CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Residential HVAC and Residential/Nonresidential IAQ
Nonresidential Indoor Air Quality & Ventilation

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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

Introduction to Ventilation and Indoor Air Quality (IAQ)

- Why is ventilation and indoor air quality important?
  - Ventilation helps to dilute contaminants in indoor spaces. Contaminants are primarily from two sources:
    - Occupants and their activities
    - Off-gassing from building materials and furnishings

Introduction to Ventilation and Indoor Air Quality (IAQ)

- Why is ventilation and indoor air quality important?
  - California Air Resources Board (CARB) concluded in 2005 that impact of indoor air pollutions on health was far greater than outdoor pollutants
    - Causal link between indoor air pollutants and:

      - Asthma
      - Cancer
      - Sick Building Syndrome (SBS)
      - Respiratory disease
      - Work loss and reduced productivity
      - Lung damage
      - Breathing difficulties
      - Nausea
      - Tremors
      - Drowsiness
      - Dizziness
      - Impacts to neurodevelopmental outcomes in unborn children
      - Dermal allergic sensitization
      - Headaches

Introduction to Ventilation and Indoor Air Quality (IAQ)

- Why is ventilation and indoor air quality important?
  - Numerous studies have documented the health, productivity, and economic benefits of improving indoor air quality.
    - Potential productivity gains from improved IAQ are orders of magnitude greater than the increased equipment and operating costs (Fisk, 1999)
    - Lower ventilation rates results in decreases in decision making (Maddalena et al, 2014)
    - When CO2 concentrations increase to 3,000 ppm, mental tasks require more effort and capacity to concentrate attention declines (Kajtar, Herczeg, 2011)

Introduction to Ventilation and Indoor Air Quality (IAQ)

- In light of these concerns and findings, California state legislature enacted laws to protect IAQ
  - Passed in 1988, the Warren-Alquist Act requires the California Energy Commission (CEC) to consider the impacts of any new building standard on IAQ
- In 1992, the CEC developed ventilation requirements (Title 24, Part 6, Section 121) that balanced IAQ and energy efficiency
  - However, these ventilation requirements and rates have remained unchanged since 1992
  - Represents an opportunity to make code revisions to align with the latest science and consensus on ventilation and indoor air quality

Relevant Code History

- There are existing requirements in Title 24, Part 6
- Other Relevant Code Requirements in Title 24, Part 4 and CALGreen

	Title 24, Part 6	Other Code Requirements
Mechanical Ventilation	Section 120.1	Title 24, Part 4 Sections 403.2 - 403.5
Natural Ventilation	Section 120.1	Title 24, Part 4 Sections 402.2
Outdoor Air Treatment	None	CALGreen Mandatory 5.504.5.3; Voluntary A5.504.5.3.1
Exhaust Ventilation	None	Title 24, Part 4 Section 403.7

What do you think?

- Does this context make sense to you?
- Any questions or comments??

2. Proposed Code Changes

Proposed Code Change

Alignment of ventilation and indoor air quality requirements found in ASHRAE 62.1.

1. Update the minimum ventilation rates for all Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1 (including requirements for multiple zone recirculating systems)
3. Revise requirements for natural ventilation
4. Revise requirements for outdoor air treatment
5. Move requirements for exhaust ventilation from Title 24, Part 4 to Title 24, Part 6

Proposed Code Change

1. **Update the minimum ventilation rates for all Title 24, Part 6 nonresidential occupancy categories**
   - Expand Title 24, Part 6 Table 120.1-A to include and specify ventilation rates for all Title 24, Part 6 occupancy categories, aligning with 130% of the ASHRAE 62.1 ventilation rates

   – Mandatory
   – Revision to existing requirement
   – All nonresidential buildings
   – Alignment with ASHRAE 62.1 ventilation rates x 130%

Why Are We Proposing This Code Change

- Align with ASHRAE 62.1 (the nonresidential buildings ventilation standard that is required in most states)
  - Ventilation rates in ASHRAE 62.1 reflect the latest science and consensus on indoor air quality
- Improve indoor air quality
  - Reduce disease transmission and sick building symptoms
  - Improve worker productivity

