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2019 Building Energy Efficiency Standards
Pre-Rulemaking Workshop

Residential Indoor Air Quality

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Acknowledgements

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Agenda

1. Background
2. Proposed Code Changes
3. Technical and Market Barriers
4. Compliance and Enforcement
5. Impacts to IAQ, Cost and Energy

Background

- Study of Ventilation and IAQ in New Homes (Offermann), 2009
- ASHRAE 62.2
- CA Title 24 Building Energy Efficiency Standards (BEES)

- Offermann study sponsored by CA Air Resources Board and CA Energy Commission (PIER).
- 105 homes, built between 2002 – 2004.
- Nearly all homes had formaldehyde concentrations that exceeded guidelines for cancer and chronic irritation, while 59 percent exceeded guidelines for acute irritation.
- 2008 CA Title 24 Part 6 BEES adopted ASHRAE 62.2-2007 by reference.
  - Mandatory mechanical ventilation in newly constructed buildings.
  - Window operation not allowed for compliance with IAQ ventilation requirement.
  - MERV 6 air filters.
- 2013 and 2016 CA Title 24 Part 6 BEES adopted by reference ASHRAE Standard 62.2-2010 Including Addenda b, c, e, g, h, i, j, l, and n (ASHRAE 62.2-2010-CA).
  - Mandatory HERS verification of Whole-Building IAQ ventilation airflow.

Reducing In-Home Exposure to Air Pollution (Singer) 2016

- Singer study sponsored by CA Air Resources Board.
- Evaluated eight combinations of ventilation and air cleaning systems for pollutant removal and energy use.
- Systems were installed in an unoccupied 2006 house located 800 ft. downwind of Interstate 80 in Sacramento.
- Results demonstrate substantial benefits of high efficiency filtration at reducing air pollutant exposures, but with varying energy costs.
- MERV13 to MERV16 filtration on the central forced air system reduced outdoor PM2.5 by 90-97% when operated at least 20 min each hour or continuously at low-speed.
- Exhaust ventilation pulling outdoor air through the envelope (the reference system) yielded indoor PM2.5 levels that were 70% lower than outdoors.
- Supply ventilation with a MERV13-rated filter resulted in less protection than the Reference, indicating a need for high performance filtration (MERV 16) when using supply ventilation.
- The robustness of using the air handler for filtration improves when the filter cabinet can accommodate a deep-pleat, low resistance filter that removes a high percentage of all size fractions of PM2.5 (including ultrafine particles)

Key changes in ASHRAE 62.2-2016 Compared to Current CA Version of ASHRAE 62.2-2010

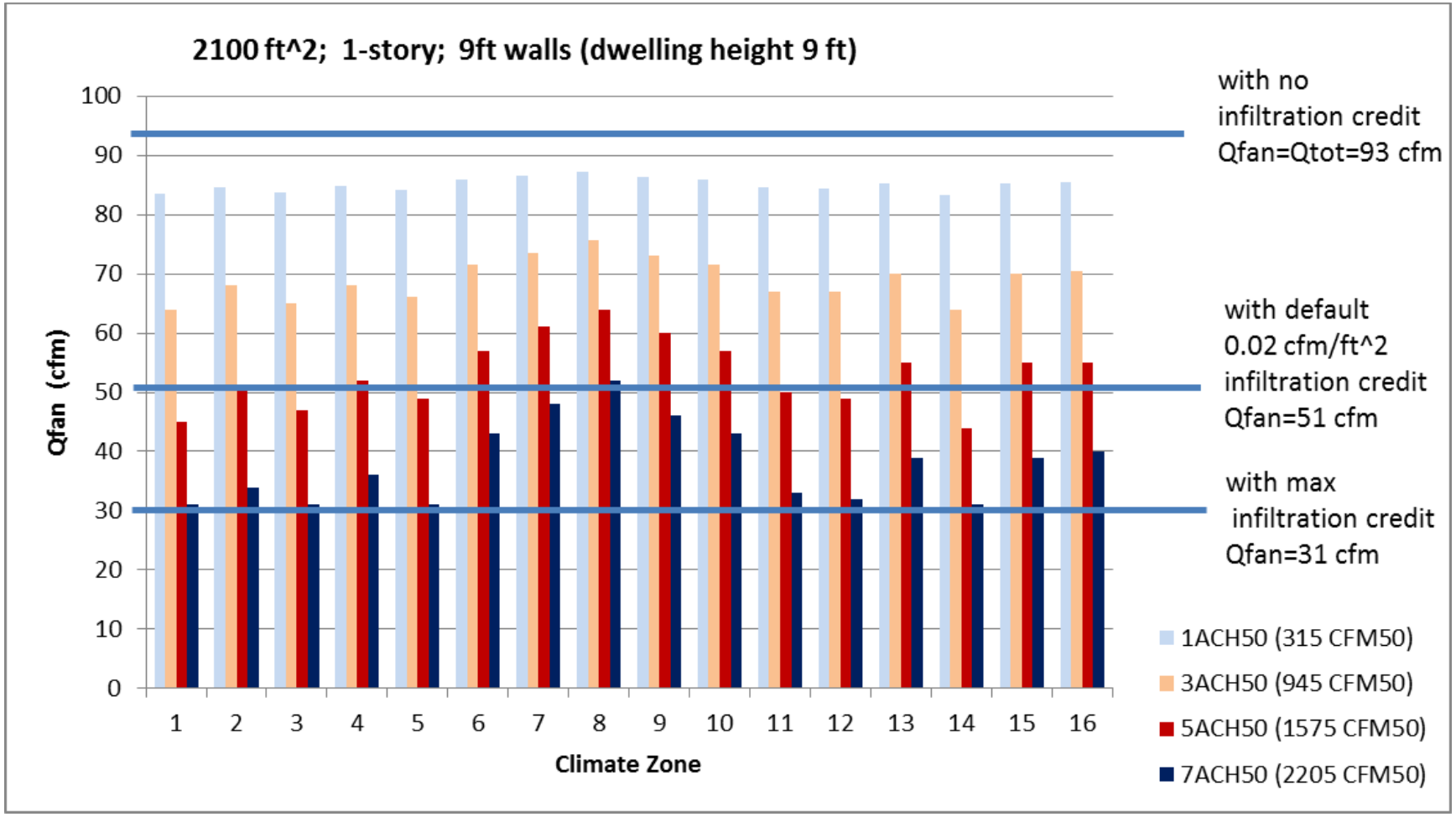
- Fan Ventilation Rate Method is eliminated. $Q_{fan} = 0.01 \times A_{floor} + 7.5x(N_{br} + 1)$
  - This assumed a *default* $0.02 \times A_{floor}$ infiltration credit.
- Total Ventilation Rate Method now required. $Q_{tot} = 0.03 \times A_{floor} + 7.5x(N_{br} + 1)$
  - An infiltration credit (Q_{inf}) up to a maximum value of 2/3 x Q_{tot} can be taken which reduces the required IAQ ventilation fan airflow (Q_{fan}). A blower door measurement is required to calculate the credit.
  - $Q_{fan} = Q_{tot} - Q_{inf}$
  - Partial infiltration credit is allowed for horizontally attached single family dwellings - see ASHRAE 62.2-2016 section 4.1.2 (townhouse, duplex).
- A change in scope: 62.2 now covers ALL residential dwelling units, including high rise residential dwelling units.

