Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

Multifamily Indoor Air Quality

Multifamily Envelope and HVAC
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Introduction

This CASE Report would build on prior code changes to Title 24, Part 6 approved by the CEC and add a mandatory measure, including supply or balanced ventilation and compartmentalization, for all new construction multifamily and single-family dwelling units. For the largest group, multifamily units, the proposed measure would protect Indoor Air Quality (IAQ) by requiring builders to take the following steps:

- Use supply-only or balanced ventilation as a whole dwelling unit strategy, rather than exhaust-only ventilation.
- Make IAQ system components accessible for replacement and maintenance.
- Enforce mandator compartmentalization at a maximum of level of 0.3 cfm/ft2 @50Pa.

For the smaller group, single-family dwelling units, the proposed measure would protect IAQ by implementing the following:

- Mandatory requirements for IAQ system component accessibility within 10 feet of a walking surface, except for ventilation systems with a fault indicator display (FID).
- A prescriptive requirement for an FID that serves the outdoor air fan or the heat recovery ventilator (HRV)/energy recovery ventilator (ERV).

The two components of this proposed measure would provide reasonable peak demand savings and per-unit LSC Savings for newly constructed buildings. The average 2026 present value Long-term Systemwide Cost (LSC) savings per dwelling unit over a 30-year period would range from $75 to $916 across 16 climate zones. The peak savings were slightly positive for most climate zones. Due to compartmentalization during the cooling season, the proposed measure would not generate significant peak savings. See Section 6.2.1 for details.

Three California investor-owned utilities (IOUs)—Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison—and two publicly owned utilities—Los Angeles Department of Water and Power, and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author)—sponsored this effort. The program goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings.

The Statewide CASE Team submits code change proposals to the CEC, the state agency that has authority to adopt revisions to Title 24, Part 6. The CEC would evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The CEC may revise or reject proposals. See the CEC's 2025 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

Ventilation and Compartmentalization

Proposed Code Change

The current requirements of 2022 Title 24, Part 6 includes:

- A mandatory requirement in Section 160.2(b)2Aiv that all new construction multifamily units must have either:
  - Balanced ventilation OR
  - Meet a compartmentalization limit of 0.3 cfm at 50 pascals per square foot of dwelling enclosure area (cfm50/ft^2). Compartmentalization refers to sealing each dwelling unit's enclosure area—its exterior envelope as well as the ceiling, floor, and walls shared with neighboring units and common use areas (corridors, common rooms, etc.).
    - This mandatory requirement was added in the 2019 Title 24, Part 6 code cycle to ensure adequate IAQ, as opposed to energy savings.
- A prescriptive requirement in Section 170.2(c)3Biv that multifamily dwelling units in Climate Zones 1, 2, and 11 through 16 that choose the balanced ventilation path must use a HRV or ERV.

For the 2025 Title 24, Part 6 requirements, the Statewide CASE Team proposes to:

- Revise the mandatory requirement in Section 160.2(b)2Aiv such that all new construction multifamily units must have both:
  - Balanced or supply-only ventilation, AND
  - Meet a compartmentalization limit of 0.3 cfm50/ft^2 dwelling enclosure area.
    - The purpose of this change is to promote adequate IAQ by ensuring that each dwelling unit receives sufficient outdoor air through balanced or supply-only ventilation and by reducing the transfer of pollutants from neighboring units through compartmentalization.
    - The Statewide CASE team also proposes that the IAQ filter and HRV/ERV accessibility requirement be added as a mandatory requirement for all multifamily projects, with an exception for

ventilation systems with an FID. This measure is currently required in the ACM.

- Revise the prescriptive requirement in Section 170.2(c)3Biv such that all multifamily dwelling units in Climate Zones 1, 2, 4, 11 through 14, and 16 must use an HRV or ERV. As a prescriptive requirement, projects following the performance path that are in these climate zones could choose to install a supply-only ventilation system to comply with the mandatory requirement, but they would need to add other energy efficiency measures to compensate for the lack of energy savings from an HRV/ERV.
- Make a minor change in the climate zones that trigger the prescriptive HRV/ERV requirement, by adding Climate Zone 4 and removing Climate Zone 15. This is because cost effectiveness using the latest energy modeling software, weather files, and cost estimates show that the measure is cost effective in Climate Zone 4, but not cost effective in Climate Zone 15.
- Add a prescriptive requirement that balanced or supply ventilation systems include an FID. Projects that do not install an FID must use the performance path and take a reduction in fan efficacy and HRV SRE. This measure is currently required in the ACM. Under the proposed code change, projects that do not meet this requirement must use the performance path.
    - By requiring balanced or supply-only ventilation, this proposal would prohibit the use of exhaust-only ventilation for meeting whole-dwelling ventilation requirements. However, local exhaust systems, such as bathrooms, kitchens, and dryers, would still be required to meet local exhaust requirements, and exhaust fans could be used as part of a balanced ventilation approach.

While most of this CASE Report discusses proposals for multifamily units, the Statewide CASE Team proposes the following requirements for single-family dwelling units:

- Mandatory requirements for IAQ filter, HRV/ERV heat/energy recovery core, and outdoor air intake accessibility. Ventilation systems with an FID would not need to meet the filters, HRV/ERV energy recovery core or outdoor air intake accessibility requirements.
- For balanced and supply-only ventilation systems: A prescriptive requirement for an FID that serves the outdoor air fan or, where applicable, the HRV/ERV.

These proposed measures align with 2022-Title 24 Part 6 ACM requirements. They match the IAQ system accessibility and FID requirements proposed for multifamily, with an additional requirement (specific to single family) for outdoor air intake accessibility. Projects that do not comply with the prescriptive FID requirements must use the performance path.

Table 1: Scope of Code Change Proposal

Proposal Information	Details
Type of Requirement	Mandatory and Prescriptive
Applicable Climate Zones	All climate zones for Mandatory Measure Climate Zones 1, 2, 4, 11 through 14, and 16 for Prescriptive Measure
Modified Sections of Title 24, Part 6	100.1, 150.0(o)1C, 150.1(c), 160.2(b)2A.iv, 170.2(c)3B, 180.1(a)2, 180.2(b)5
Modified Title 24, Part 6 Appendices	Joint Appendix JA15, to add FID criteria Residential Appendix 3.8.3 Residential Appendix 3.8.4 Nonresidential Appendix 1.9.1 Nonresidential Appendix 2.3.3 Nonresidential Appendix 2.3.4
Would Compliance Software Be Modified	Yes. From the Multifamily ACM: Sections 6.6.1 Building Air Leakage and Infiltration, and Section 6.8.6 IAQ System Type and IAQ System Fan Efficacy
Modified Compliance Documents	Certificate of Compliance: LMCC/NRCC-MCH-01-E Mechanical Systems: Supply and balanced ventilation approaches are covered in these forms. Certificate of Installation: LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter or 2022-NRCI-MCH-E Mechanical Systems: Supply and balanced ventilation approaches are covered in these forms. Certificate of Verification: LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Automatic Meter: Supply and balanced ventilation approaches are covered in these forms.

Table 2: Summary of Stakeholders Interviewed

Stakeholder Type	Number of Individuals Contacted for Interviews	Number of Individuals That Declined Interview Invitations	Number of Individuals Interviewe d	Number of Organizations Interviewed
Architects	4	0	4	3
Contractors / Builders	7	2	5	4
Designers	4	1	3	2
Developers	17	13	4	4
HERS Raters or Acceptance Test Technicians (ATT)	10	4	4	4
Regulatory Agencies	1	1	0	0
Researchers	5	0	5	5
Social Justice Community Organizations	1	1	0	0
Total	49	22	25	22

Cost Effectiveness

At the direction of the CEC, the proposed mandatory measures are not required to be cost effective as they are proposed for IAQ reasons. However, the Statewide CASE Team analyzed costs and energy impacts. The proposed code change was found to generate energy savings in almost all climate zones. Considering the prescriptive HRV/ERV requirement is proposed for energy savings (not IAQ), this component of the measure is not required be cost effective. The prescriptive requirement for an HRV/ERV was found to be cost effective compared to a mix of 15 percent supply-only and 85 percent balanced ventilation systems (the assumed mix under the proposed mandatory measure) in Climate Zones 1, 2, 4, 11 through 14, and 16. Consequently, the Statewide CASE Team proposes the prescriptive HRV requirement for Climate Zones 1, 2, 4, 11 through 14, and 16.