Proposed Code Change

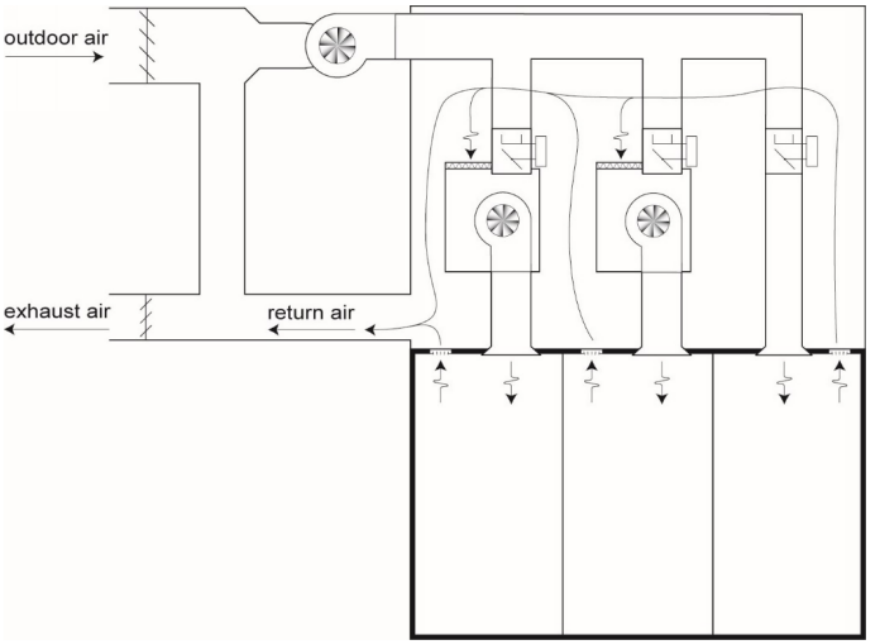
2. Harmonize with the full VRP found in ASHRAE 62.1 (including the requirements for multiple zone recirculating systems)

- Calculates ventilation rate as the sum of the ventilation required to control both people-related sources and building-related sources
- Accounts for ventilation efficiencies for zone air distribution and at the system level for multiple zone recirculating systems

– Mandatory

– Revision to existing requirement

– All nonresidential buildings



Why Are We Proposing This Code Change

- Align with ASHRAE 62.1 (the nonresidential buildings ventilation standard that is required in most states)
  - Ventilation calculations in ASHRAE 62.1 reflect the latest science and consensus on indoor air quality

Proposed Code Change

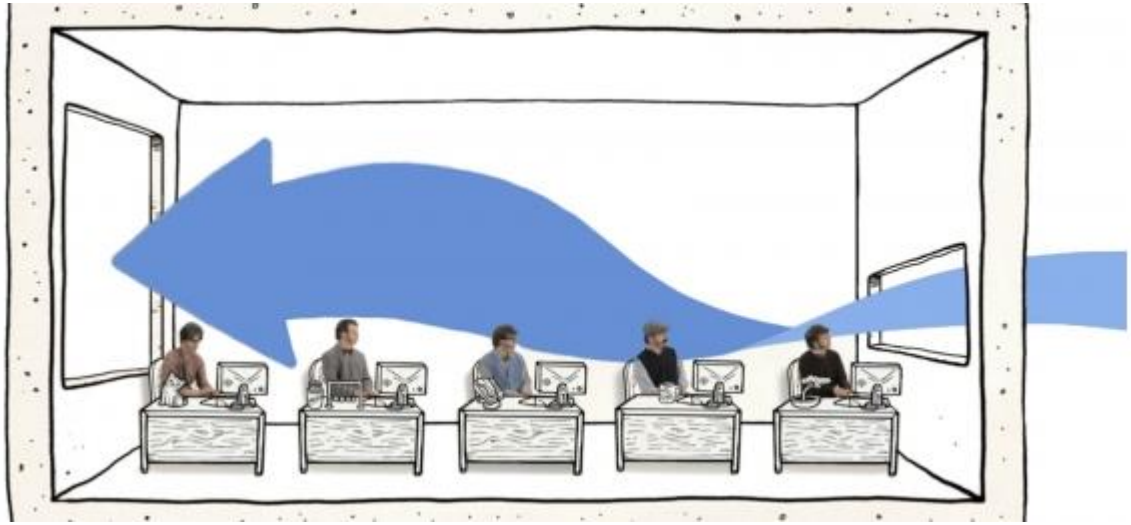
3. Revise requirements for natural ventilation

- Include calculation that establishes floor area allowed to be naturally ventilated based on the size and types of openings
- Allows a greater floor area of the building to be naturally ventilated (without mechanical ventilation) compared to Title 24, Part 6

– Mandatory

– Revision to existing requirement

– All nonresidential buildings



Why Are We Proposing This Code Change

- Align with ASHRAE 62.1 (the nonresidential buildings ventilation standard that is required in most states)
- Achieve energy savings
- Decrease sick building syndrome symptoms (Seppanen, Fisk, 2002)

Proposed Code Change

4. Revise requirements for outdoor air treatment

- Require outdoor air treatment of particulate matter (PM) if regional and/or local air quality where building is located is above threshold concentrations
  - MERV 11 for PM2.5
    - » There are existing filtration requirements in Title 24, Part 11 (CALGreen) for MERV 8 filters.

