CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Residential Indoor Air Quality

March 16, 2017

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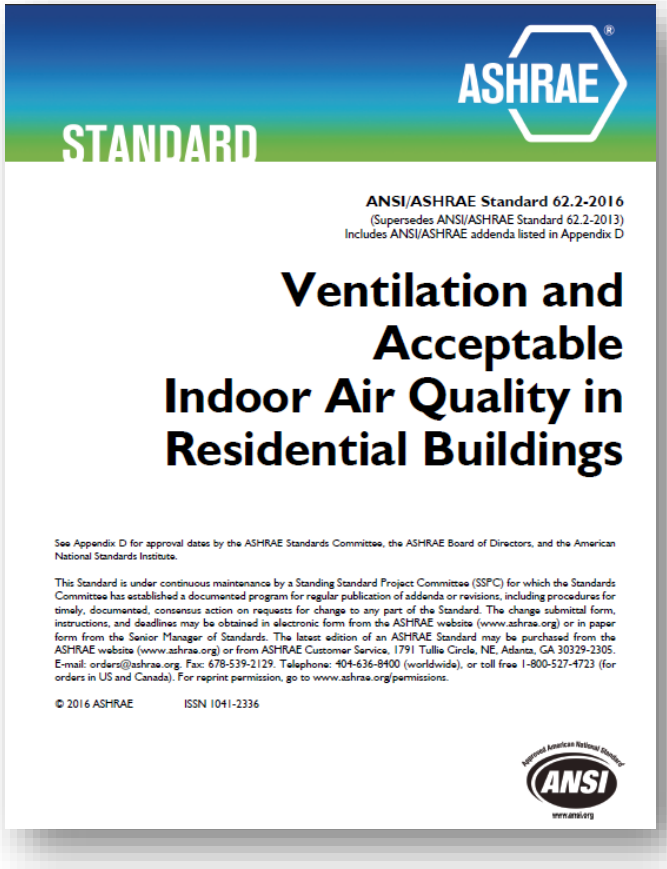
Los Angeles Department of Water & Power | SMUD | SDGE A Sempra Energy utility | SoCalGas A Sempra Energy utility | Southern California Edison An EDISON INTERNATIONAL Company | Pacific Gas and Electric Company

Agenda

1. Background
2. Proposed Code Changes
3. Technical and Market Barriers
4. Compliance and Enforcement
5. Cost-Effectiveness and Energy Impacts
6. Next Steps

1. Background

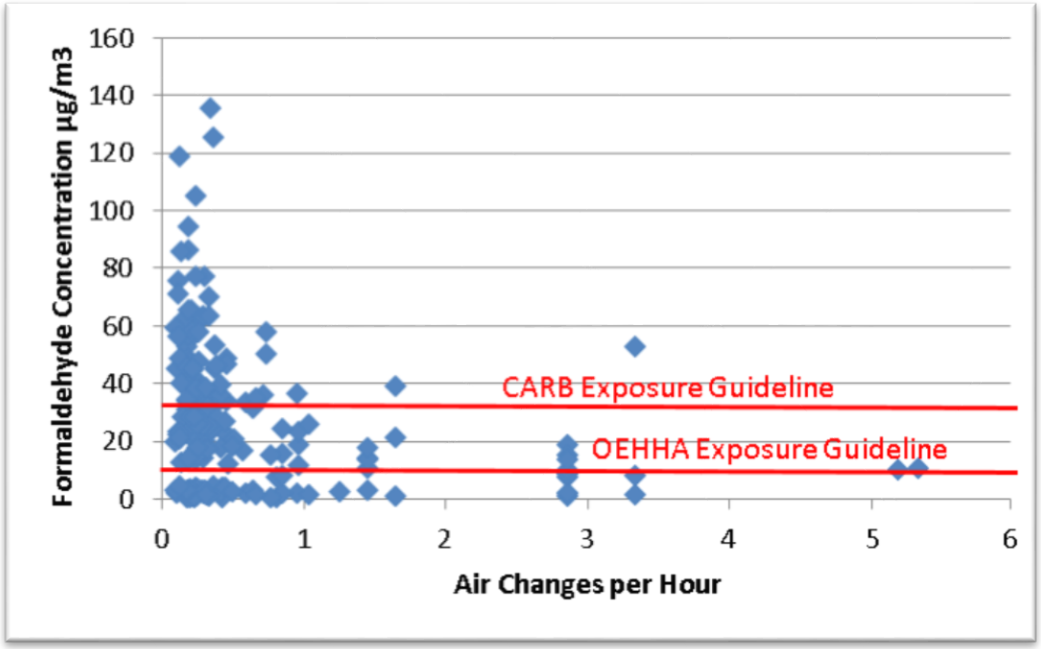
- Indoor Air Quality Issues
  - Formaldehyde and particulate concentrations exceed state guidelines
  - Sources of pollutants are difficult to control
- Building Science Basics
  - Tighter buildings and lower leakage means less pollution dilution
  - Risk of moisture damage increases with insulation R-value