Key changes in ASHRAE 62.2-2016 Compared to Current CA Version of ASHRAE 62.2-2010

- The Intermittent Ventilation Section has been eliminated.
- New sections for Variable Mechanical Ventilation, Real Time Control, and Equivalent Ventilation provide options for compliance using alternative system designs or controls (ASHRAE 62.2-2016 sections 4.5, 4.6 and Normative Appendix C).
  - Methods to verify that these systems would comply with required ventilation airflow rate are not specified.
- Air sealing target for the optional blower door test for multifamily dwelling units:
  - Now 0.3 cfm/ft2 at 50 Pa (was 0.2 cfm/ft2) This is roughly equivalent to a value of between 4 and 6 ACH50 depending on dwelling architectural features. (ASHRAE 62.2-2016 section 6.1.1).
- Gravity or barometric dampers in non-powered makeup air systems are not allowed for providing compensating outdoor air (ASHRAE 62.2-2016 section 6.4).

Infiltration Credit Q_{inf} Impact on Ventilation Fan Airflow Q_{fan}

Qtot = 0.03 x Afloor + 7.5x(Nbr + 1); Qfan = Qtot - Qinf



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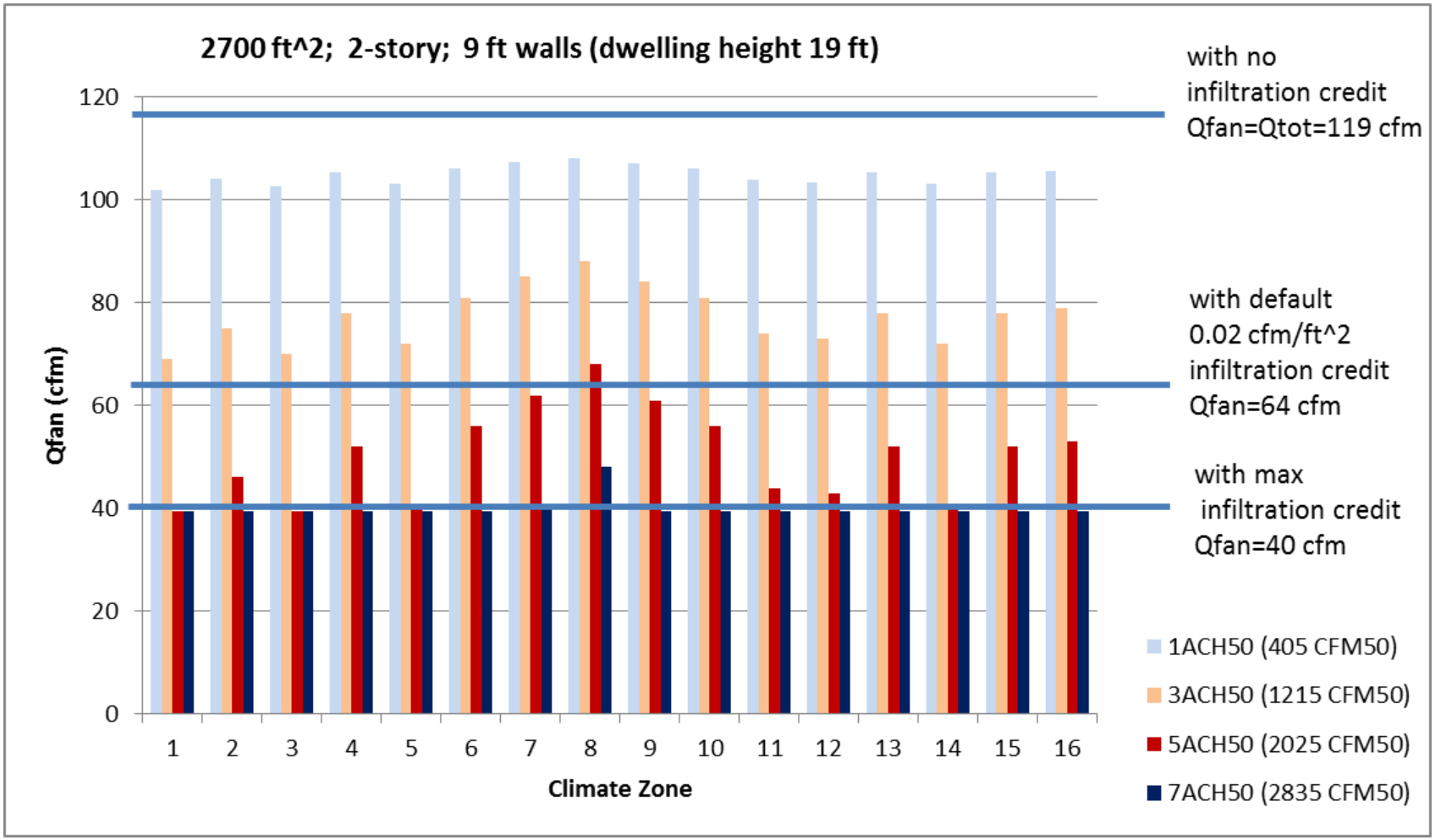


Proposed Code Changes

Proposed Code Changes - Overview

- Type of changes:
  - Mandatory with optional compliance paths
  - Updated to reference ASHRAE 62.2-2016 (with new California amendments)
- Scope:
  - Newly constructed buildings
  - Additions greater than 1000 ft^2
  - Single family
  - Low-rise multifamily
  - High-rise multifamily (new)
  - Altered components in existing buildings

Proposed Code Changes - Summary

- **New ASHRAE 62.2-2016 California Amendments:**
  - Amend method for calculation of dwelling-unit mechanical ventilation rate.
    - Use a default value of 2 ACH_{50} for calculation of infiltration credit for determining required dwelling ventilation rate for all dwellings (no blower door test).
  - Increase air filter efficiency from MERV 6 to MERV 13; require 2-inch depth filter grille.
  - Require air filtration for:
    - supply ventilation systems, and
    - the supply side of balanced ventilation systems .

    Note: air filter requirement currently applies only to ducted space conditioning systems.
  - For Multifamily dwellings, comply with either:
    - Use of only balanced ventilation, or
    - HERS verified dwelling enclosure sealing (blower door test)

Proposed Code Changes – Summary (cont.)