Table 3: Summary of Impacts for Multifamily IAQ Measure from First Year of Construction

Category	Metric	New Construction
Cost Effectiveness	Benefit-Cost Ratio Range (varies by climate zone and building type)	Not applicable
Statewide Impacts	First-Year Electricity Savings (GWh)	1.7
	First-Year Peak Electrical Demand Reduction (MW)	0.3
	First-Year Natural Gas Savings (Million Therms)	0.001
	First-Year Source Energy Savings (Million kBtu)	3.4
	30-Year LSC Electricity Savings (Million 2026 PV$)	12.0
	30-Year LSC Gas Savings (Million 2026 PV$)	0.1
	30-Year Total LSC Savings (Million 2026 PV$)	12.1
	First-Year Avoided GHG Emissions (Metric Tons CO_2e)	184.8
	Monetary Value of Avoided GHG Emissions during First Year ($)	22,755
	First-Year On-site Indoor Water Savings (Gallons)	Not applicable
	First-Year On-site Outdoor Water Savings (Gallons)	Not applicable
	First-Year Embedded Electricity in Water Savings (kWh)	0
Per dwelling unit Impacts	First-Year Electricity Savings (kWh)	31.8
	First-Year Peak Electrical Demand Reduction (W)	5
	First-Year Natural Gas Savings (kBtu)	2.0
	First-Year Source Energy Savings (kBtu)	64.7
	30-Year LSC Savings (2026 PV$)	227.6
	First-Year Avoided GHG Emissions (kg CO_2e)	3.5
	First-Year On-site Indoor Water Savings (Gallons)	Not applicable
	First-Year On-site Outdoor Water Savings (Gallons)	Not applicable
	First-Year Embedded Electricity in Water Savings (kWh)	0

Addressing Energy Equity and Environmental Justice

The Statewide CASE Team reviewed studies that considered how the proposed measure would impact disproportionately impacted populations (DIPs) and analyzed interviews with stakeholders who design or construct affordable multifamily housing on how it would impact residents. The proposed measure would provide additional IAQ and health benefits for low-income multifamily residents. In response to concerns from developers that the proposed measure would increase construction costs, the Statewide CASE Team revised the compartmentalization component of the proposal from an initially proposed limit of 0.2 cfm50/sf to 0.3 cfm50/ft^2. Full details addressing energy equity and environmental justice can be found in Section 2.

1. Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the CEC efforts to update California's Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The three IOUs—Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison—and two publicly owned utilities—Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author)—sponsored this effort. The program's goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The CEC is the state agency that has authority to adopt revisions to Title 24, Part 6. One of the ways the Statewide CASE Team participates in the CEC's code development process is by submitting code change proposals to the CEC for consideration. The CEC would evaluate proposals the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. See The California's Energy Commission's Title 24 website for information about the rulemaking schedule and how to participate in the process.

The goal of this CASE Report is to present a code change proposal for multifamily IAQ. The report contains pertinent information supporting the proposed code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders including multifamily developers, general contractors, mechanical engineers, architects, HERS Raters, and ventilation researchers. The proposal incorporates feedback received during two public stakeholder workshops held on February 21, 2023, and May 17, 2023.

The following is a summary of the contents of this report:

- **Section 2: Addressing Energy Equity and Environmental Justice** presents the potential impacts of proposed code changes on DIPs, as well as a summary of research and engagement methods.
- **Section 3: Measure Description** provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.

- **Section 4: Market Analysis** includes a review of the current market structure. Section 4.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- **Section 5: Energy Savings** presents the per-unit energy, demand reduction, and LSC Savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and LSC Savings.
- **Section 6: Cost and Cost Effectiveness** presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- **Section 7: First-Year Statewide Impacts** presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2025 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants (reductions) and impacts (increases) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.
- **Section 8: Proposed Revisions to Code Language** concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, and Alternative Calculation Manual (ACM) Reference Manual. Generalized proposed revisions to sections are included for the Compliance Manual and compliance forms.
- **Section 9: Bibliography** presents the resources that the Statewide CASE Team used when developing this report.
- **Appendix A: Statewide Savings Methodology** presents the methodology and assumptions used to calculate statewide energy impacts.
- **Appendix B: Embedded Electricity in Water Methodology** presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.
- **Appendix C: California Building Energy Code Compliance (CBECC) Software Specification** presents relevant proposed changes to the compliance software (if any).

- **Appendix D: Environmental Analysis** presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.
- **Appendix E: Discussion of Impacts of Compliance Process on Market Actors** presents how the recommended compliance process could impact identified market actors.
- **Appendix F: Summary of Stakeholder Engagement** documents the efforts made to engage and collaborate with market actors and experts.
- **Appendix G: LSC Savings in Nominal** Dollars presents LSC savings over the period of analysis in nominal dollars.

The California IOUs offers free energy code training, tools, and resources for those who need to understand and meet the requirements of Title 24, Part 6. The program recognizes that building codes are one of the most effective pathways to achieve energy savings and GHG reductions from buildings, and well-informed industry professionals and consumers are key to making codes effective. With that in mind, the California IOUs provide tools and resources to help both those who enforce the code, as well as those who must follow it. Visit EnergyCodeAce.com to learn more and to access content, including a glossary of terms.

2. Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in disproportionately impacted populations (DIPs) and the role this history plays in the environmental justice issues that persist today. While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017). Similar to the California Public Utilities Commission (CPUC) definition, DIPs refer to the populations throughout California that "most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, the presence of hazardous wastes, as well as a high incidence of asthma and heart disease" (CPUC n.d.). DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret them, and experience the world.[1]

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and facing the unjust legacies of the past all serve as critical steps to achieving energy equity. Recognizing the importance of engaging DIPs and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. A participatory approach allows individuals to address problems, develop innovative ideas, and bring forth a different perspective. Please reach out to the Statewide CASE Team lead for EEEJ, Marissa Lerner (mlerner@energy-solution.com), or the lead for the MF IAQ topic, Marian Goebes (mgoebes@trccompanies.com), for engagement.

Energy equity and environmental justice (EEEJ) is a newly emphasized component of the Statewide CASE Team's work and is an evolving dialogue within California and

[1] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur at higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

beyond.[2] To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences of proposals on DIPs. The Statewide CASE Team identified potential impacts via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. As the Statewide CASE Team continues to build relationships with CBOs, these partnerships would inform and further improve the identification of potential impacts. The Statewide CASE Team is open to additional peer-reviewed studies that contribute to or challenge the information on this topic presented in this report. The Statewide CASE Team is currently continuing outreach with CBOs and EEEJ partners. Results of that outreach as well as a summary of the 2025 code cycle EEEJ activities, would be documented in the 2025 EEEJ Summary Report that is expected to be published on title24stakeholders.com by the end of 2023.

2.1 General Equity Impacts

This subsection describes the equity impacts of all residential building code change proposals. Section 2.2 describes the EEEJ considerations and anticipated impacts for the MF IAQ code change proposal specifically.

2.1.1 Procedural Equity and Stakeholder Engagement

When developing code change proposals, the Statewide CASE Team considered unintended consequences for DIPs and strategies to mitigate negative impacts.