Introduction to Indoor Air Quality – IEES Study (Offerman, 2009)

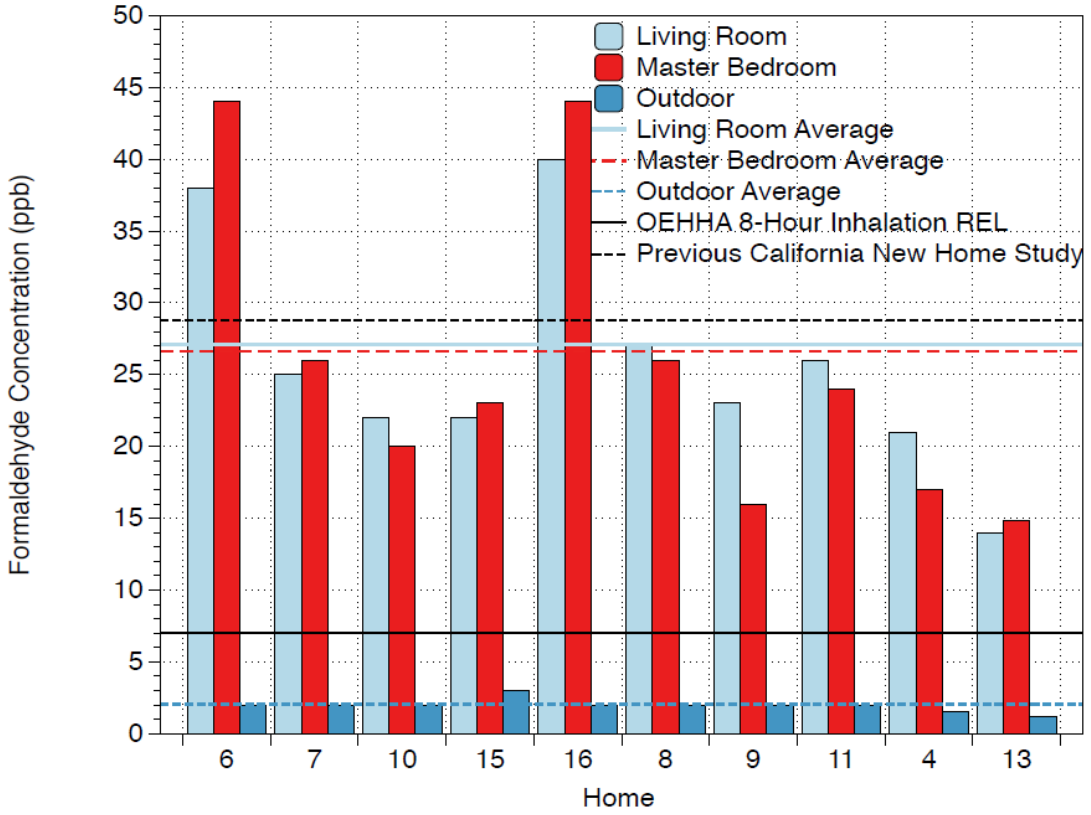
- Sponsored by the Energy Commission and CARB
- 105 homes, built 2002 - 2004
- Median ACH50 = 4.8

"The only indoor air contaminants that exceeded recommended non-cancer and non-reproductive toxicity guidelines were formaldehyde and PM2.5 particulate matter."



HENGH* Field Study (LBNL, ongoing)

- 12 homes, 3 supply & 12 exhaust
- Vintage 2011-2015
- All but two homes exceeded ASHRAE 62.2-2010 ventilation rate



*Healthy Efficient New Gas Homes

The Hazards of Cooking

- Pollutants
  - Fine particles (PM 2.5)
  - NO_2, CO, formaldehyde
- Ratings
  - HVI
    - CFM
    - sones
  - Energy Star
    - ≥ 2.8 cfm / W at 25 Pa
    - ≤ 2 sone
    - < 500 cfm
  - ASTM
    - Capture efficiency
    - Coming in 2018?