- **New Title 24 BEES requirements:**
  - HERS verification to ensure kitchen range hood is HVI certified to meet the 100 cfm and 3 sone requirement.
- **New for high-rise multifamily:**
  - Scope change: high-rise multifamily subject matter is moved from ASHRAE 62.1 to ASHRAE 62.2 which will result in a reduction to the mechanical ventilation airflow rate requirements for these dwellings.
  - HERS verification of
    - MF building central ventilation duct/shaft leakage ≤ 6%.
    - MF building central ventilation system - air balance
    - Dwelling-unit ventilation airflow ≥ ASHRAE 62.2 minimum.

Changes in Ventilation Rate Calculation

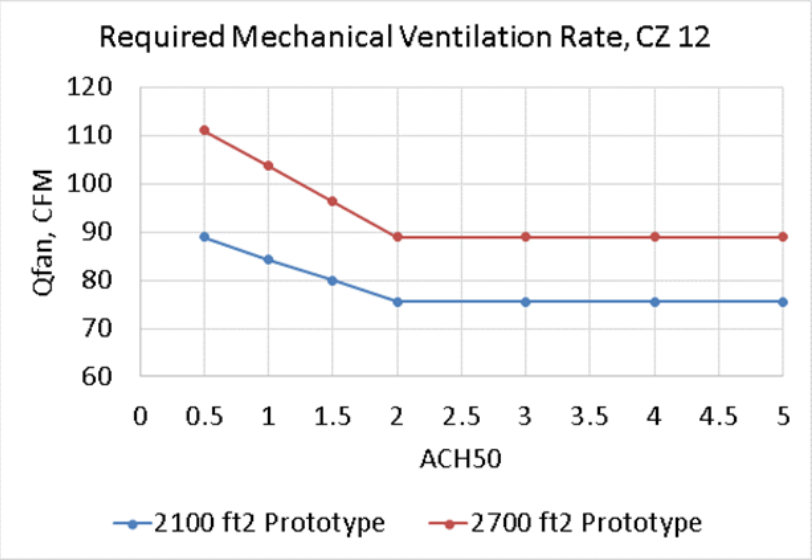
- Single family ventilation rate Q_{fan} will increase with the new calculation method
  - $Q_{fan} = Q_{tot} - Q_{inf}$ where $Q_{tot} = 0.03 \times A_{floor} + 7.5x(N_{br} + 1)$
  - Q_{inf} calculation will be based on:
    - Default value of 2 ACH_{50} (applicable to most dwellings),
    - The building height,
    - Climate zone or weather station data

Note: CBECC inputs for building envelope infiltration for building energy modeling will not be linked to the IAQ ventilation rate calculation. The envelope leakage value (ACH_{50}) for building energy credit is not required to be the same value (ACH_{50}) as used to determine Q_{inf} for the mechanical ventilation rate. CBECC will include a result for ventilation airflow Q_{fan} in the building energy model calculations.

- Q_{fan} will be calculated for each dwelling by the ACM for the performance compliance approach.
- Low-rise multifamily ventilation rate will not change
  - Infiltration credit is not allowed for multifamily dwellings, thus $Q_{fan} = Q_{tot}$
- High-rise multifamily ventilation rate will decrease due to the transition from ASHRAE 62.1 scope to ASHRAE 62.2 scope

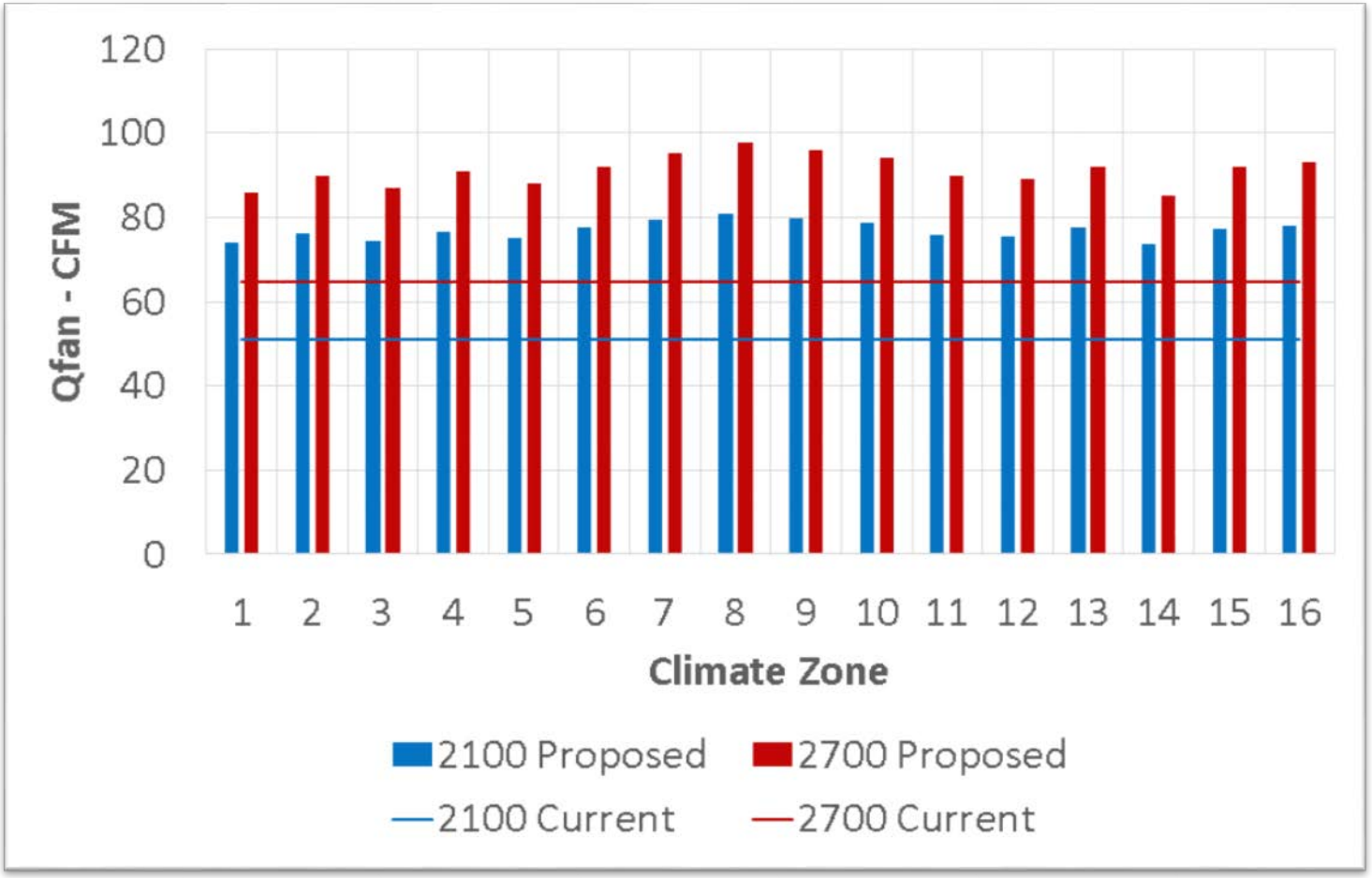
Single Family Dwelling Implementation of ASHRAE 62.2-2016