As mentioned, representation from DIPs is crucial to considering factors and potential impacts that may otherwise be missed or misinterpreted. The Statewide CASE Team is committed to engaging with representatives from as many affected communities as possible. This code cycle, the Statewide CASE Team is focused on building relationships with CBOs and representatives of DIPs across California. To achieve this end, the Statewide CASE Team is prioritizing the following activities:

- Identification and outreach to relevant and interested CBOs
- Holding a series of working group meetings to solicit feedback from CBOs on code change proposals

[2] The CEC defines energy equity as “the quality of being fair or just in the availability and distribution of energy programs” **Invalid source specified.**. American Council for an Energy-Efficient Economy (ACEEE) defines energy equity as that which “aims to ensure that disadvantaged communities have equal access to clean energy and are not disproportionately affected by pollution. It requires the fair and just distribution of benefits in the energy system through intentional design of systems, technology, procedures and policies”**Invalid source specified.**. Title 7, Planning and Land Use, of the California Government Code defines environmental justice as “the fair treatment and meaningful involvement of people of all races, cultures, incomes, and national origins, with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies”.

- Developing a 2025 EEEJ Summary Report

In support of these efforts, the Statewide CASE Team is also working to secure funds to provide fair compensation to those who engage with the Statewide CASE Team. While the 2025 code cycle would end, the Statewide CASE Team's EEEJ efforts would continue, as this is not an effort that can be "completed" in a single or even multiple code cycles. In future code cycles, the Statewide CASE Team is committed to furthering relationships with CBOs and inviting feedback on proposed code changes, with the goal of engaging with these organizations representing DIPs throughout the code cycle. Several strategies for future code cycles are being considered, including:

- Creating an advisory board of trusted CBOs that may provide consistent feedback on code change proposals throughout the development process
- Establishing a robust compensation structure that enables participation from CBOs and DIPs in the Statewide CASE Team's code development process
- Holding equity-focused stakeholder meetings to solicit feedback on code change proposals that seem more likely to have strong potential impacts

2.1.2 Potential Impacts on DIPs in Multifamily Buildings

2.1.2.1 Health Impacts

Understanding the influences that vary by demographics, location, or type of housing is critical to developing equitable code requirements. For example, homes that are identified as disadvantaged communities based on the California Office of Environmental Health Hazard Assessment's EnviroScreen[3] are more likely to be located in areas with high levels of ambient pollution, and multifamily units have the additional IAQ concern of pollutant transfer from neighboring units.

Several of the potential negative health impacts of buildings on DIPs are reduced by energy efficiency and ventilation measures (Norton and Brown 2014, Cluett and Amann 2015, Rose and Hawkins 2020). For example, IAQ improvements through ventilation or the removal of combustion appliances can lessen the incidence of asthma, chronic obstructive pulmonary disease (COPD), and some heart problems. Water heating and building shell improvements can lower stress levels associated with energy bills by lowering utility bill costs. Better insulation and tighter building envelopes can reduce the health impacts from the intrusion of dampness and contaminants, as well as provide a measure of resilience during extreme conditions.

2.1.2.2 Energy Efficiency and Energy Burden

As explained in Section 2.2.3, the measure would result in LSC Savings in almost all climate zones through reduced heating and cooling energy from compartmentalization

[3] For more on the EnviroScreen, go to: CalEnviroScreen | OEHHA

and through heat recovery for climate zones where an HRV is prescriptively required. Because low-income households have a higher energy burden (percent of income spent on energy) than average households, energy efficiency alone can benefit them more acutely compared to the average. Numerous studies have shown that low-income households spend a much higher proportion of their income on energy (two to five times) than the average household (Power 2007, Norton and Brown 2014, Rose and Hawkins 2020). See Section 6.2 for an estimate of LSC Savings from the current proposal. Moreover, utility cost stability is typically more important to these households compared to average households; for households living paycheck to paycheck, an unexpectedly high energy bill can keep that household cyclically impoverished (A. L. Drehobl 2020). Energy burdened households are 175 to 200 percent more likely to remain impoverished for longer than households not experiencing energy burden (A. L. Drehobl 2020).The impact of a rate increase or weather-related spike is more easily handled by the greater efficiency of the home. The cost impacts of efficiency and renewables can be significantly different for those in subsidized housing (where the total of rent plus utilities is controlled) versus those in single-family homes or market rate multifamily buildings.

2.1.2.3 First Cost and Cost of New Construction

One potential negative consequence of code-based efficiency for DIPs improvements is the potential for increased housing costs. While this CASE report did find the proposed code measure would increase construction costs, this increase is likely to be small compared with total development and construction costs. However, a study found that increased construction costs do not have a statistically significant impact on home prices, as prices in the new home market are driven overwhelmingly by demand (Stone, Nickelsburg and Yu, New Home Cost v. Price Study 2018). According to a peer-reviewed study done for the California Tax Credit Allocation Committee (CTCAC), land costs and developer characteristics (size, experience, and profit structure of the firm) have the most significant effect on affordable housing costs (CTCAC 2014). The 2014 study echoes the same findings in CTCAC’s cost study prepared in 1996 as well as the 2015 study by Stone et al. (Stone, Nickelsburg and Yu, Codes and Standards White Paper: Report - New Home Cost v. Price Study 2015). Similarly, developers of market-rate apartments conduct studies to investigate rent history and other information for comparable multifamily properties, which informs rent levels for specific projects[4].

[4] As examples, Yardi-Matrix: https://www.yardimatrix.com/Property-Types/Multifamily, HCA: https://apartmentstudy.gr8.com/, and Foley & Puls: http://foleypuls.com/apartment_market_research.html conduct market studies.

2.1.2.4 Cost Impacts for Renters

Renters within DIPs can also benefit from home energy efficiency improvements. Whether market rate or affordable, utility bills would be lower in homes that are more energy efficient. However, the utility bill impacts of energy efficiency in subsidized affordable housing are less clear since CTCAC staff regularly review tax credit properties to assure that affordable housing renters pay utility bills virtually equal to the utility cost estimates that were used when establishing rents (Internal Revenue Service, Treasury 2011). Renters of market-rate housing seldom ask about energy efficiency and utility bills,[5] so efficiency has little impact on rents, whereas it can have a large impact on utility bills (NMHC 2022).

2.2 Specific Impacts of the Proposal

2.2.1 Research Methods and Engagement

The Statewide CASE Team reviewed literature to identify how the MF IAQ measure could impact DIPs, including:

- Data from the CalEnviroScreen website indicating how DIPs may be disproportionately affected
- Studies showing how DIPs may be more susceptible to health and quality of life impacts, including (The Greenlining Institute 2023) and other studies
- Interviews with market actors that are active in affordable housing

The Statewide CASE Team's interviews included 16 multifamily market actors that are active in designing, constructing, verifying, or researching multifamily buildings, including many that work on affordable multifamily buildings.[6] They included subject matter experts (SME), architects (Arch), raters (Rtr), general contractors (GC), mechanical engineers (ME), and developers (Dev). On average, the market actors interviewed reported that 71 percent of the multifamily projects that they work on are affordable, as shown in Table 4. As part of the interviews, many of these stakeholders described how the proposed measure would impact residents of affordable multifamily dwelling units.

[5] According to manager and renter surveys conducted by the Multi-Housing Council in 2022, residents are interested in internet connectivity, package delivery services, gyms, and similar amenities. Smart thermostats were the only energy related feature they reported as essential or nearly so.

[6] The Statewide CASE Team conducted 25 total interviews, but 5 of these were with subject matter experts whose expertise includes energy modeling in multifamily buildings, but who do not conduct market research, so they could not report on typical practices or impacts to residents.