Relevant Title 24 Code History

- No changes to single family ventilation requirements in Title 24, Part 6 since 2008 standards adopted ASHRAE 62.2-2007
- Ventilation rate for multifamily increased with 2013 standards
- 2013 and 2016 standards reference ASHRAE Standard 62.2-2010 (CA), which includes:
  - Whole house mechanical ventilation based on floor area and number of bedrooms with infiltration credit ≈ 5 ACH50
  - MERV 6 HVAC filter (or minimum Particle Size Efficiency of 50% in the 3.0–10 µm range) and labeled filter location
  - Kitchen ventilation – Either a 100 cfm or greater range hood or a 5 ACH continuously operating exhaust fan – exhausting to outdoors
  - 3 sone noise limit for range hoods rated less than 400 cfm

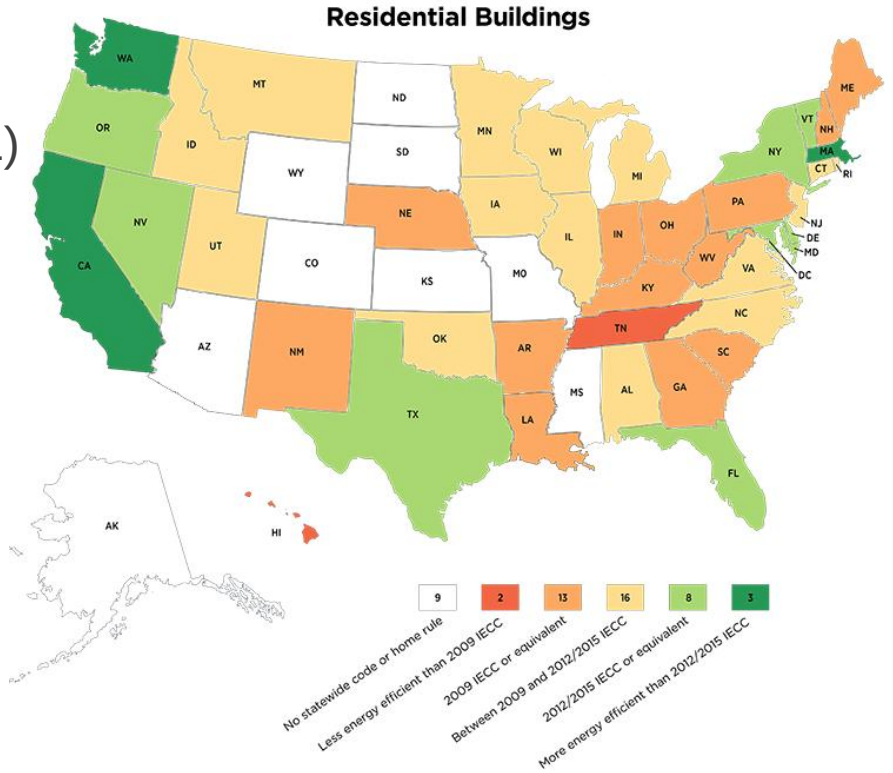
Ventilation Requirements in Other States

- ASHRAE 62.2 is not referenced by IECC or IRC
- 2012 IECC:

  $Q_{fan} \leq 0.01 \times CFA + 7.5 \times (N_{BR} + 1)$

- 2015 IECC references IRC:

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165



Energy Star V3.1 references RESNET 380 references ASHRAE 62.2-2013

Feedback

2. Proposed Code Changes

Code Change Summary

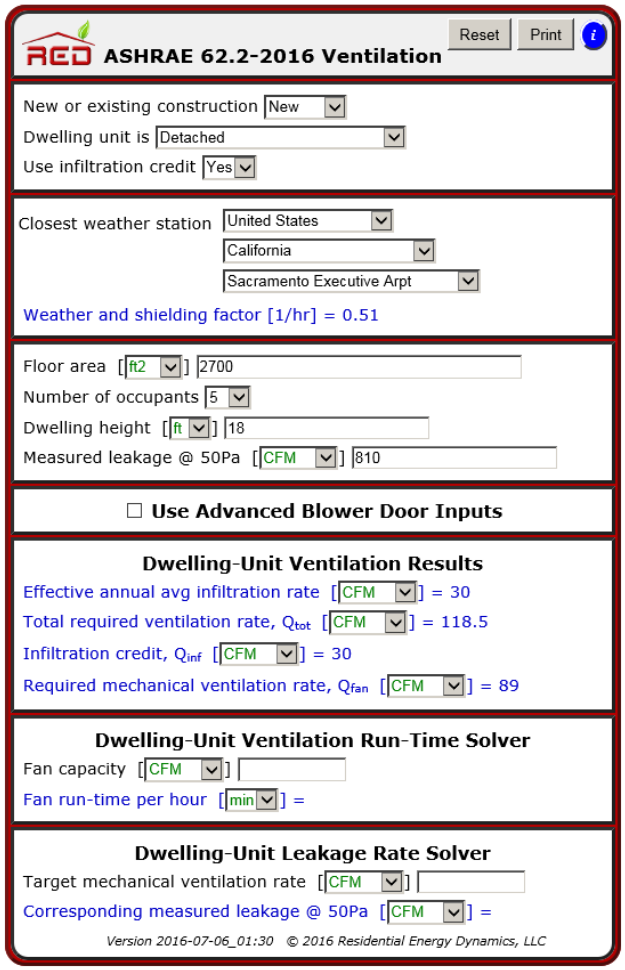
- Type of change:
  - Mandatory with optional compliance paths for high-rise multifamily
  - Revision to existing ASHRAE 62.2 code reference (with California provisions)
- Buildings impacted:
  - Single family
  - Low-rise multifamily
  - High-rise multifamily
  - Only applicable to additions greater than 1000 ft^2 and alterations involving altered components