- When HERS verification of envelope leakage (blower door) is not required for building energy efficiency credit:
  - ACM uses the default value 5 ACH_{50} in calculations for building envelope leakage
  - Q_{fan} is determined from Q_{inf} which is calculated using default value of 2 ACH_{50}
- When HERS verification of envelope leakage is required for building energy efficiency credit:
  - When proposed envelope leakage is between 5ACH_{50} and 2 ACH_{50}
    - ACM uses the proposed ACH_{50} in calculations
    - Q_{fan} is based on the default 2 ACH_{50}
    - Blower door test verifies proposed
  - When proposed is below 2 ACH50
    - ACM uses the proposed ACH_{50}
    - Q_{fan} based on proposed ACH_{50}
    - Blower door test verifies proposed



Single Family Ventilation Rate by Climate Zone

Based on Default 2 ACH_{50}



Increase Air Filter Efficiency from MERV 6 to MERV 13

- Goal: Reduce dwelling indoor particulate matter (PM) concentrations due to both indoor and outdoor contaminant sources.
- California has one of the most serious particulate pollutant problems among the states
  - human-caused emissions (mainly vehicles)
  - windblown particulates from roadways, deserts, and agricultural operations.
  - PM 10 contamination affects almost all areas in the state
  - PM2.5 contamination is more concentrated near busy roadways; in the central valley; in metropolitan areas. Kitchen ranges are also major source of PM2.5.

Proposed requirement:

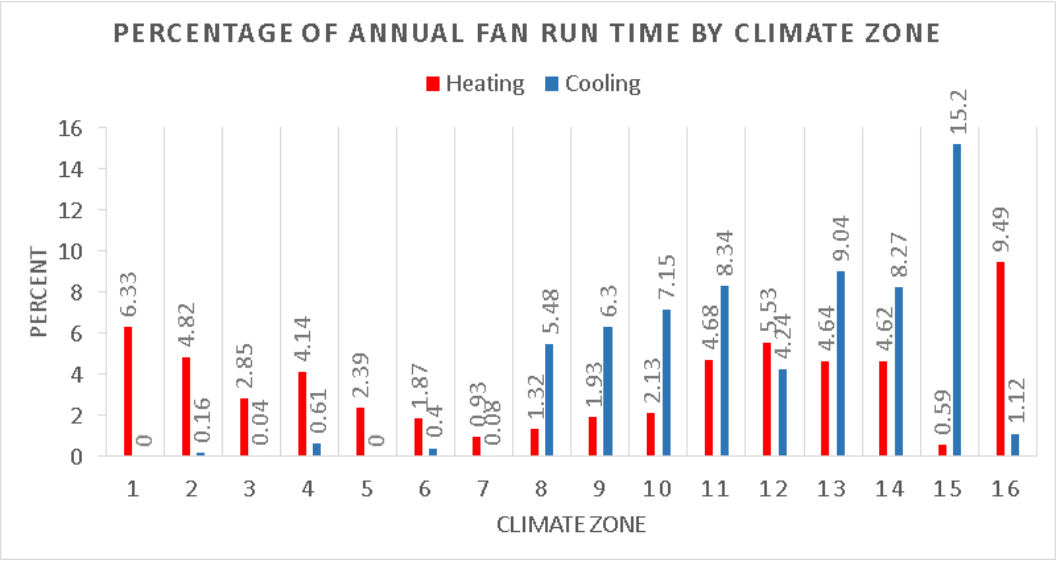
- Require MERV 13 air filtration on ducted space conditioning systems (currently MERV 6 is required)
- Require MERV 13 air filtration on supply ventilation systems and on the supply side of balanced ventilation systems (new requirement).

Particle Removal Efficiency (ASHRAE 52.2-2017)			
	Particle Size in microns		
MERV	0.3-1.0	1.0-3.0	3.0-10.0
6	n/a	n/a	35 ≤ E3
8	n/a	20 ≤ E2	70 ≤ E3
11	20 ≤ E1	65 ≤ E2	85 ≤ E3
12	50 ≤ E1	80 ≤ E2	90 ≤ E3
13	50 ≤ E1	85 ≤ E2	90 ≤ E3

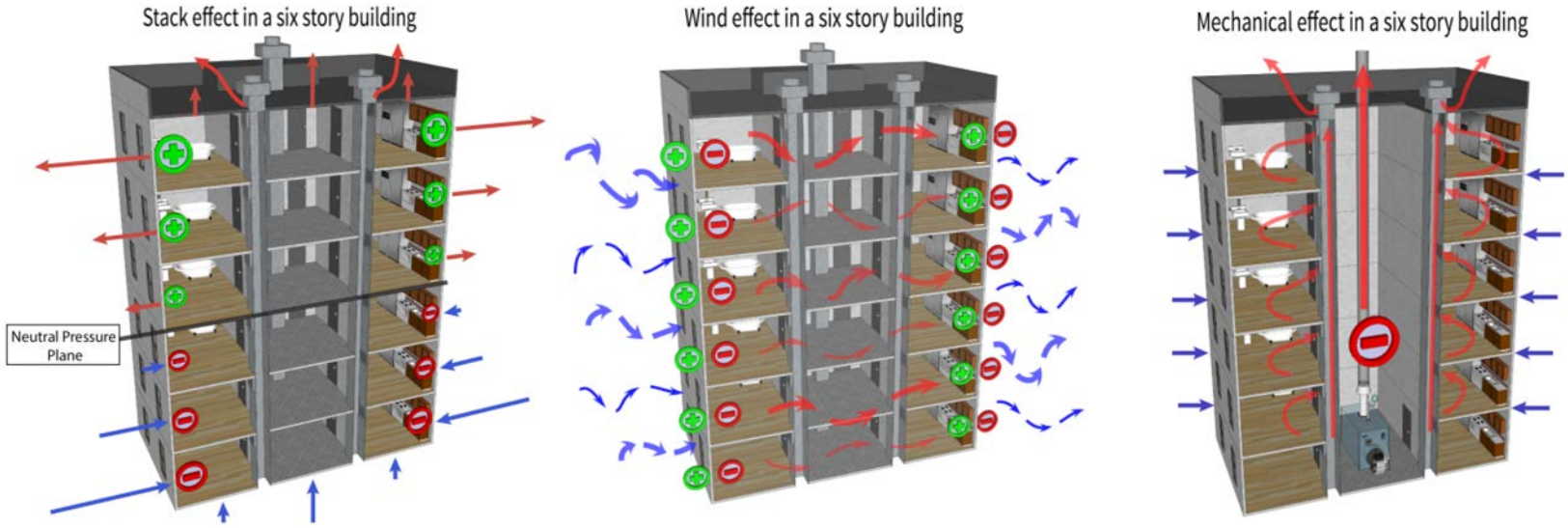
Considerations for use of MERV 13 filters on ducted HVAC systems

- Central fan run time is limited to calls for space conditioning.
- MERV 13 filters may impose approximately 5% higher pressure drops for equivalent filter face area sizes, so attention to proper filter grille sizing is necessary during the system design/installation. A 2-inch depth filter grille is proposed.
- Increased HVAC filter replacement cost.
- Increased cost for installation of 2-inch filter grille.
- Title 20 labeling requirement effective date postponed until 2019, however some filter manufacturers have already begun complying with the labeling requirement.