Table 4: Percent of Multifamily Projects that Interviewees Designed, Constructed, or Verified that are Affordable

% of Market Actor Multifamily Projects	SME (n=1)	Arch (n=3)	Rtr (n=3)	GCs (n=4)	ME (n=2)	Dev (n=3)	Total (n=16)
% of projects that are affordable	95%	73%	60%	56%	70%	100%	71%
% of projects that are market rate	5%	27%	40%	44%	30%	0%	29%

2.2.2 Potentially Impacted Populations

While the proposed change would impact all residents of multifamily dwelling units, several DIP communities should uniquely benefit because they have increased asthma incidences or experience more asthma symptoms. As described in Section 3.2, the measure should reduce the concentration of pollutants that can exacerbate asthma. Consequently, the proposed measure could uniquely impact the following DIPs:

- Low-income Californians are 39 percent more likely to live in multifamily housing than the general population, and low-income multifamily residents should uniquely benefit from the proposed measure since asthma rates were found to be higher among low-income families (American Lung Association 2018). Children aged 5–17 years were also found to have significantly higher rates of asthma (CDPH 2017), and low-income children may also spend more time at home than non-low-income children (Zhu, et al. 2020), which increases their exposure time to pollutants.
- Multifamily residents who are Black or Native American should uniquely benefit because these populations have higher rates of asthma than the general population (Meng, et al. 2007).
- Multifamily residents that live in the areas identified by CalEnviroScreen as Disadvantaged Communities (DACs) should benefit from the proposed measure. These residents live in areas that are "disproportionately affected by environmental pollution and other hazards," which include higher outdoor (ambient) PM2.5 and traffic (CALEPA 2022). As described in Section 3.2, the proposed measure should decrease the penetration of outdoor PM2.5 and reduce traffic noise.
- Smoking rates are also higher in some DIP communities, including adults who are receiving federal housing assistance. A study found that "smoking rates among adults receiving federal housing assistance are almost twice the rate of the general population, and secondhand smoke exposure is almost twice as high among Black people as White people (Hernández, et al. 2019). While secondhand smoke exposure primarily includes exposure within a dwelling unit, studies have documented secondhand smoke transfer between dwelling units (D. L. Bohac, M. J. Hewett, et al. 2011).
- The proposed measure could impact all multifamily residents, including DIPs, in that additional construction costs could be passed on to residents. For example,

multifamily developers may increase the sales price of condominiums, and multifamily building owners may increase rental prices. On the other hand, the measure would reduce energy bills through lower heating and cooling needs.

The next section describes anticipated impacts.

2.2.3 Potential Impacts

The Statewide CASE Team anticipates the following impacts to DIPs.

2.2.3.1 Reduction in pollutants that can exacerbate asthma

In general, compartmentalization should reduce many of the pollutants that can exacerbate asthma. Through the combination of filtered outdoor air and compartmentalization, the measure should reduce chronic exposure to PM2.5, which affects both the respiratory and cardiovascular systems and results in negative health impacts, including an increased incidence of all-cause mortality and stroke (Bowe 2019). Additionally, compartmentalization should reduce exposure to gaseous pollutants such as formaldehyde, NO_2, and benzene in secondhand smoke from neighboring units (Modera, et al. 2023). NO_2 and secondhand smoke are associated with asthma (Anenberg, et al. 2022); (U.S. Center for Disease Control 2022) and formaldehyde is a respiratory irritant, Studies have found an association between exposure to these pollutants and cancer (U.S. EPA n.d.).

The Greenlining Institute set a goal of cutting the number of asthma-induced emergency room visits in half, and IAQ measures are an important step towards that goal (The Greenlining Institute 2023, U.S. EPA n.d.).

One potential concern is that compartmentalization can increase pollutant concentrations released within occupants' own units if they do not operate their local exhaust, particularly their kitchen fans (Modera, et al. 2023). This highlights the importance of resident education, and 2022 Title 24, Part 6 Section 10-103(b)4 requires that residents be trained on the ventilation equipment they must operate. A recent survey of 142 California residents found that about two-thirds reported using their range hood most of the time (37 percent) or always (30 percent), and another one-quarter (27 percent) reported using it sometimes (TRC Advanced Energy 2022). The results found that non-White respondents were more likely to report using their hood most of the time or always (75 percent) compared to White respondents (56 percent), but there were no other significant differences by race, ethnicity, or income (TRC Advanced Energy 2022). These results are an increase compared to previous research and may indicate that range hood use is increasing over time.

2.2.3.2 Noise reduction, contribution to a peaceful environment, and pest control

Compartmentalization reduces noise transfer from the exterior and from neighboring units. One subject matter expert who designs affordable housing noted that a source of mechanical ventilation with compartmentalization is important because these units are quieter while providing fresh air. They are often sited in dense areas next to highways. “To be able to close the door and have quiet in your unit is huge."

Two interviewees who design affordable housing noted that compartmentalization reduces pest transfer between units, which can be a particular concern in affordable multifamily housing.

2.2.3.3 Reduction in LSCs

The measure would result in LSC Savings in the majority of climate zones through reduced heating and cooling energy from compartmentalization. This would provide a higher benefit to people in low-income households and low-income census tracts who spend a higher percentage of their income on energy and rent than the general population.

2.2.3.4 Higher construction costs have potential to be passed on as higher rent or purchase price

The measure results in higher construction costs for new construction, which may be offset by higher rents or the purchase price of the dwelling units, putting a higher burden on low-income households and residents in low-income census tracts. The Statewide CASE Team also conducted outreach to learn more from those in the industry. Two interviewees who were developers of affordable multifamily projects were generally in favor of the proposed measure, but they raised concern over costs, since this could reduce the total number of dwelling units constructed. One recommended that financiers provide additional funding to affordable developers to offset the additional cost. Another developer of affordable multifamily projects was against the proposed measure because of cost concerns for switching from exhaust-only to balanced ventilation. As discussed in Section 6, one reason the Statewide CASE Team proposes to require compartmentalization at a maximum value of 0.3 $cfm50/ft^2$ instead of 0.2 $cfm50/ft^2$ is cost concerns, particularly for affordable housing.

2.2.3.5 Competing effects on cooling needs during heat waves

Many Americans die each year from overheating, and extreme heat disproportionately impacts low-income residents and people of color (Shivaram 2021). The Statewide CASE Team considered the impact of this measure on cooling needs during heat waves. As described below, the measure package has competing impacts on cooling needs.

- The requirement for balanced or supply-only ventilation would increase the amount of outdoor air provided to dwelling units on average, which increases overall cooling loads.
- Because of the prescriptive HRV requirement, the proposed measure should generally reduce cooling needs in Climate Zones 1, 2, 4, 11–14, and 16 because the HRV/ERV would pre-cool incoming supply air. An HRV could increase cooling needs in Climate Zones 3, 5–10, and 15 due to the mild climates in these regions, where cooler outside air would be unnecessarily heated by the HRV during shoulder seasons.
- Compartmentalization reduces the amount of air that infiltrates through the building envelope. This has a mixed impact on cooling loads during the cooling season. When it is hotter outdoors than indoors, compartmentalization reduces cooling loads. When it is cooler outdoors than indoors, compartmentalization increases cooling loads. However, residents could reduce this impact by opening windows or balcony doors when it is cooler outside.

Many existing dwelling units do not have air conditioning, but the proposal does not affect alterations.

2.2.3.6 Competing effects on residents' ability to control their own IAQ

The proposed measure is likely to have competing impacts on residents' ability to control their own IAQ. By reducing the transfer of pollutants from their neighbors, compartmentalization allows each resident to have more control over their unit's IAQ. However, supply or balanced ventilation may be provided centrally or through a system that may not be visible or controllable by the occupant. One architect who works primarily on affordable housing noted the simplicity of an exhaust-only approach for ventilation. Two interviewees reported that operable windows and easily accessible controls are important. However, one architect who builds 100 percent affordable housing and one rater who primarily verifies affordable housing indicated that many of their units are close to highways and thus saw the filtration connected to dedicated supply air through supply-only or balanced ventilation as a benefit to the occupants.