Summary of Measures

- ASHRAE 62.2-2016 adoption impacts
  - Change in method of calculation of mechanical ventilation rate (Q_{fan}) for single family and high-rise multifamily
  - California enhancements and required enforcements
    - Applies 2 ACH50 infiltration rate (Q_{infil}) for determining Q_{fan}
    - Verified kitchen range hood exhaust to exterior and HVI airflow & noise ratings (noise exclusion if minimum airflow > 400 cfm)
    - Increase in HVAC filter MERV from 6 to 13
    - Credit for balanced ventilation (high-rise only)
- Proposed for high-rise multifamily:
  - ASHRAE 62.1 ⇨ 62.2, lower ventilation rates
  - New requirements for makeup air and sealing
  - Central ventilation duct/shaft sealing and balancing

ASHRAE 62.2-2016 Impacts

- Single family ventilation rate will increase
  - Q_{inf} and Q_{fan} calculated by ACM
  - Q_{inf} calculation based on 2 ACH50, building height, and climate
  - No change to ACM default of 5 ACH50
- Low-rise multifamily ventilation rate will not change
- High-rise multifamily ventilation rate will decrease



Source: Residential Energy Dynamics

Changes in Ventilation Rate Calculations

- Current
  - ASHRAE 62.2-2010-CA: single family

    $Q_{fan} = 0.01(CFA) + 7.5(BR +1)$ or:

    $Q_{fan} = Q_{total} - Q_{inf}$ where,

    $Q_{total} = 0.03(CFA) + 7.5(BR +1)$

    Q_{inf} = value calculated using normalized leakage based on blower door test, floor area, height, number of bedrooms, and weather shield factor (wsf)

$$NL = 1000 \times \frac{ELA}{A_{floor}} \times \left[\frac{H}{H_r}\right]^z \qquad Q_{inf}(\text{cfm}) = \frac{NL \times wsf \times A_{floor}}{7.3}$$

  - Low-rise multifamily $Q_{fan} = Q_{total}$ (no infiltration credit allowed)
  - High-rise multifamily: CMC 403.2.1:

    $Q_{total} = 0.06(CFA) + 5.0(BR+1)$; natural ventilation allowed

Changes in Ventilation Rate Calculations

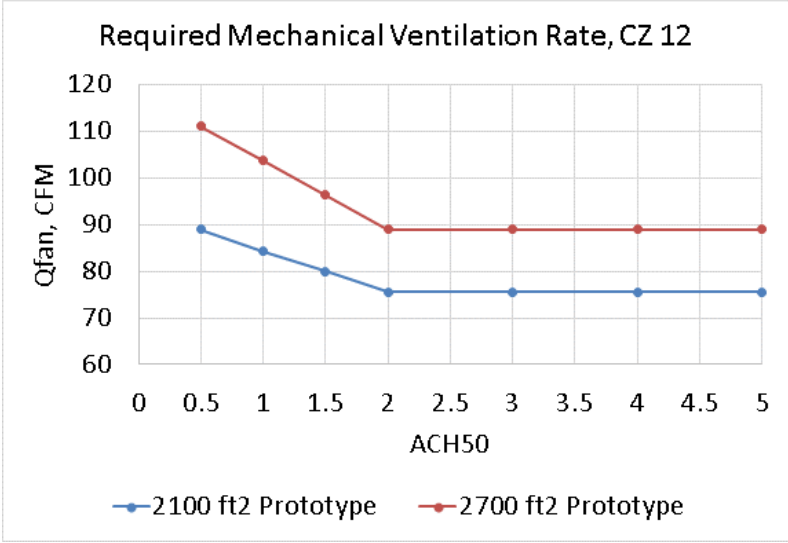
- Proposed
  - ASHRAE 62.2-2016 applies to all residential occupancies
  - $Q_{total} = 0.03(CFA) + 7.5(BR + 1)$
  - Single family:

    $Q_{fan} = Q_{total} - Q_{inf}$

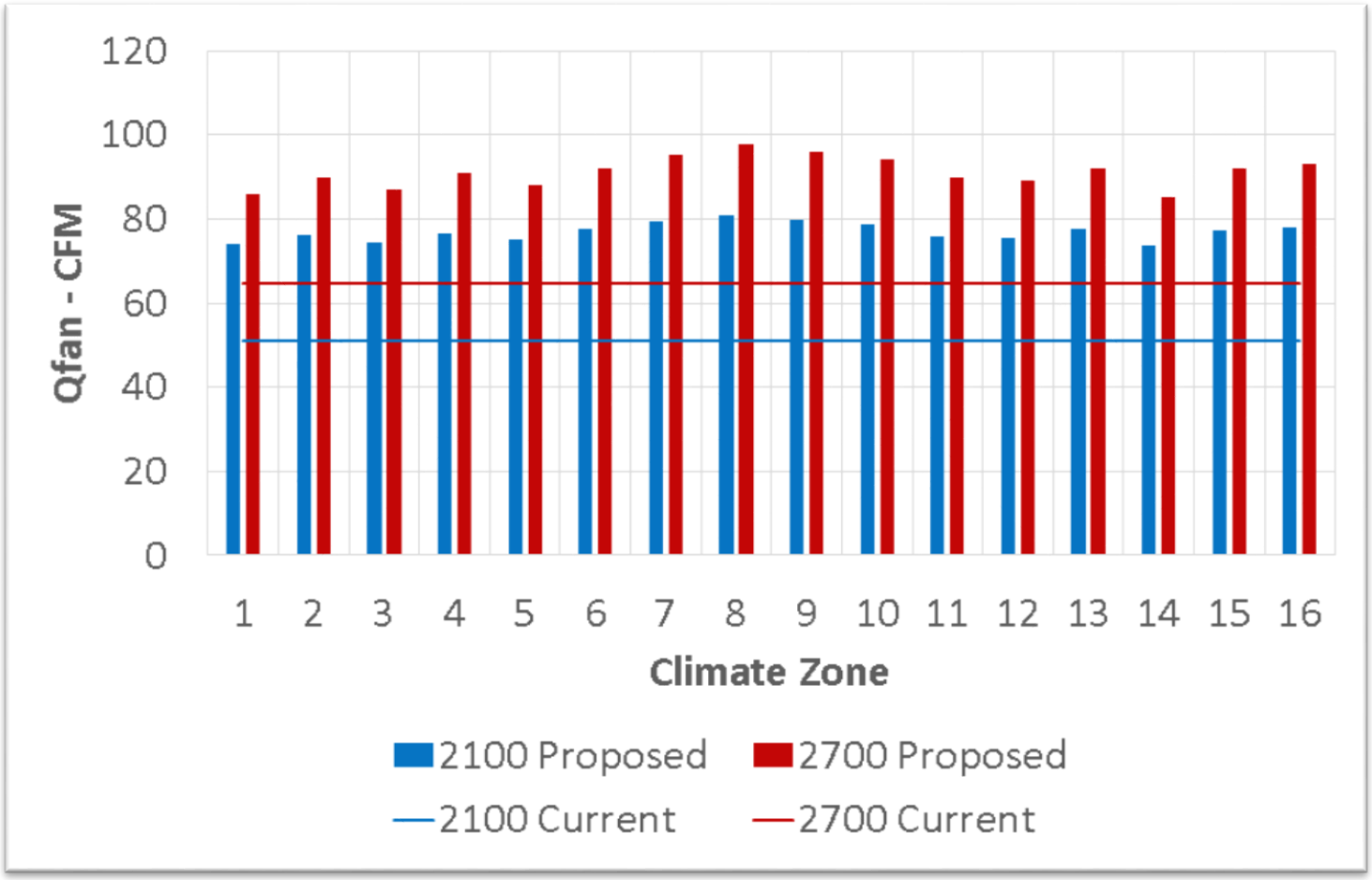
    Q_{inf} calculated by CBECC using same methods as 2010 version, except using 2 ACH50 (unless tested below 2 ACH50)
  - Multifamily: $Q_{inf} = 0$

Single Family Implementation of ASHRAE 62.2-2016

- If no blower door test completed
  - Q_{fan} determined from Q_{inf} which is calculated using 2 ACH50
  - ACM applies 5 ACH50
- If blower door test completed
  - Between 5 and 2 ACH50
    - ACM applies measured ACH50
    - Q_{fan} based on 2 ACH50
  - Below 2 ACH50
    - ACM applies leakage credit, and
    - Q_{fan} based on measured ACH50