Annual Fan Run Time from CBECC			
	% Time	Hours	CZ
Average	7.8	683	
Maximum	15.8	1383	15
Minimum	1.0	88	7



Multifamily Building Infiltration and Exfiltration



Multifamily Compartmentalization Sealing and Testing

- Multifamily dwelling envelope sealing for building energy efficiency is mainly concerned with infiltration air leakage to outside the building.
- CA Title 24 BEES currently does not require multifamily buildings/dwellings to comply with a blower door verification to limit building envelope leakage
- Many states require compliance with the IECC Blower door performance metric (3 ACH_{50} or 5 ACH_{50} (depending on climate zone)
- CA Title 24 BEES currently does not offer energy efficiency credit for multifamily buildings for reduced infiltration air leakage (to outside the building).
- Blower door testing of individual MF dwelling units determines leakage that is a combination of leakage to outside the building, and leakage to adjoining dwelling units through the floor, ceiling, and walls (transfer air).
- Transfer air can transmit pollutants between dwellings, thus adversely affect IAQ.
- Unbalanced (supply-only and exhaust-only) ventilation systems may create pressure differences between dwellings, thus increase transfer airflow between dwellings.
- A balanced ventilation system minimizes pressure differences in the dwelling due to the ventilation airflows.

Multifamily Compartmentalization Sealing

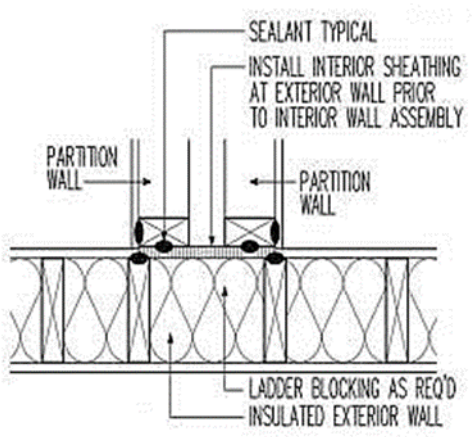
- Title 24, Part 6 Section 110.7 generally requires sealing of the building envelope, but does not specifically require sealing to limit air leakage between dwellings (transfer air) in multifamily buildings.

- ASHRAE 62.2-2016 Section 6.1 requires sealing of partition walls between MF dwellings.

SECTION 110.7 – MANDATORY REQUIREMENTS TO LIMIT AIR LEAKAGE

All joints, penetrations and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weather stripped, or otherwise sealed to limit infiltration and exfiltration.

6.1 Adjacent Spaces and Transfer Air. Measures shall be taken to minimize air movement across envelope components to dwelling units from adjacent spaces such as garages, unconditioned crawlspaces, unconditioned attics, and other dwelling units. Pressure boundary wall, ceiling, and floor penetrations shall be sealed, as shall any vertical chases adjacent to dwelling units. Doors between dwelling units and common hallways shall be gasketed or made substantially airtight. Supply and balanced ventilation systems shall be designed and constructed to provide ventilation air directly from the outdoors.



Multifamily Ventilation Systems and Compartmentalization Verification

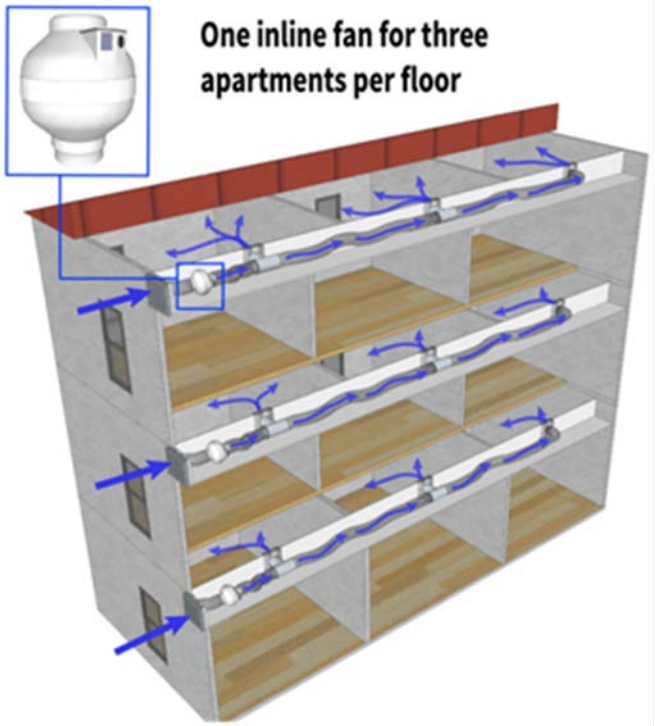
Proposed Requirements for all Multifamily Dwellings

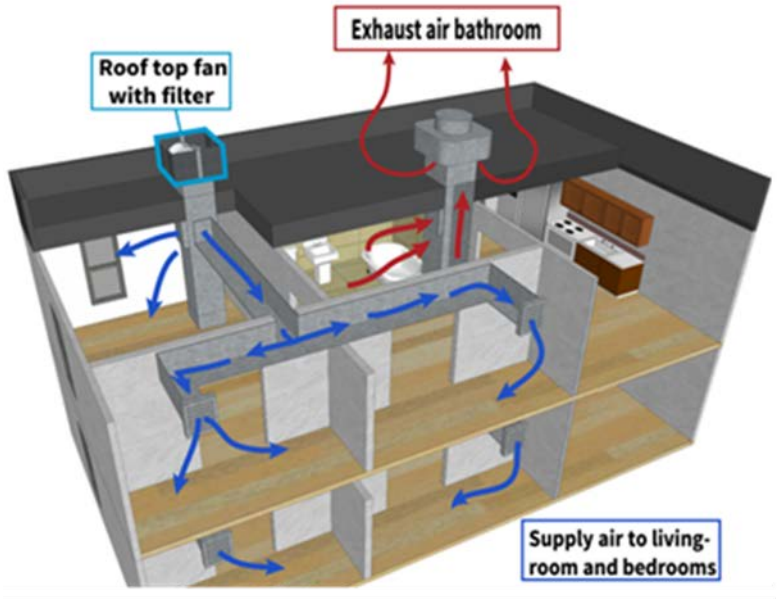
Compliance with either Option A or Option B is required for compliance with the dwelling-unit ventilation airflow rate requirement in section 4 of ASHRAE 62.2-2016 (with CA Amendments).