2.2.4 Evolution of the Code Change Proposal and Future Opportunities

The potential increase in rent or purchase price and its impact on DIPs is one reason why the Statewide CASE Team proposes a compartmentalization limit of 0.3 cfm50/ft^2 instead of 0.2 cfm50/ft^2, which was the Statewide CASE Team's original proposal (to align with ASHRAE Standard 62.2-2022). In interviews, market actors reported that it is more expensive to compartmentalize to a lower (tighter) value, which would result in higher construction costs. While only a few interviewees provided cost estimates on compartmentalization, the few estimates collected and the qualitative interview results indicate that costs increase steeply as compartmentalization tightens, as documented in

Section 6.3.2. Several interviewees who design, build, or verify affordable housing agreed that compartmentalization should be required, but they recommended requiring 0.3 instead of 0.2 $cfm50/ft^2$ for feasibility and cost reasons. Section 3.2 discusses the monetized health benefits of improved IAQ.

While this research gathered input from stakeholders such as affordable housing developers that work directly with DIPs, the Statewide CASE Team did not gather feedback directly from impacted residents. One consideration for a future opportunity would be to gather feedback directly from DIPs that are affected by multifamily code change proposals for high-level insights. This could take the form of focus groups or a survey to gather feedback on residents' concerns and priorities for housing conditions, as well as to understand how residents rank low energy bills and health compared with higher incremental housing costs. The focus groups or survey could include questions on several multifamily topics, and they could collect responses from one or more of the following groups aligned with multifamily properties in DIPs: residents, maintenance staff, resident support specialists, and property owners. Affordable housing owners, housing advocacy groups, environmental justice groups, and other organizations could potentially provide contacts for focus groups or survey respondents. While this data collection is unlikely to provide insights in time to affect the Title 24 2025 cycle, results could provide broad insights for future cycles.

3. Measure Description

This section describes a measure that would impose a mandatory requirement for multifamily dwelling unit ventilation systems and would impose a compartmentalization requirement. The dwelling unit ventilation system describes the system(s) of fans for bringing in outside air to meet a minimum dwelling unit ventilation rate. The requirement for a dwelling unit ventilation system is separate from local exhaust requirements, which call for exhaust fans to remove air from kitchens, bathrooms, or dryers. However, as described below, local exhaust fans can be used as part of a dwelling unit ventilation system.

As key terminology, this section categorizes dwelling unit ventilation systems into:

1. **Exhaust-only systems:** One or more fans remove air from the unit, causing outdoor air to enter by normal leakage paths through the building envelope. Project teams may also incorporate passive ventilation inlets with the intent of providing airflow into the unit.[7]
2. **Supply-only systems:** One or more fans bring outdoor air into the unit, causing indoor air to flow out of the unit through passive ventilation relief outlets or normal leakage paths through the building envelope.
3. **Balanced systems:** A fan removes air from the unit while another fan simultaneously brings outdoor air into the unit at the same rate.

Compartmentalization refers to air sealing the dwelling unit envelope with the exterior (for energy savings) and with adjacent spaces (such as adjacent units, the corridor, etc.) to reduce pollutant transfer for indoor air quality (IAQ). The level of compartmentalization achieved is measured through a blower door test that is conducted on a sample of individual dwelling units.

The Statewide Codes and Standards Enhancement (CASE) Team proposes this change for new construction dwelling units and does not propose changes for additions nor alterations.

3.1 Proposed Code Change

The 2022 version of Title 24, Part 6 requires multifamily units to comply with either of the following: providing balanced ventilation or meeting a compartmentalization

[7] While passive ventilation inlets are used in the market, the Statewide CASE Team discourages the use of them, since they do not allow for filtration of outdoor particulate matter. In addition, while they are intended to provide supply air, air could unintentionally flow out of the passive ventilation inlets if the dwelling unit is pressurized due to wind effects, stack effects, or other reasons.

maximum of 0.3 cfm/ft^2 @50 Pa. This proposal would add a mandatory measure for all new construction multifamily units, with the purpose of protecting IAQ to:

- Use supply-only or balanced ventilation as a whole dwelling unit strategy. Use of exhaust-only ventilation cannot be used for whole dwelling unit ventilation. The proposed language also requires that IAQ system components (i.e., filter and HRV/ERV heat/energy recovery core) be accessible for replacement and maintenance. And
- Require mandatory compartmentalization at a maximum of level of 0.3 cfm/ft^2 @50Pa.

Local exhaust systems would still be used to meet local exhaust requirements, such as in bathrooms, kitchens, and dryers, and exhaust fans could be used as part of a balanced ventilation approach.

In addition to these changes to the mandatory requirements, the Statewide CASE Team proposes the following changes to the prescriptive requirements and compliance options to promote energy savings:

- Revise the prescriptive requirement in the 2022 Title 24, Part 6 that requires multifamily dwelling units in Climate Zones 1, 2, 4, 11 through 14, and 16 that use the balanced ventilation path to include a heat recovery ventilator (HRV) or energy recovery ventilator (ERV). The proposed change is to prescriptively require all multifamily dwelling units in Climate Zones 1, 2, 4, 11 through 14, and 16 to use balanced ventilation with an HRV or ERV. Multifamily dwelling units in these climate zones that use a performance path could use supply-only ventilation, but the project would need to compensate by exceeding code requirements for energy efficiency with another measure.
- A prescriptive requirement for an FID that serves the outdoor air fan or, where applicable, the HRV/ERV. Projects could instead follow the performance path and incur a penalty in the modeling software that assumes 10 percent lower ventilation fan efficacy, and 10 percent lower SRE for an HRV/ERV.

The proposal does not make changes for additions or alterations.

- For additions, Title 24, Part 6 Section 180.1(a)2 specifies that additions must meet the local exhaust requirements for new construction in any areas of the addition that trigger local exhaust (e.g., any bathrooms or kitchens in additions), and they must provide whole dwelling unit ventilation for additions larger than 1,000 ft^2. Furthermore, Title 24, Part 6 Section 180.1(a)2Aii specifies that additions that increase conditioned floor area by more than 1,000 ft^2 shall meet the airflow specified for new construction dwelling units. The Statewide CASE Team proposes adding language to specify that additions could use exhaust, supply, or balanced ventilation systems for whole dwelling unit ventilation, so there would be no change for additions. Compartmentalization is not required for additions.

- For alterations, 2022 Title 24, Part 6 Section 180.2(b)5 specifies that entirely new or complete replacement ventilation systems (defined as a system where the ventilation system and at least 75 percent of ductwork is replaced) must meet the ventilation requirements for new construction. The Statewide CASE Team proposes adding language to that section to allow altered multifamily dwelling units to use exhaust, supply, or balanced ventilation systems for dwelling unit ventilation. There would be no changes for alterations for ventilation strategy. Consistent with the requirements in 2022 Title 24, Part 6, dwellings that were not required by a previous building permit to have a whole-dwelling unit ventilation system shall not be required to comply with the whole-dwelling unit ventilation. Compartmentalization is not required for any alterations. The proposed mark-up includes language that compartmentalization is not required for additions or alterations. This is to address a stakeholder comment regarding an error in an automatically generated CF1R form, calling for compartmentalization in an alterations project.

While most of this CASE Report discusses proposals for multifamily units, the Statewide CASE Team proposes the following requirements for single-family dwelling units.

- Mandatory requirements for IAQ system component accessibility, in which the filter panel, HRV/ERV access panel, and outdoor air inlet must be accessible or within 10 feet of a walking surface. Ventilation systems with an FID would not need to meet the filters, HRV/ERV energy recovery core or outdoor air intake accessibility requirements.
- A prescriptive requirement for an FID that serves the outdoor air fan or, where applicable, the HRV/ERV. Projects could instead follow the performance path and incur a penalty in the modeling software that assumes 10 percent lower ventilation fan efficacy, and 10 percent lower SRE for an HRV/ERV.

Both of these proposed measures for single-family homes align with the proposed requirement for multifamily units, and with 2022-Title 24 Part 6 ACM requirements.

3.2 Justification and Background Information

There are two components of the proposed measure: a dedicated source of outdoor air for ventilation through balanced or supply-only ventilation, and compartmentalization. The two components work hand-in-hand—a mechanical source of supply air for ventilation is important for IAQ as a unit’s envelope is tightened to ensure adequate outdoor air. Compartmentalization would provide IAQ benefits by reducing pollutant transfer between units and comfort benefits by reducing noise transfer between units.