Single Family Ventilation Rate by Climate Zone



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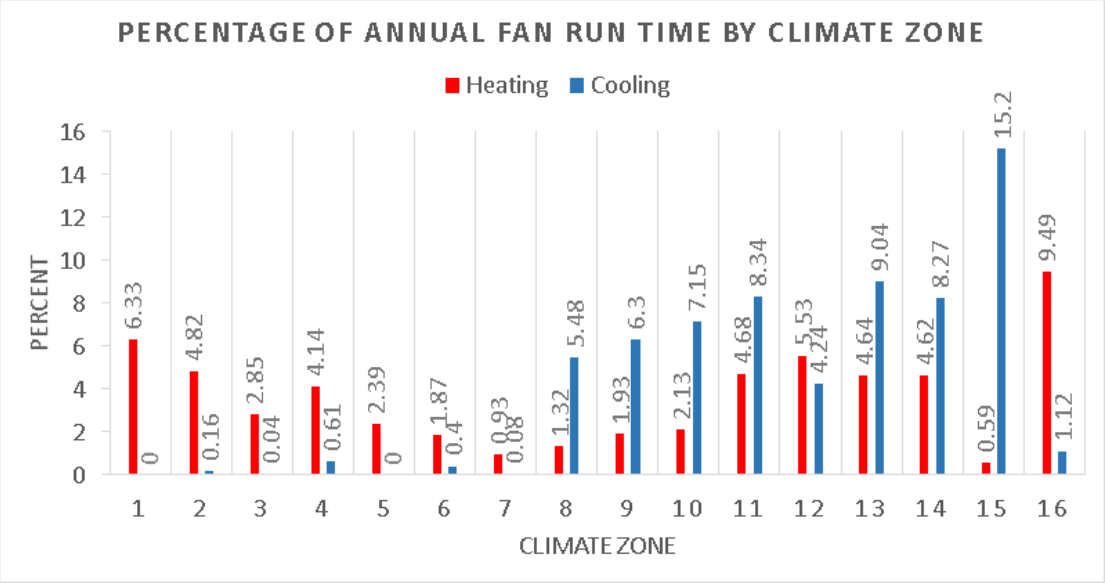
Increasing HVAC Filter MERV from 6 to 13*

- **Goal**: Reduce PM 2.5 concentration from indoor and outdoor sources
- **Issues**: Low fan run hours; higher MERV filters may increase Watts/cfm and increase replacement cost; Title 20 labeling requirement delayed to 2019 but some filters already labeled)

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

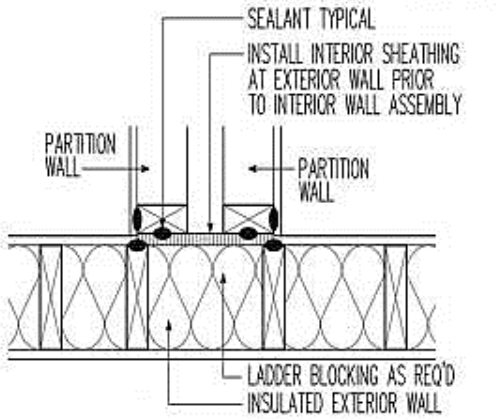
Particle Removal Efficiency (ASHRAE 52.2-2017)			
	Particle Size in microns		
MERV	0.3-1.0	1.0-3.0	3.0-10.0
6	n/a	n/a	35 ≤ E3
8	n/a	20 ≤ E2	70 ≤ E3
11	20 ≤ E1	65 ≤ E2	85 ≤ E3
12	35 ≤ E1	80 ≤ E2	90 ≤ E3
13	50 ≤ E1	80 ≤ E3	90 ≤ E3



*or AHRI 680-2015 particle size efficiency of > 80% in the 1.0 – 3.0 µm range

Multifamily Ventilation & Compartmentalization

- **Option 1***
  - Continuous exhaust fans
  - High-rise multifamily has additional requirements:
    - Passive vents
    - Seal exterior walls and partition walls



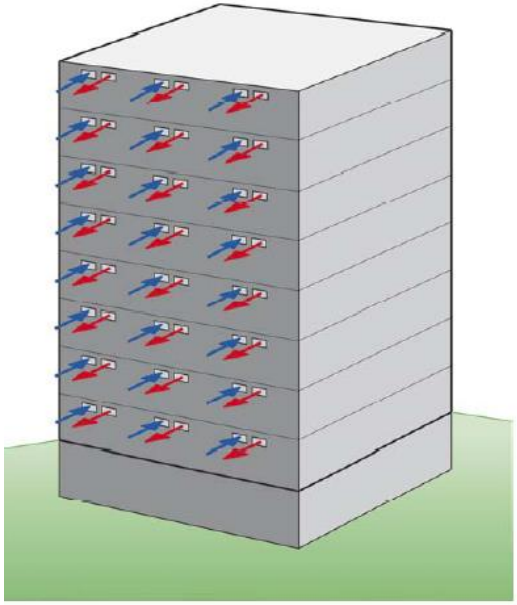
SECTION 110.7 – MANDATORY REQUIREMENTS TO LIMIT AIR LEAKAGE

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.