- ***Option A:*** Allow use of unbalanced ventilation systems (e.g. exhaust-only or supply-only) with passive make-up/relief air vents only if HERS blower door test verifies the dwelling unit envelope leakage is less than 0.30 cfm_{50}/ft^2 of dwelling envelope area according to ASHRAE 62.2-2016 Section 6.1.1.
- ***Option B:***
  - Require use of a balanced ventilation system (e.g. dwelling HRV, ERV or paired standalone supply and standalone exhaust, or balanced MF building central system).

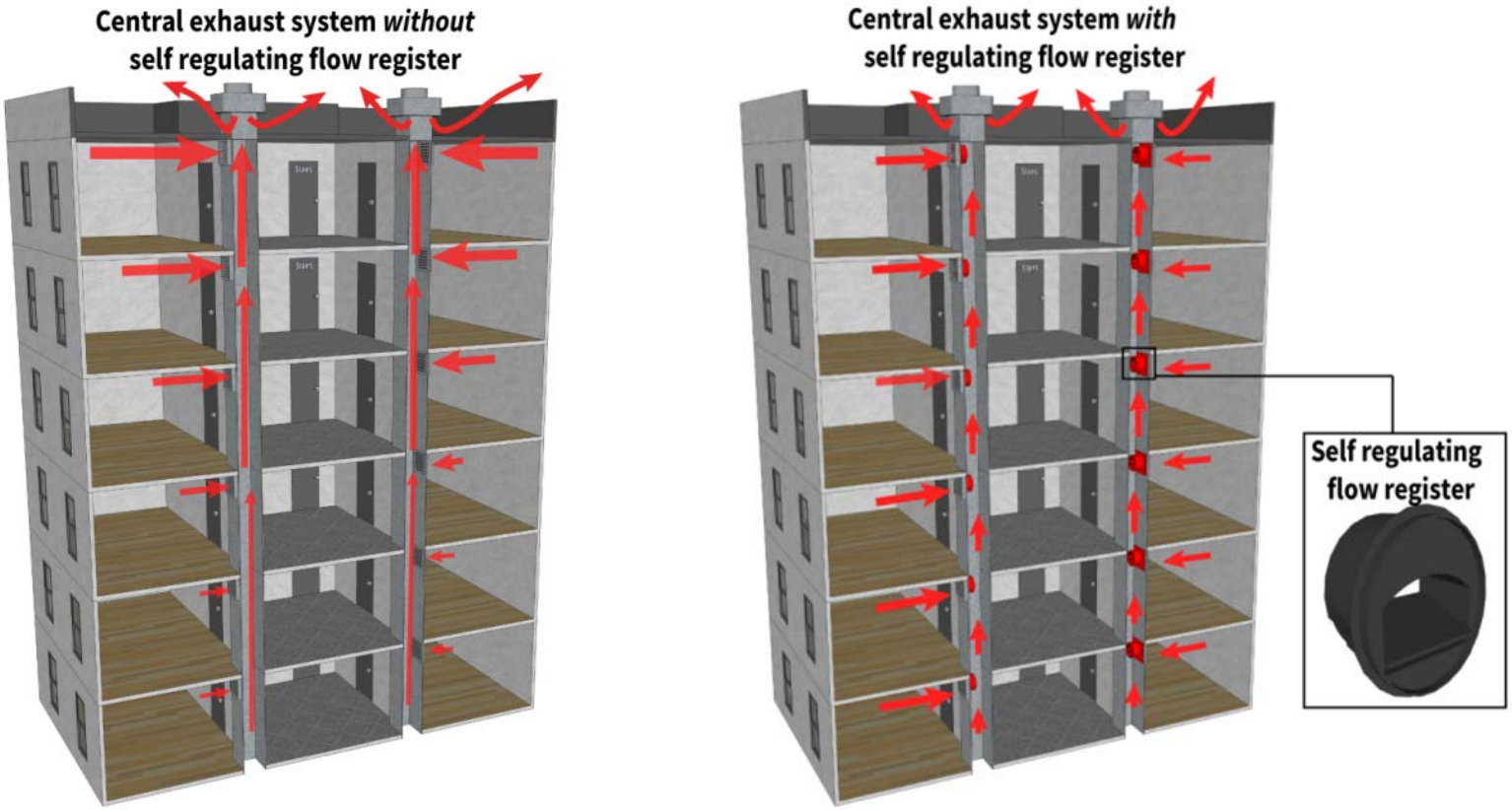
- Additional guidance for best practices to assist with improved compartmentalization sealing will be provided in the Residential Compliance Manual.

Example Multifamily Building Ventilation System Configurations





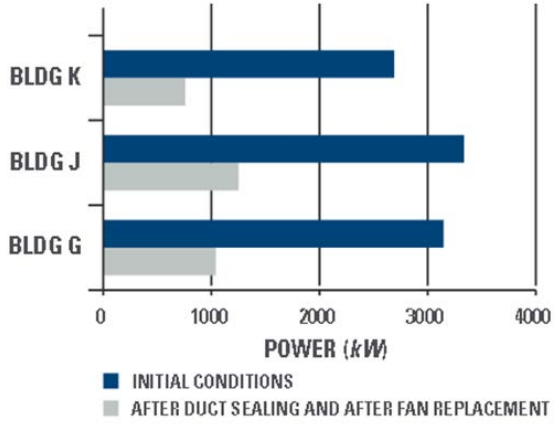
Multifamily Building Central Ventilation System Flow Balancing



Requirements for Multifamily Building Central Ventilation Systems

- HERS or ATT verification of sealed ventilation shafts/ducting to meet ≤ 6% of total central system airflow
- HERS or ATT verification of ventilation system air balance
  - All dwelling-unit ventilation airflows to be ≥ the required dwelling unit rate, but not more than 10% greater than the required dwelling unit rate (method of balance is optional)
  - Methods such as constant air regulation devices or orifice plates may be used in conjunction with VFD-controlled central fans.

Energy Plus Simulations



WCEC: Aerosol Duct Sealing in Central Exhaust Systems

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Indoor Air Contamination from Cooking and Kitchen Range

- Many studies have reported substantial emission rates of pollutants from cooking.
- Cooking associated pollutants include
  - fine particulate matter PM2.5
  - PM10
  - ultrafine particles
  - polycyclic aromatic hydrocarbons (PAH)
  - various volatile organic compounds
- High operating noise levels discourage range hood use
- Range Hood capture efficiency is not yet regulated for residential products
  - An ASTM standard method of test in in development for residential products
  - By contrast, commercial hoods are required to have very high capture efficiency
- 2008, 2013, and 2016 Title 24 BEES adopted ASHRAE 62.2 requirements for use of HVI certified kitchen range hoods rated to provide 100 CFM at 3 sone.
- Energy Commission staff has the understanding that the required HVI certification for 100 CFM and 3 sone is often not enforced.
- There are currently no over-the-range microwave combination kitchen hood products certified to HVI.