Because compartmentalization tightens a unit's envelope on all sides—with the exterior and with adjacent spaces (e.g., corridor, adjacent units, trash chutes, etc.)—the measure would also save energy by reducing leakage to the exterior, thereby reducing heating and cooling energy. An argument against this proposal could be to not require either, so to allow a leaky envelope that would reduce the need for supply or balanced ventilation. But with multifamily dwelling units, this approach jeopardizes IAQ because of the potential for pollutant transfer from neighboring units. In addition, just doing one of these components (balanced / supply-only ventilation, or compartmentalization, but not both) does not provide adequate protection against outdoor PM2.5 (i.e., particulate matter 2.5 micrometers or smaller) infiltration into dwelling units, as described in Section 3.2.2. Tightening the building envelope also provides energy savings and reduces noise from the exterior.

While the two components of this measure (balanced or supply-only ventilation, and compartmentalization) complement each other and promote good IAQ, they provide distinct benefits. Consequently, this section provides separate justifications for each of the two components.

Various studies have identified major costs associated with the negative health effects of poor indoor air quality. The disability adjusted life years (DALY) loss due to poor indoor air quality is estimated to be 0.011 per person per year (J. M. Logue, et al. 2012) which corresponds to an economic value of $580 per person per year in 2026 dollars ($380 in 2008 dollars) (Brown 2008). In addition, the net value of treatment for asthma, for which poor indoor air quality is a cause, was estimated to be around $782 per patient per year in 2026 dollars ($518 in 2010 dollars) (Highfill and Bernstein 2014).

3.2.1 Background for Balanced or Supply-only Ventilation

Dwelling unit ventilation can be provided using three overall approaches: exhaust-only, supply-only, or balanced. The following table provides a description of each and example strategies. Section 4.1 describes how often these strategies are used in the market.

Table 5: Dwelling Unit Ventilation Strategies

Dwelling unit ventilation strategy	Description	Common Approach(es)
Exhaust-only	One or more fans remove air from the unit, causing outdoor air to enter by normal leakage paths through the building envelope.	Bathroom fan (or less typically kitchen fan) runs continuously. The fan may have a *boost* mode for a higher speed to provide local exhaust or run at a high enough rate to meet continuous local exhaust requirements. The unit may have passive ventilation inlets with the intent of bringing in outdoor air.[8]
Supply-only	One or more fans bring outdoor air into unit, causing indoor air to flow out of the unit through normal leakage paths through the building envelope.	Individual (through-wall) in-line fan provides outside air to each unit, or Rooftop dedicated outdoor air system (DOAS) is ducted through each corridor and branched to each unit to provide outside air to each unit.
Balanced	One or more fans exhaust air from the unit, while another fan simultaneously supplies outdoor air into the unit. These could be separate (supply fan disconnected from exhaust fan but running on same schedule) or part of the same system. May or may not have heat or energy recovery (HRV/ERV).	One of the supply-only approaches with continuous bathroom exhaust, or: • Individual HRVs or ERVs, where each dwelling unit has its own system, ducted through-wall. • One or more central HRVs/ ERVs, that serves multiple dwelling units, and which could be located on the roof or in a mechanical room on one or multiple floors.

As illustrated in Section 5.2, different ventilation strategies use different amounts of energy. In general, exhaust-only, and supply-only use similar amounts of energy. Balanced ventilation without heat recovery uses more energy than exhaust-only or supply-only, because it uses both exhaust and supply fans. Depending on climate zone, balanced ventilation with heat recovery can use less energy than exhaust-only or supply-only, since it captures the heat or energy of exhausted air and transfers some of the heat[9] to the incoming outside air.

While both supply-only and balanced ventilation provide a dedicated source of outdoor air, balanced ventilation has the additional benefit of reducing pollutant transfer between

[8] While passive ventilation inlets are used in the market, the Statewide CASE Team discourages the use of them, since they do not allow for filtration of outdoor particulate matter. In addition, while they are intended to provide supply air, air could unintentionally flow out of the passive ventilation inlets if the dwelling unit is pressurized due to wind effects, stack effects, or other reasons.

[9] Under Title 24, Part 6-2022 Section 170.2(c)3Bivb, projects using balanced ventilation in Climate Zones 1, 2, and 11-16 must install an ERV or HRV with a sensible recovery efficiency of at least 67 percent.

dwelling units, as it reduces pressure differences between units. While units with balanced ventilation may still become unbalanced due to the use of intermittent (local) exhaust fans, wind pressures, or other conditions, pressure differences between dwelling units are reduced if the dwelling unit ventilation strategy is not adding to the pressure differences. Starting in the 2019 version of Title 24, Part 6, all new construction multifamily dwelling units are required to implement balanced dwelling unit ventilation or compartmentalization as an IAQ measure. The 2022 versions of Title 24, Part 6 require that if a multifamily building uses supply-only or exhaust-only ventilation, all dwelling units in the building must use the same ventilation strategy to reduce pressure differences between units.

3.2.2 Justification for Balanced or Supply-only Ventilation

Both balanced ventilation and compartmentalization (≤0.3 cfm50/ft^2) have been available compliance paths since 2019 Title 24, Part 6. The proposed measure for balanced or supply-only ventilation aligns with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.2-2022, which requires balanced ventilation or supply-only ventilation for new multifamily dwelling units, with an exception for garden-style units in which each dwelling unit is accessed directly from the outdoors. The Statewide CASE Team proposes that balanced or supply-only ventilation be required for all multifamily units (including garden-style), because garden-style units may also receive outdoor air at rates lower than the required ventilation rates and for simplicity.

The proposed measure provides a reliable rate of outdoor air. The purpose of the requirement is to provide a reliable rate of outside air. Because a multifamily dwelling unit has neighboring units, an exhaust-only approach would bring in a mix of:

- Outside air, which meets the intent of the dwelling unit ventilation requirement, and
- Air from adjacent spaces, such as neighboring units, corridors, elevator shafts, or other areas bordering the dwelling unit. These areas do not directly provide outside air, so they do not meet the intent of the dwelling unit ventilation requirement.

Based on air leakage testing of low-rise multifamily buildings (excluding garden style), the Center for Energy and Environment found huge variability among units for the percent of leakage from the exterior, as well as a median value of 27 percent of dwelling unit leakage from the exterior (Bohac, et al. 2020). Figure 1 below illustrates the difference between total unit leakage (blue diamonds) and leakage from the exterior (red dots for units on the top floor; green dots for units on lower floors). In other words, each dwelling unit is represented by a green or red dot, and a blue diamond, to show the relationship between exterior leakage (green or red dot) and total unit leakage (blue diamond). The data combines dwelling units in 20 common-entry buildings. The “percent of units” in the y-axis allows the reader to identify the percent of units with a total unit leakage. For example, 90 percent of units had an air leakage at or below 6 ACH50, which (depending on unit geometry) is roughly equivalent to a compartmentalization value of 0.3 cfm50/ sf.

Similar field measurements were conducted by the California Code Readiness Team for three buildings with common corridors in California, and that research found that 22 to 43 percent of air leakage came from the exterior (Staller, et al. 2023).