**For PM 2.5 non-attainment areas must use Option 2*

Multifamily Ventilation & Compartmentalization

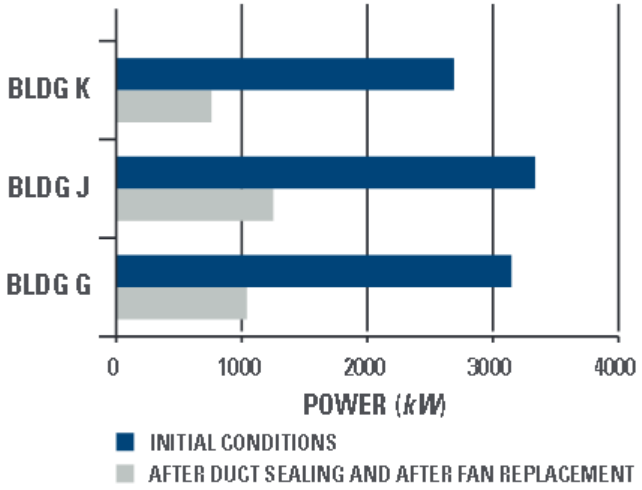
- **Option 2**
  - Balanced supply & return
    - HRV, ERV, or supply & return fans
    - $Q_{fan} = 85\% \times Q_{total}$
  - High-rise multifamily has additional requirements:
    - Required in areas of PM 2.5 non-attainment
    - Outside air filtration
      - MERV 6 in areas with low outdoor PM 2.5
      - MERV 13 in areas of PM 2.5 non-attainment



High-Rise Multifamily Central Ventilation Systems

- Seal ventilation shafts/ducting to 6% of total ventilation rate
- Balance to ±10% of total airflow (method of balance is optional)
- Both measures must be verified by HERS or ATT

Energy Plus Simulations



WCEC: Aerosol Duct Sealing in Central Exhaust Systems

Kitchen Range Hoods

- **Current requirement (62.2-2010-CA)**
  - 100 cfm minimum range hood vented to outdoors or 5 ACH continuous exhaust
  - Maximum 3 sones unless over 400 cfm rating, then no limit
- **Proposed requirement (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

Why Are We Proposing This Code Change

- Align with model codes – ASHRAE 62.2-2016
- To ensure that Title 24, Part 6 improvements do not endanger public health or building durability
- Improve compliance with existing requirements in 62.2
- Because it's the law

PRC 25402.8 New Building Standards for Residential, etc.

25402.8. When assessing new building standards for residential and nonresidential buildings relating to the conservation of energy, the commission shall include in its deliberations the impact that these standards would have on indoor air pollution problems.

Feedback

3. 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

Panasonic FV-08VQ5

WhisperCeiling 80 CFM Ceiling Mounted Fan

★★★★★ from 16 customers

- WhisperCeiling Collection
- Cfm: 80
- Light Included: No
- Sones: 0.3
- UI Listed: Yes

Free Shipping!

$105.91

Panasonic FV-11VQ5

WhisperCeiling 110 CFM 0.3 Sone Ceiling Mounted Energy Star Rated Bath Fan with 4" Duct Diameter

★★★★★ from 28 customers

- WhisperCeiling Collection
- Cfm: 110
- Light Included: No
- Sones: 0.3
- UI Listed: Yes

Free Shipping!

$114.00

Technical and Market Barriers (2 of 4)

- Kitchen hood / microwave combinations that meet ASHRAE 62.2 noise requirements may not be available, and there will be additional costs for verification
- Resolution:
  - Install combination microwave / ovens
  - Urge manufacturers to produce compliant products
  - Have builder provide HVI rating to reduce time required to look it up

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 MERV 13 vs. MERV 6 < $10
  - Use multiple filter grilles and/or deeper filter with lower pressure drop

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)

- Resistance to higher cost of meeting ventilation and compartmentalization requirements for multifamily buildings, especially in PM2.5 non-attainment areas
- **Resolution:**
  - Units that are advertised as having cleaner, healthier air should have a higher market value
  - Utilize the same contractor and strategies for sealing partition walls as for sealing exterior walls – may be economy of scale cost reductions
  - Research is needed to define how non-attainment areas are identified

Feedback

4. Compliance and Enforcement

Compliance Process

Design Phase

- CF1Rs are prepared which indicate required mechanical ventilation rates (new procedure for single family homes only)
- 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 higher pressure drops of high efficiency filters
- 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**: no change other than following specifications for mechanical ventilation rate
- **Low-rise multifamily**: no change
- **High-rise multifamily**
  - If a central ventilation system is used:
    - Verified leakage rate (≤ 6% leakage)
    - Balanced (≥10% of required cfm)
  - Requirements for outside air and sealing
    - Option 1: Sealing of the entire perimeter of the unit including interior and exterior walls, and passive vents for outside air installed
    - Option 2: Balanced ventilation system; MERV 13 filter in PM 2.5 non-attainment areas

