
  - **Total Incremental Maintenance Cost ($0)**

- **Total Incremental Cost over 15/30-year period of analysis = $0.30-$0.48/ft²**

Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of $\$0.40/ft^2$ to $\$1.25/ft^2$ depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = $\$0.40/ft^2$ to $\$1.25/ft^2$**

Benefit-to-Cost Ratio

Climate Zone	Benefit to Cost
1	1.15
2	1.45
3	1.29
4	1.45
5	1.33
6	1.66
7	1.68
8	1.72
9	1.76
10	1.55
11	1.53
12	1.50
13	1.46
14	1.69
15	1.81
16	1.18

Cost-Effective in All Climate Zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	**4.66**	**$0.41**
2	**6.25**	**$0.56**
3	**5.49**	**$0.49**
4	**6.37**	**$0.57**
5	**5.67**	**$0.50**
6	**7.22**	**$0.64**
7	**7.23**	**$0.64**
8	**7.58**	**$0.67**
9	**7.84**	**$0.70**
10	**7.54**	**$0.67**
11	**6.89**	**$0.61**
12	**6.48**	**$0.58**
13	**6.56**	**$0.58**
14	**7.99**	**$0.71**
15	**8.43**	**$0.75**
16	**6.44**	**$0.57**

Annual Energy Savings per Square Foot

Climate Zone	Annual Electricity Savings (kWh/ft²-yr)	Annual Natural Gas Savings (therms/ft²-yr)	Peak Electric Demand Reduction (kW/ft²)
1	0.19	-0.003	0.00002
2	0.22	-0.002	0.00003
3	0.21	-0.002	0.00003
4	0.23	-0.001	0.00003
5	0.22	-0.002	0.00003
6	0.24	-0.001	0.00003
7	0.24	0.000	0.00003
8	0.24	-0.001	0.00003
9	0.25	-0.001	0.00004
10	0.24	-0.001	0.00004
11	0.24	-0.002	0.00004
12	0.23	-0.001	0.00004
13	0.24	-0.001	0.00004
14	0.27	-0.001	0.00004
15	0.28	-0.000	0.00004
16	0.25	-0.003	0.00004

What about costs and energy savings?

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Exhaust Air Heat Recovery

March 29, 2017

Ken Takahashi
510-663-2070
ktakahashi@integralgroup.com

Los Angeles Department of Water & Power · SMUD · SDG&E A Sempra Energy utility · SoCalGas A Sempra Energy utility · Southern California Edison · Pacific Gas and Electric Company

1. Background

Introduction to Technology

Exhaust Air Heat/Energy Recovery

- Type of air heat exchanger that preconditions outdoor ventilation air by coming into indirect contact with the exhaust air

- Can recovery sensible or total energy
  - – Wheel type - total and sensible
  - – Plate type - total and sensible
    - Typically sensible only
  - – Run around coil - sensible only

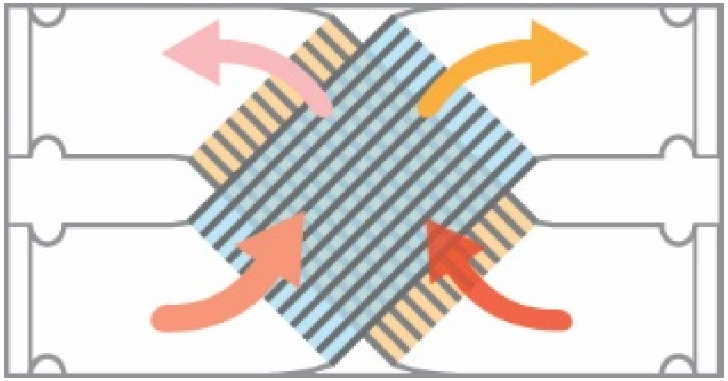
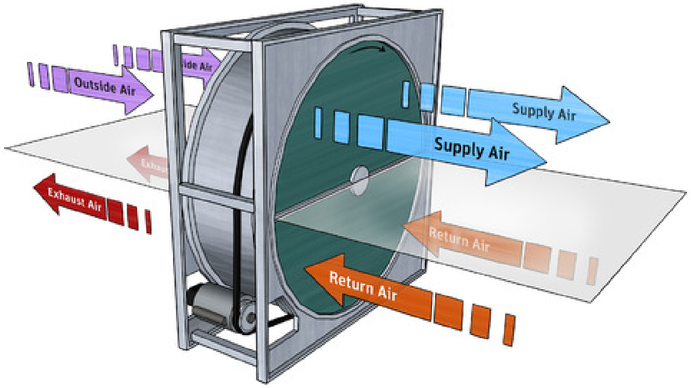


Plate type heat recovery



Wheel type heat recovery

Introduction to Technology

Exhaust Air Heat/Energy Recovery

- Saves energy by reducing the heating/cooling load on the incoming ventilation air.
- Uses the temperate exhaust air that will otherwise be released outside.