Kitchen Range Hood Certified Performance Ratings

- Ratings
  - **HVI**
    - CFM
    - Sones
  - Energy Star
    - ≥ 2.8 cfm / W at 25 Pa
    - ≤ 2 sone
    - < 500 cfm
  - ASTM
    - Capture efficiency standard development in progress

Kitchen Range Hood Performance

- Current requirement (ASHRAE 62.2-2010-CA)
  - 100 cfm minimum range hood vented to outdoors or 5 ACH continuous exhaust
  - Maximum 3 sones unless maximum rated airflow exceeds 400 cfm

- **Proposed requirement (ASHRAE 62.2-2016)**
  - *Enclosed kitchen*: 100 cfm range hood (or 300 cfm downdraft) vented to outdoors, or 5 ACH continuous exhaust
  - *Non-enclosed kitchen*: 100 cfm range hood vented to outdoors
  - All range hood exhaust fans ≤ 3 sones (unless min. speed >400 cfm)
- **Proposed enforcement measure**
  - HERS verification that the hood is HVI certified to meet the 100 cfm and 3 sone requirements

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Technical and Market Barriers

Technical and Market Barriers (1 of 4)

- Cost of larger ventilation fans for single family homes
- Resolution:
  - In most cases the increased ventilation rate will require a step up in fan size, for example from 50 cfm to 80 cfm, or from 80 cfm to 110 cfm
  - The incremental cost is typically not more than $10
  - More than one bathroom fan can be operated to provide whole-house ventilation in larger homes

Technical and Market Barriers (2 of 4)

- Kitchen hood / microwave combinations that meet ASHRAE 62.2 airflow and noise requirements may not be available
- Additional costs for HERS verification
- Resolution:
  - Consider Installation of combination microwave / ovens
  - Urge manufacturers to certify products with HVI that comply with ASHRAE 62.2 airflow and noise requirements.

Technical and Market Barriers (3 of 4)

- Higher cost to install high efficiency filters
  - Higher cost of filter
  - Increased size of filter & grille required to accommodate higher pressure drop
- Resolution:
  - Incremental cost for 1-inch depth MERV 13 vs. MERV 6 may be less than $4
  - 2-inch depth filters will cost more than 1-inch depth filters, but they will have reduced resistance to airflow which will improve air distribution airflow, and allow use of smaller return grille face area as compared to systems designed for 1-inch.

PRODUCT Details	MERV 6 MPR 300 FPR N/A	MERV 8 MPR 600 FPR 5	MERV 11 MPR 1000-1200 FPR 7	MERV 13 MPR 1500-1900 FPR 10
20 x 30 x 1 Air Filter				
Performance	Basic	Dust & Pollen	Micro Allergen	Ultimate Allergen
SAVE 10% buying a 12 Pack or more	$87.60 $7.30 each Add to Cart or subscribe	$88.68 $7.39 each Add to Cart or subscribe	$109.80 $9.15 each Add to Cart or subscribe	$128.16 $10.68 each Add to Cart or subscribe

Technical and Market Barriers (4 of 4)

- Builder resistance to higher cost of meeting ventilation air and compartmentalization sealing requirements for multifamily buildings
- Resolution:
  - Units that are advertised as having cleaner, healthier air may have a higher market value
  - Utilize the same sealing contractors and strategies for sealing partition walls as currently used for sealing exterior walls, which may provide for economy of scale cost reductions

Compliance and Enforcement

Compliance Process

Design Phase

- CF1Rs are prepared which indicate required mechanical ventilation rates (new calculation procedures)
- Products are specified that meet the mechanical ventilation rates and other ASHRAE 62.2 requirements (current practice)
- The HVAC designer/contractor must size filter grilles to accommodate the pressure drops of MERV 13 air filters (new design criterion)
- For multifamily buildings, one of the two ventilation options is selected and construction methods and ventilating products are described in plans & specifications (new approach to current practice)

Compliance Process

Permit Application Phase

- Plans and specifications are submitted – no change from current practice
- For high-rise buildings, the plan checker may need to be educated on the changes in ventilation regulations

Compliance Process

Construction Phase

- **Single family**:
  - Comply with dwelling-unit IAQ airflow and kitchen range hood certification
- **Low-rise and High-rise multifamily**:
  - Compartmentalization
    - Seal dwelling enclosure including party walls, ceilings, floors
    - Option A: Install unbalanced ventilation system with passive vents, comply with ≤ 0.3 CFM/ft^2 dwelling enclosure leakage (blower door)
    - Option B: Install balanced ventilation system
  - Comply with dwelling-unit IAQ airflow and kitchen range hood certification
  - If a central shaft ventilation system is used:
    - Balance IAQ airflow (≥ 10% of required cfm)
    - Comply with central shaft leakage rate (≤ 6% leakage)

Compliance Process

Verification Phase

- **All Residential Dwellings:**
  - Verify dwelling-unit IAQ ventilation airflow (per current practice for single family & low-rise, new practice for high-rise)
  - Verify range hoods are HVI certified to meet ≥ 100 cfm airflow and ≤ 3 sone requirements (new protocol)
- **Multifamily Dwellings:**
  - Verify compliance with ≤ 0.3 CFM/ft^2 dwelling enclosure leakage (blower door) if unbalanced ventilation system is installed to meet dwelling-unit IAQ ventilation airflow;
  - Verify central shaft ventilation leakage ≤ 6% (if applicable - new practice)
- **Who performs the multifamily tests?**
  - Low rise: HERS
  - High-rise: CEC will determine (ATT or HERS)

Compliance and Enforcement Barriers (1 of 2)

- **Verification of kitchen range hoods**
  - **Issue:** How is the performance information obtained?
  - **Possible resolutions**
    - HERS rater carries HVI directory (hard copy or electronic)
    - Designer provides HVI listing to builder and builder attaches to the hood

Compliance and Enforcement Barriers (2 of 2)

- Testing and verification of multifamily central ventilation ducts, fans, and outside air provisions
  - **Issue:** Who tests and verifies?
  - **Possible resolutions**
    - HERS rater or ATT tests
    - HERS, ATT, or building official verifies
    - To be determined by Energy Commission staff

Impacts to IAQ, Cost and Energy

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - Single family: 2,100 ft^2 and 2,700 ft^2 residential prototypes (45%-55% weighted results)
  - Multifamily: 870 ft^2 – 2 bedroom units
  - Compliant with ASHRAE 62.2-2010-CA
  - Minimally compliant with 2016 CA BEES or industry standard practice