– Mandatory

– New requirement

– All nonresidential buildings

Why Are We Proposing This Code Change

- Align with ASHRAE 62.1 (the nonresidential buildings ventilation standard that is required in most states)
- Improve indoor air quality
  - Reduce disease transmission and sick building symptoms
  - Improve worker productivity

Proposed Code Change

5. Move requirements for exhaust ventilation from Title 24, Part 4 to Title 24, Part 6

- Incorporate requirements for exhaust ventilation from ASHRAE 62.1 Section 6.5.1

– Mandatory

– New requirement

– All nonresidential buildings

Why Are We Proposing This Code Change

- Align with ASHRAE 62.1 (the nonresidential buildings ventilation standard that is required in most states)

What about the proposed code changes?

3. Technical and Market Barriers

Technical and Market Barriers

1. **Ensure indoor air quality is maintained or improved with the proposed code change**
   - Proposed code change uses ASHRAE 62.1 ventilation rates x 130%
   - Requires engagement with entities that advocate for indoor air quality (LBNL, CARB) to obtain and integrate feedback into code changes
   - Perform literature review on health and productivity cost impacts related to ventilation rates and filtration

Technical and Market Barriers

2. Ventilation rate calculations are more complex, affecting design engineers, energy consultants, and plans examiners

- Requires engagement with design engineers and energy consultants to obtain feedback on their level of facility with the ASHRAE 62.1 VRP and its inclusion in Title 24, Part 6
- Local governments will need to train building department staff on revisions to the ventilation requirements
  - However, this is not a new cost associated with the 2019 code change cycle, and local governments plan and budget for this retraining

4. Compliance and Enforcement

Compliance Process

Design Phase

- Mechanical designer/energy consultant:
  - Determines outside air requirements and equipment sizes
  - Specifies product and performance requirements for ventilation components
- Ventilation calculations and compliance forms are more complex with the proposed code change, and may require a spreadsheet-type calculation to be submitted
- Potential benefit for designers in California to leverage tools and resources in use throughout the country

Compliance Process

Permit Application Phase

- Mechanical designer submits submittal package for permit
- Plans Examiner reviews submittal package for code compliance and issues construction permit
- Since ventilation calculations are more complex, plans examiner may need more time to confirm calculations are completed correctly

Compliance Process

Construction Phase

- General contractor coordinates with the design team and installers to install ventilation equipment
- Duties for the general contractor and installer will generally remain the same.

Inspection Phase

- Building inspector makes site visits to verify code compliance and proper installation of ventilation systems
- Building inspector will need to become familiar with new ventilation rate requirements to verify code compliance and proper installation of building features

Compliance and Enforcement Barriers

- Ventilation rate calculations are more complex
  - Provide resources to support mechanical designers and energy consultants in completing the proposed ventilation rate calculations from ASHRAE 62.1

What about the barriers?

5a. Cost-Effectiveness and Energy Impacts

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

Definition of Baseline and Proposed Conditions

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

- Analysis to compare energy impacts of minimum ventilation rates calculated using existing Title 24, Part 6 standards, and proposed code change.
- Assumptions: 24,416 ft^2 small school prototype

Baseline Conditions

- Minimally compliant with 2016 Standards
- Minimum ventilation rates calculated using 2016 standards

Proposed Conditions

- Minimum ventilation rates calculated using the full ASHRAE 62.1 VRP x 130%, including zone and system ventilation efficiencies.
- Zone Air Distribution Effectiveness (Ez): 0.8

Cost-Effectiveness Analysis – Incremental Costs

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

- Incremental First Cost
  - Should remain the same for both the baseline and proposed cases (system's peak airflow rate is dependent on heating and cooling loads)
- Incremental Maintenance Costs over 15-year period of analysis
  - Should remain the same for both the baseline and proposed cases

Cost Effectiveness Analysis – Incremental Cost Savings (Benefits)

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

- TDV Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of -$24,850 to -$93,400 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 = -$865,000**

Energy and cost savings are negative for the Small School prototype model.