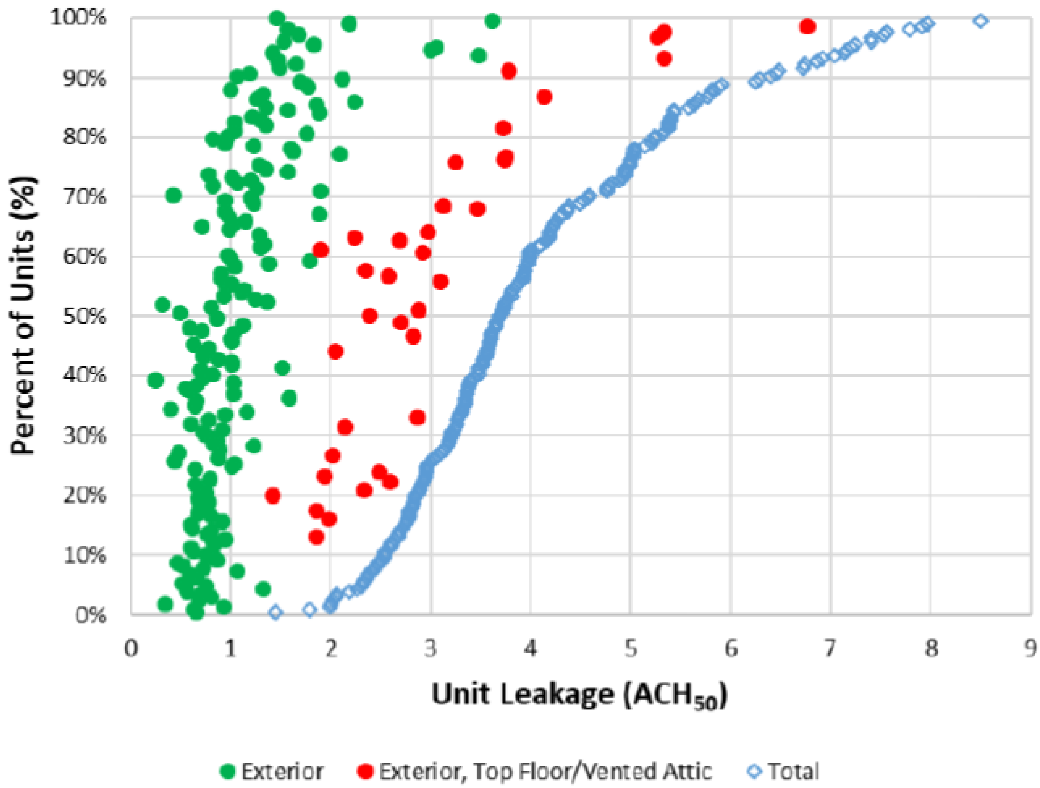

Figure 1: Cumulative distribution of unit total leakage (blue dots) and exterior leakage (green and red dots) from common-entry multifamily dwelling units

Source: (Bohac, et al. 2020)

A higher fraction of exterior leakage has been found in garden-style units – i.e., dwelling units in which each unit is accessed by its own exterior entry. For garden-style units, a study that used field measurements (Bohac, et al. 2020) 2020 found variability among units. Approximately half of air leakage came from the outdoors. Similar field measurements were conducted by the California Code Readiness Team for three garden-style buildings in California. The results found that 62 to 76 percent of air leakage came from the exterior (Staller, et al. 2023).

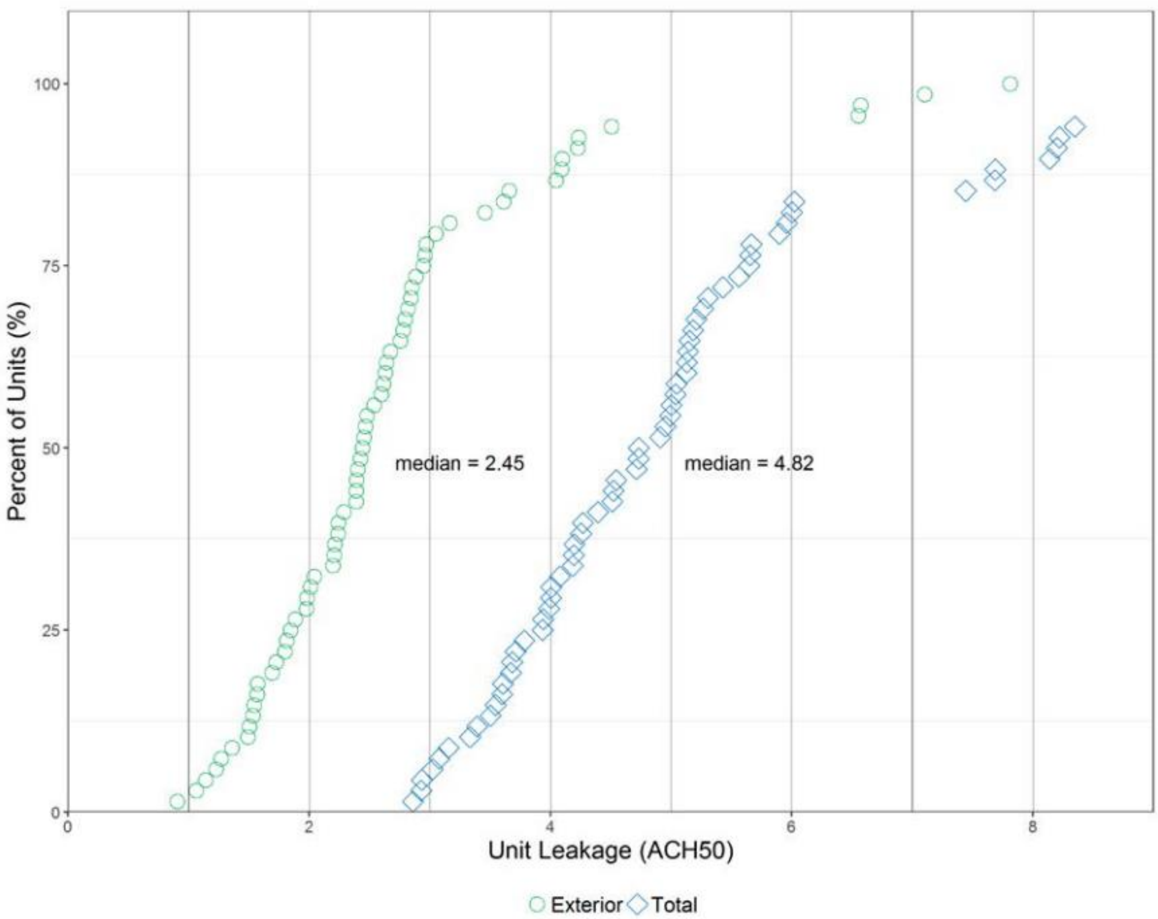

Figure 2: Cumulative distribution of unit total leakage (blue diamonds) and exterior leakage (green circles) from garden-style multifamily dwelling units

Source: (Bohac, et al. 2020)

While pressure differences would also influence leakage in the building, these data indicate that exhaust-only ventilation is not a reliable way to provide outdoor air to a multifamily dwelling unit, instead of a mix of outdoor air and indoor air from other areas of the building (such as neighboring units).

The Consortium for Energy Efficiency (CEE) 2020 study measured air leakage into dwelling units from different parts of the building, and it did not account for the ventilation system's operation and the pressure differences it would create. Although all units could use an exhaust-only strategy, which would reduce pressure differences between units, there are several factors that can still create pressure differences and therefore airflow between units. These include residents turning on an intermittent exhaust fan like a kitchen or dryer fan, residents opening windows, the stack effect or the tendency for air to move upward in a building during the heating season, and wind effects such as units on the windward side of the building that would be at a higher pressure than units on the leeward side.

A recent study by the University of California (UC), Davis for the California Air Resources Board of multifamily ventilation and compartmentalization did estimate the impact of ventilation system operation using CONTAM modeling, where modeling assumptions were based on field measurements in three multifamily buildings (Modera, et al. 2023). The figure below shows the average airflow (in cfm) for dwelling units from four sources under an exhaust-only ventilation strategy: ventilation supply ("sup"), the outdoors ("ambt" for ambient), the common interior hallway ("hall"), and neighboring units ("nbr"). The figure shows these results at three levels of compartmentalization: 0.15, 0.3, and 0.45 cfm50/ft^2. The 2022 Title 24, Part 6 requires that multifamily dwelling units have a dwelling unit ventilation rate of 38 to 60 cfm, depending on size and number of bedrooms. However, at a compartmentalization rate of 0.3 cfm50/ft^2, this figure shows on average 31 cfm comes from the outdoors (ambient, through infiltration) under an exhaust-only approach. Supply air is zero since this is an exhaust-only approach. Furthermore, there is considerable variation among units, with some receiving less than 20 cfm of outdoor air, which is insufficient for IAQ.