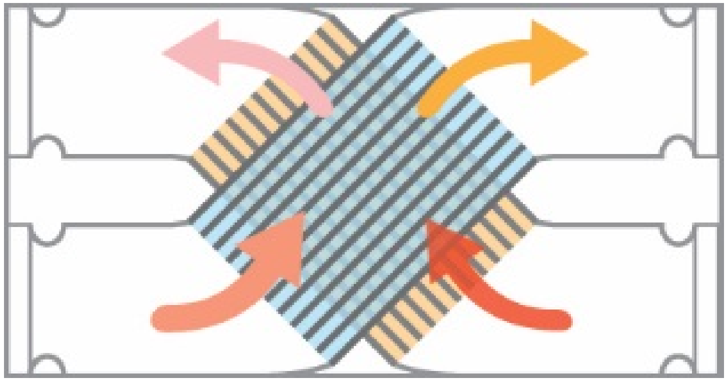
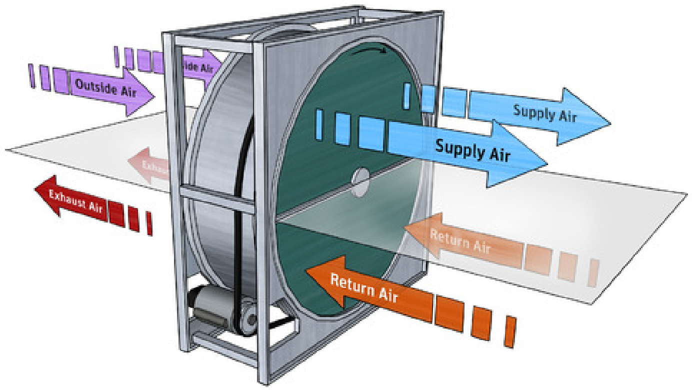


Plate type heat recovery

- Economizer bypass
  - When outdoor conditions are more suitable for air side economizers, the outdoor air should bypass the heat exchanger



Wheel type heat recovery

Introduction to Technology

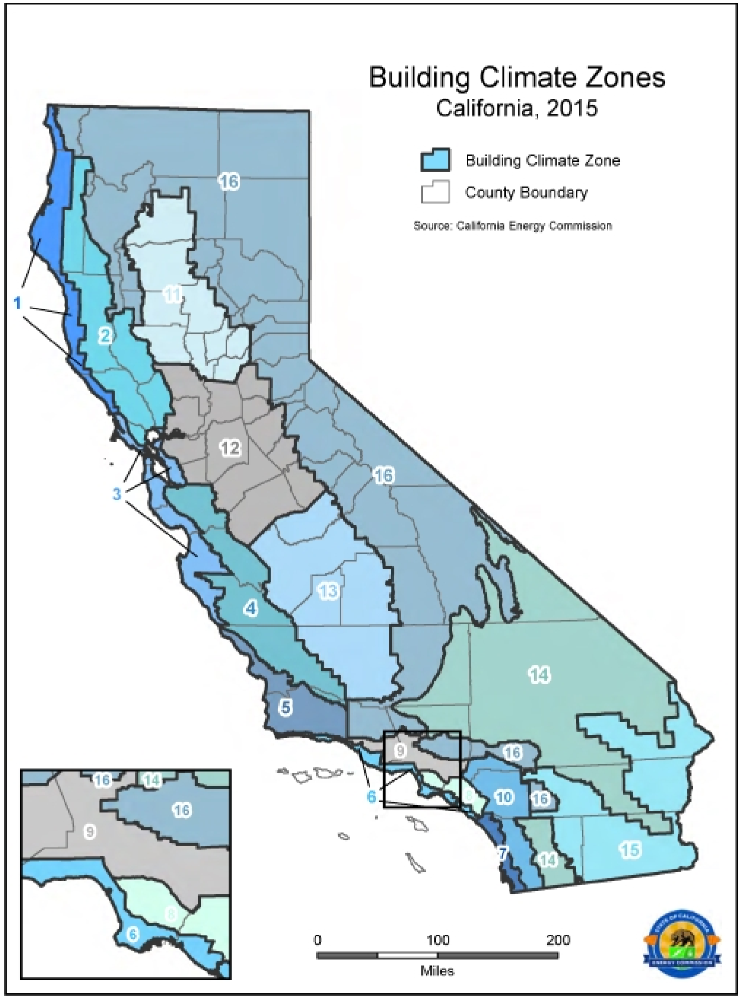
Warning

- Not cost effective in all California climate zones
  - Economizers should have priority over exhaust air heat recovery

- Energy recovered at the penalty of increased static pressure on fan system.
  - Wheel types also have a motor to rotate the wheel.