Compliance Process

Inspection Phase

- **All residential building types:**
  - Ventilation airflows are measured and verified (per current practice for single family & low-rise, new practice for high-rise)
  - Range hoods are HVI certified and meet airflow and sone requirements and vented to exterior (new practice – by HERS verifier)
- **High-rise multifamily:**
  - Central ventilation systems tested for airtightness (new practice for high-rise)
  - Balanced airflow (current practice)
  - Outside air source verified (new practice for high-rise)
- **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

Feedback

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2016 Standards or industry standard practice
- 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

Proposed Conditions

- Compliant with ASHRAE 62.2-2016 with noted exceptions
- Single family: 2,100 ft^2 and 2,700 ft^2 residential prototypes (45%-55% weighted results)
- Multifamily: 870 ft^2 – 2 bedroom units

Cost Effectiveness Analysis

Incremental Costs – Single Family

- Incremental First Cost (weighted)
  - Larger ventilation fans: ~ $5 per unit
  - Kitchen hood compliance: No change in product, estimate $50 for verification
  - High MERV filters (MERV 6 vs. MERV 13): $3.50*
- Maintenance Cost: No change
- **Total Incremental First Cost: $58.50**

*Not including larger return grille and filter to accommodate pressure loss

Cost Effectiveness Analysis

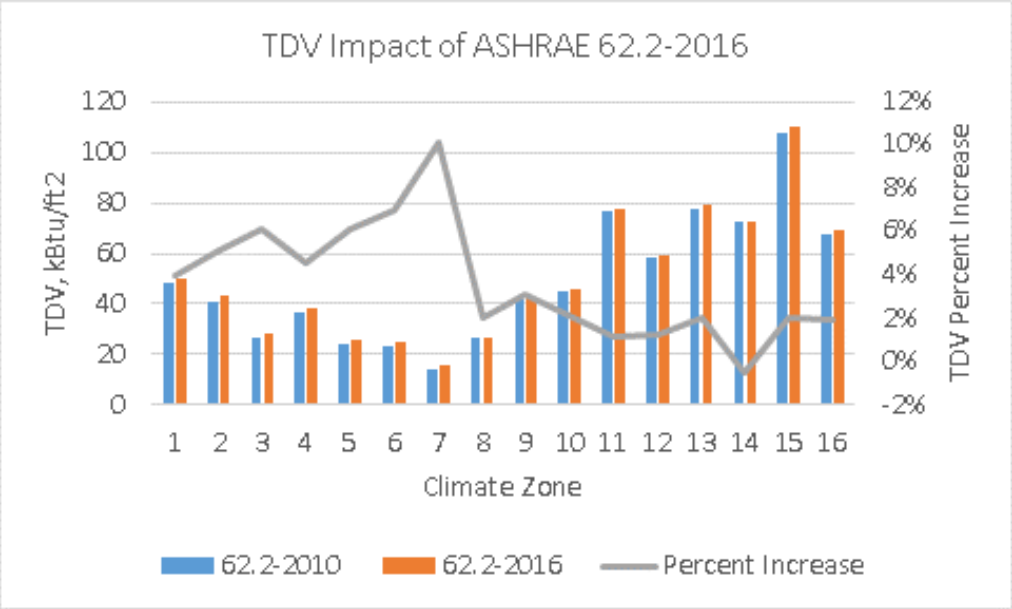
Incremental Costs – Multifamily

- Incremental First Cost (per-unit)
  - Ventilation fans: Small increase for single family, no change for low-rise, slight cost reduction for high-rise
  - Kitchen hood compliance: No change in product, estimate $50 for verification
  - High MERV filters (MERV 6 vs. MERV 13): $3.50 each
  - Costs for alternative high-rise ventilation strategies (per unit)
    - Individual exhaust fans: $141 for sealing & makeup air vents
    - Central exhaust: $414 for partition wall & shaft sealing, makeup air vents, balancing
    - Balanced ventilation: $945 for HRV
- Maintenance costs: no change for single family & 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



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 of six story building

		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 shaft sealing
- *CBECC analysis used for other 2019 CASE measures included ASHRAE 62.2-2016 ventilation assumptions*
- Penalty for increased ventilation 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

Feedback

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)

Thank you.

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Appendix

References

- Title24Stakeholders.com
- EnergyCodeAce.com
  - See Reference Ace for 2016 Standards, Appendices, and Compliance Manuals
- California Energy Commission 2019 Standards Webpage