- **Proposed Conditions**
  - Single family: 2,100 ft^2 and 2,700 ft^2 residential prototypes (45%-55% weighted results)
  - Multifamily: 870 ft^2 – 2 bedroom units
  - Compliant with ASHRAE 62.2-2016 including Proposed CA amendments

Incremental Cost Analysis

Incremental Costs – Single Family

- Incremental First Cost (weighted)
  - Larger ventilation fans: estimate $8 per unit
  - Kitchen hood compliance: No change in product, estimate $50 for verification
  - Increased MERV rating for air filters (MERV 6 to MERV 13), includes increase in filter grille cost: estimate $117
- Maintenance Cost: No change
- **Total Incremental First Cost: estimate $175**

Incremental Cost Analysis

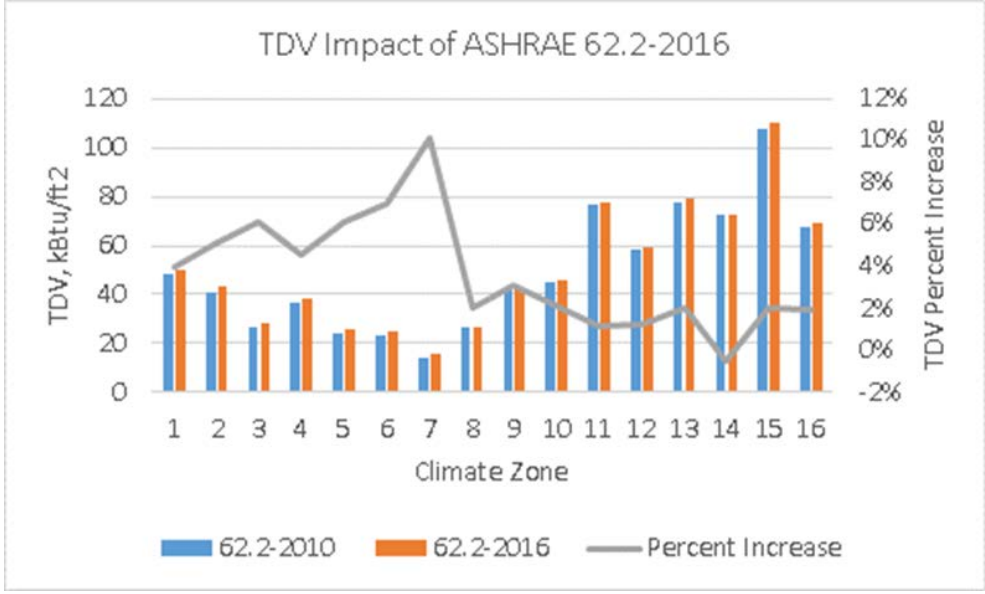
Incremental Costs - Multifamily

- Incremental First Cost (per-unit)
  - Ventilation Fans: no change for low-rise, slight cost reduction for high-rise
  - Kitchen Range Hood compliance: No change in product, estimate $50 for HERS verification
  - Increased MERV rating for air filters (MERV 6 to MERV 13): $117
  - Costs for high-rise ventilation strategies (per unit)
    - MF Dwelling Unbalanced system alternative:
      - partition wall sealing & makeup air vents: estimate $57
      - HERS blower door test: estimate $200
    - MF Dwelling Balanced system alternative: for HRV: estimate $945-$1600; for standalone exhaust paired with standalone supply: estimate $TBD
    - MF Building Central Exhaust: partition wall sealing, central exhaust shaft/duct sealing, makeup air vents, exhaust airflow balancing: estimate $563
    - MF Building Central Balanced: shaft/duct sealing and airflow balancing: estimate $TBD
- Maintenance costs: no change for low-rise, dependent on system type for high-rise

Cost Effectiveness Analysis

Energy Impact of Ventilation Rate Changes

- Single family energy use for blended 2100 & 2700 ft^2 prototypes
- Multifamily low-rise energy use will not change
- Multifamily high-rise energy use will decrease due to lower ventilation rate and sealing
- CBECC analysis completed for other measures includes change in ventilation rate assumptions in calculation of benefit-cost



MF Building Central Shaft Sealing and Balancing Annual Energy Savings

- CEC 500-10-019 project report:

  "For high-rise multifamily buildings that use central shaft ventilation systems, we recommend:

  – Limiting central shaft leakage to 5 percent of total ventilation fan flow

  – Requiring self-balancing dampers at each ventilation grille"

- EnergyPlus modeling results for six story building shown in table below

		Electricity Savings, kWh/year	Natural Gas Savings, therms/year	TDV Electricity Savings	TDV Gas Savings	Net TDV Savings
CZ 3 San Francisco	Per prototype building	-689	1,749	-31,981	88,881	**56,900**
	Per square foot floor area	-0.024	0.061	-1.110	3.086	**1.976**
CZ 8 Los Angeles	Per prototype building	-1,050	816	-30,263	42,944	**12,681**
	Per square foot floor area	-0.036	0.028	-1.051	1.491	**0.440**
CZ12 Sacramento	Per prototype building	-114	2,048	1,568	106,608	**108,176**
	Per square foot floor area	-0.004	0.071	0.054	3.702	**3.756**

Source: Western Cooling Efficiency Center (WCEC) Multifamily Ventilation Code Change Proposal_012814.docx.

Benefit-to-Cost Ratio

- Not calculated for IAQ measures
- Energy savings neutral or negative except for MF building central shaft sealing
- CBECC analysis used for 2019 CASE measures other than these IAQ proposals included assumed use of ASHRAE 62.2-2016 ventilation rates (CA amendments)
- Energy penalty for increased ventilation airflow rate included in benefit-cost calculations of other 2019 CASE measures

Annual Energy "Savings" for Single Family (blended)

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (Therms/yr)	Peak Electric Demand Reduction (kW)
1	-59.3	-12.01	-0.01
2	-67.1	-9.09	-0.01
3	-58.4	-9.29	-0.01
4	-67.0	-6.88	-0.02
5	-58.8	-7.64	-0.01
6	-68.0	-7.15	-0.02
7	-70.4	-6.45	-0.01
8	-47.8	-5.34	0.05
9	-52.5	-5.68	0.01
10	-38.2	-5.12	0.02
11	-45.9	-3.91	0.02
12	-39.0	-3.93	0.05
13	-58.9	-5.81	0.00
14	-23.0	2.10	0.05
15	-152.3	-2.36	-0.04
16	-67.1	-3.16	-0.01

Key Web-Links/Resources

2019 Title 24 Utility-Sponsored Stakeholder Info

http://www.title24stakeholders.com/

Building Energy Efficiency Program

http://www.energy.ca.gov/title24/

Docket for Comments

https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=17-BSTD-01

Compliance Software

http://www.bwilcox.com/BEES/BEES.html

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Thank You