- Cross contamination

- **Energy savings on heating/cooling must overcome the fan penalty**



Relevant Code History

- There are no existing requirements in Title 24, Part 6
- Other Relevant Code Requirements
  - ASHRAE 90.1 2016 - Requires exhaust air heat recovery systems based on outdoor air fraction, supply airflow rate, hours of operation, and climate zone.

2. Proposed Code Changes

Proposed Code Change

- High-level description of the proposed code change include:
  - New prescriptive requirement
  - Affects nonresidential buildings in certain climate zones found to be cost effective
  - Based on ASHRAE 90.1 2016 requirements
    - Changes to minimum heat recovery effectiveness and climate zones

Why Are We Proposing This Code Change

- Capturing energy savings in certain climates
- Support ZNE goals
- Keep up with ASHRAE 90.1 as required by federal statues
- Prepare for future climate conditions and HVAC systems
  - Most effective in systems with 100% outdoor air supply

What do you think? (Discussion)

- What do you think of the code change proposal?
- Any questions or concerns?

3. Technical and Market Barriers

Technical and Market Barriers

- Economizer Bypass
  - Outdoor ventilation air must bypass heat recovery device when economizer is in operation
    - Recovering heat from exhaust air when outdoor air conditions are more favorable to economize can increase cooling energy.
  - Proper controls and monitoring will allow to maintain the free energy from economizer without compromising the heat recovery

Technical and Market Barriers

- Collocating intake and exhaust airstreams
  - Increased ductwork to reroute the exhaust duct near the intake
  - Most system with return air will have a relief air stream
  - Not all exhaust air must be recovered
    - Cross Contamination
  - Exception 6 in ASHRAE 90.1 Section 6.5.6.1
    - If the sum of airflow rates exhausted and relieved within 20 feet of each other is less than 75% of the design outdoor airflow rates, then exhaust air heat recovery is not required.

What about technical and market barriers?

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - Mechanical designer specifies and designs for exhaust air heat recovery.
  - Coordinate with contractor, manufacturer, and architect for technical feasibility of including heat recovery system.
  - Changes to design practice to allow for exhaust air heat recovery to be properly implemented.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - Mechanical designer or energy consultant makes sure heat recovery is required for the air system or climate zone.
  - Permit reviewer checks to make sure heat recovery device is required for the air system and climate and is properly designed.
  - Changes to compliance form to reflect new requirements (NRCC-MCH-02-E).

Compliance Process

Construction Phase

- What happens in construction phase?
  - – Sheet Metal subcontractor installs heat recovery device.
  - – No changes to the current practices of installing heat recovery.

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - – Inspector check for correct installation of heat recovery device.
  - – Checks to make sure economizer bypass is working properly.

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - School buildings
    - ~30% outdoor air ventilation
    - Operates less than 8000 hours a year
  - Office/Lab mixed use building
    - 100% outdoor air ventilation
    - Operates greater than 8000 hours a year
  - No heat recovery system
  - Supply airstream
    - 4.5” w.c. of static pressure
  - Return/Relief airstream
    - 1.0” w.c. of static pressure
  - Economizer as compliant with 2016 standard

- **Proposed Conditions**
  - 70% sensible effectiveness
  - 1” w.c. of static pressure added per airstream
    - *(2.2" * Effectiveness - 0.5") per air stream (ASHRAE 90.1 2016)*
  - Economizer bypass
    - No fan savings during economizer bypass

Cost-Effectiveness Analysis for Schools

Incremental Costs

- Incremental First Cost
  - Heat recovery device ($0.89 - $1.38/ft^2 depending on climate zone)
  - **Total Incremental First Cost ($0.99 - $1.48/ft^2)**
- Incremental Maintenance Costs over 15-year period of analysis
  - Cleaning and Annual Maintenance ($0.10/ft^2)
  - **Total Incremental Maintenance Cost ($0.10/ft^2)**

- **Total Incremental Cost over 15/30-year period of analysis = $0.99 - $1.48/ft^2**

Cost-Effectiveness Analysis for Schools

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of -$0.41/ft² to +$2.01/ft² depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = -$0.41/ft² to +$2.01/ft²**

Benefit-to-Cost Ratio for Schools

Climate Zone	Benefit to Cost
1	-0.34
2	0.40
3	-0.26
4	0.36
5	-0.31
6	-0.10
7	-0.31
8	0.17
9	0.53
10	0.69
11	1.05
12	0.70
13	0.71
14	0.66
15	1.45
16	-0.26