CASE team is planning to perform further analysis for a different prototype building.

Benefit-to-Cost Ratio

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

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

Measure provides health and productivity benefits from increased ventilation and improved indoor air quality; literature suggests that these benefits outweigh the increased operational costs, although specific cost-benefit data is unavailable.

Annual Energy Savings Per Prototype Building

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

Climate Zone	TDV Energy Savings (TDV kBtu/yr)	15 Year TDV Energy Cost Savings ($2020)
1	(279,219)	($24,850)
2	(623,547)	($55,496)
3	(489,215)	($43,540)
4	(606,711)	($53,997)
5	(483,650)	($43,045)
6	(589,279)	($52,446)
7	(515,971)	($45,921)
8	(629,147)	($55,994)
9	(790,067)	($70,316)
10	(658,148)	($58,575)
11	(891,074)	($79,306)
12	(707,884)	($63,002)
13	(662,775)	($58,987)
14	(747,431)	($66,521)
15	(1,049,450)	($93,401)
16	(430,037)	($38,273)

Energy and cost savings are negative for the Small School prototype model.

CASE team is planning to perform further analysis for a different prototype building.

Annual Energy Savings Per Prototype Building

1. Updating minimum ventilation rates for Title 24, Part 6 nonresidential occupancy categories
2. Harmonize with the full VRP found in ASHRAE 62.1

Climate Zone	Annual Electricity Savings (kWh/yr)	Annual Natural Gas Savings (therms/yr)	Peak Electric Demand Reduction (kW)
1	2,250	(1,892)	(1.2)
2	(7,859)	(1,305)	(13.0)
3	(5,625)	(1,353)	(4.9)
4	(8,311)	(1,137)	(10.2)
5	(5,670)	(1,484)	(5.1)
6	(9,300)	(978)	(10.0)
7	(8,520)	(847)	(5.3)
8	(10,270)	(797)	(15.6)
9	(11,656)	(800)	(18.1)
10	(10,420)	(776)	(15.0)
11	(12,276)	(1,023)	(20.5)
12	(10,000)	(1,124)	(17.8)
13	(11,667)	(994)	(13.8)
14	(11,675)	(992)	(24.4)
15	(23,237)	(489)	(24.8)
16	(3,520)	(1,578)	(2.8)

5b. Energy Impacts

3. Revise requirements for natural ventilation
4. Revise requirements for outdoor air treatment

Impacts Analysis

3. Revise requirements for natural ventilation

- Analysis to determine if proposed code change would increase the number of spaces that are allowed to be naturally ventilated
- Assumptions:
  - 24,416 ft^2 small school prototype

Baseline Conditions

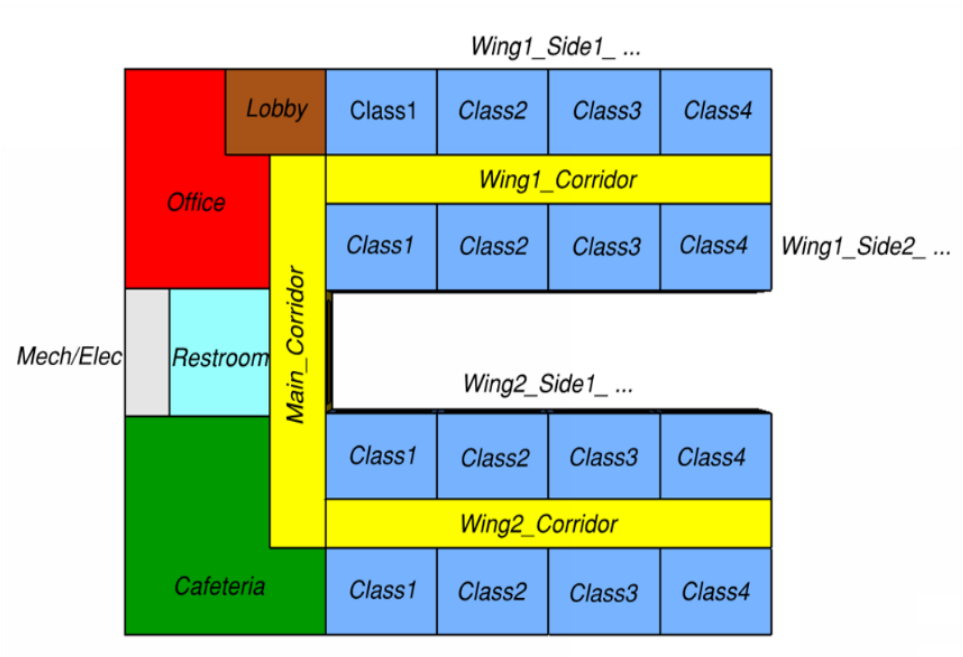
- Space must be within 20 feet of operable opening
- Openable area cannot be less than 5% of floor area of naturally ventilated space