Cost-Effective in Climate Zones 11 and 15

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot for Schools

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	-4.56	-$0.41
2	5.41	$0.48
3	-3.42	-$0.30
4	5.19	$0.46
5	-4.22	-$0.38
6	-1.44	-$0.13
7	-4.21	-$0.37
8	2.37	$0.21
9	7.13	$0.63
10	11.01	$0.98
11	14.85	$1.32
12	9.95	$0.89
13	9.98	$0.89
14	9.79	$0.87
15	22.61	$2.01
16	-4.30	-$0.38

Annual Energy Savings per Square Foot for Schools

Climate Zone	Annual Electricity Savings (kWh/ft²-yr)	Annual Natural Gas Savings (therms/ft²-yr)	Peak Electric Demand Reduction (kW/ft²)
1	-0.16	0.0018	0.0000
2	-0.06	0.0009	0.0003
3	-0.16	0.0010	0.0001
4	-0.07	0.0007	0.0002
5	-0.16	0.0009	0.0001
6	-0.16	0.0004	0.0002
7	-0.18	0.0003	-0.0000
8	-0.10	0.0004	0.0004
9	-0.02	0.0005	0.0003
10	0.06	0.0005	0.0003
11	0.12	0.0007	0.0005
12	0.03	0.0008	0.0004
13	0.11	0.0008	0.0004
14	0.11	0.0007	0.0002
15	0.44	0.0003	0.0007
16	-0.18	0.0011	-0.0000

Cost-Effectiveness Analysis for Office/Lab

Incremental Costs

- Incremental First Cost
  - Heat recovery device ($2.03 - $3.02/ft^2 depending on climate zone)
  - **Total Incremental First Cost ($2.03 - $3.02/ft^2)**
- Incremental Maintenance Costs over 15-year period of analysis
  - Cleaning and Annual Maintenance ($0.30/ft^2)
  - **Total Incremental Maintenance Cost ($0.30/ft^2)**

- **Total Incremental Cost over 15/30-year period of analysis = $2.33 - $3.32/ft^2**

Cost-Effectiveness Analysis for Office/Lab

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of -$3.93/ft^2 to +$22.04/ft^2 depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = -$3.93/ft^2 to +$22.04/ft^2**

Benefit-to-Cost Ratio for Office/Lab

Climate Zone	Benefit to Cost
1	2.47
2	3.92
3	0.22
4	2.66
5	0.32
6	-0.37
7	-1.69
8	1.20
9	2.58
10	3.69
11	6.85
12	5.71
13	6.53
14	5.15
15	6.72
16	5.08

Cost-Effective in Climate Zones 1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot for Office/Lab

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	**64.94**	**$5.78**
2	**114.72**	**$10.21**
3	**5.85**	**$0.52**
4	**70.26**	**$6.25**
5	**8.54**	**$0.76**
6	**-9.59**	**-$0.85**
7	**-44.21**	**-$3.93**
8	**31.90**	**$2.84**
9	**82.29**	**$7.32**
10	**118.05**	**$10.51**
11	**237.79**	**$21.16**
12	**173.06**	**$15.40**
13	**191.72**	**$17.06**
14	**192.33**	**$17.12**
15	**247.61**	**$22.04**
16	**136.78**	**$12.17**

Annual Energy Savings per Square Foot for Office/Lab

Climate Zone	Annual Electricity Savings (kWh/ft^2-yr)	Annual Natural Gas Savings (therms/ft^2-yr)	Peak Electric Demand Reduction (kW/ft^2)
1	-2.11	0.57	0.0001
2	-0.94	0.44	0.0004
3	-2.10	0.21	0.0010
4	-1.36	0.21	0.0008
5	-2.07	0.25	0.0000
6	-1.96	0.04	0.0004
7	-2.24	-0.04	0.0001
8	-1.11	0.07	0.0013
9	-0.22	0.17	0.0003
10	0.40	0.22	0.0029
11	1.50	0.51	0.0027
12	0.19	0.43	0.0026
13	1.24	0.45	0.0017
14	1.44	0.51	0.0017
15	5.18	0.27	0.0030
16	-1.86	0.87	-0.0000

What about costs and energy savings?

6. Next Steps

Next Steps

- Please send any additional feedback within 2 weeks to:
  - CASE Author (see contact info at end of this presentation)
  - Info@title24stakeholders.com
- Keep an eye on Title24Stakeholders.com for:
  - Presentations from today's meeting
  - Draft Code Change Language
  - Notes from today's meeting
  - Draft CASE Report (will be posted in April)

Let's move on to…

Wrap-up

- **Ken Takahashi**
  510-663-2070
  ktakahashi@integralgroup.com