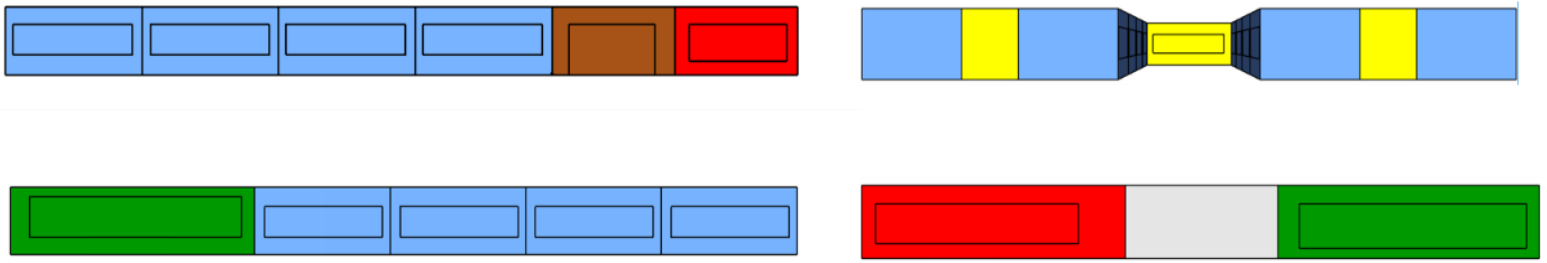
Proposed Conditions

- Maximum distance of the opening to the naturally ventilated space is a function of ceiling height (H)
  - Single Side Opening: Maximum distance is 2H
  - Corner Opening: Maximum distance is 5H
- Openable area cannot be less than 4% of floor area of naturally ventilated space

Impact Analysis

3. Revise requirements for natural ventilation





Impact Analysis

3. Revise requirements for natural ventilation

Color Key	Model Space Name	Area of Space (sf)	# of Openings	Type of Opening	Area of Openings (sf)	Opening Area / Space Area (%)	Designed Maximum Distance from Opening (ft)		Allowable Maximum Distance from Opening (ft)		Natural Ventilation Allowed?
							Title 24, Part 6	ASHRAE 62.1	Title 24, Part 6	ASHRAE 62.1	
	Cafeteria	2,860	2	Corner	915	32%	44	72	20	65	Neither
	Lobby	678	1	Single Side	228	34%	24	24	20	26	ASHRAE 62.1
	Main_Corridor	1,722	1	Single Side	181	10%	42	42	20	26	Neither
	Mech/Elec	446	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Office	2,201	2	Corner	553	25%	43	73	20	65	Neither
	Restroom	1,005	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wing1_Corridor	1,722	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wing1_Side1_Class1 *	753	1	Single Side	193	26%	23	23	20	26	ASHRAE 62.1
	Wing2_Corridor	1,722	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Impacts Analysis

4. Revise requirements for outdoor air treatment

- Analysis to determine the energy impact from increased pressure drop associated with the installation of MERV filters.
- Assumptions:
  - 24,416 ft^2 small school prototype
  - Supply airflow rate of 25,623 cfm
  - Fan efficiency of 65%
  - Motor efficiency of 90%
  - Hours of Occupancy (for schools): 1,808 hours
- **Proposed Conditions**
  - Total static pressure drop of a clean filter:
    - 0.27 in. WG for MERV 7, 0.3 in. WH for MERV 11
  - Total static pressure drop of a dirty filter: 1.0 in. WG

Impacts Analysis

4. Revise requirements for outdoor air treatment

$$BHP = \frac{(cfm)(TSP)}{6356(\mu_{fan})(\mu_{motor})}$$

Baseline: MERV 8 Filters (CALGreen Requirement)

TSP (in. WG)	Annual Energy Savings (kWh)
0.3 (clean filter, MERV 11)	(279)
1 (dirty filter)	0

What about the energy savings and costs?

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)