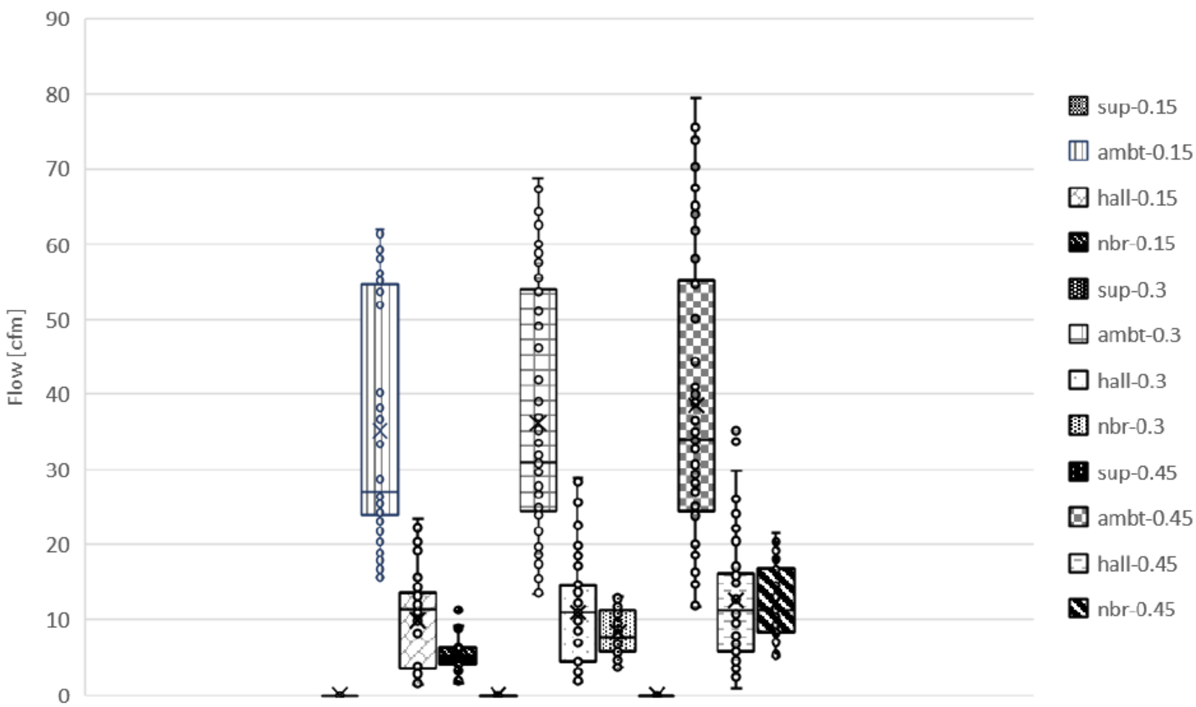

Figure 3: Average airflow into dwelling units from outdoors (ambt), common corridor (hall), and neighboring units (nbr), under an exhaust-only ventilation strategy (Modera, et al. 2023)

In contrast, (Modera, et al. 2023) found that (at a compartmentalization rate of 0.3 cfm50/ft^2), a balanced ventilation approach provided approximately 43 cfm of outdoor air through the supply fan and an additional five cfm of outdoor air through infiltration (ambient). Results were similar for the supply-only ventilation strategy.

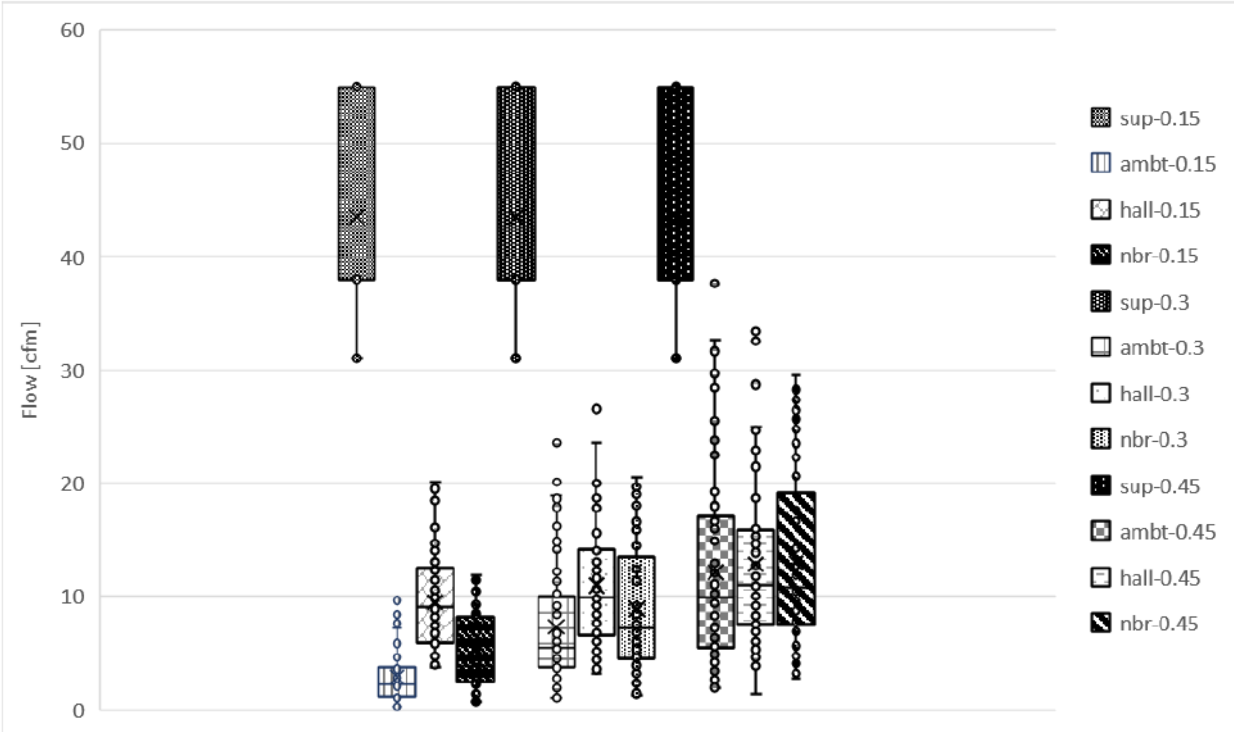

Figure 4: Average airflow into dwelling units from outdoors (ambt), common corridor (hall), and neighboring units (nbr), under balanced ventilation strategy (Modera, et al. 2023)

The proposed measure should reduce outdoor PM2.5 infiltration. While it is challenging to quantify the impact, the measure is likely to reduce PM2.5 infiltration from the exterior and from neighboring units, as explained below.

- Since the 2019 cycle, Title 24, Part 6 has required that balanced and supply-only ventilation have filtration with a minimum effective removal value (MERV) of 13, which removes at least 85 percent of PM 3 micrometers and smaller (PM3) [10] (U.S. Environmental Protection Agency 2022). PM3 is a size category slightly larger than PM2.5, so most PM2.5 is removed with MERV 13 filtration.
- As described in Section 3.2.4, studies have found that a tight dwelling unit envelope reduces PM2.5. While the Statewide CASE Team could not identify studies that measured the ability of a leaky envelope to remove outdoor PM2.5, it is logical that a leakier envelope could have larger holes that reduce its ability to filter outdoor PM2.5.

[10] Specifically, a MERV 13 filter removes at least 50 percent of PM that is 0.30-1.0 micrometers, 85 percent of PM that is 1.0-3.0 micrometers, and 90 percent of PM that is 3.0-10.0 micrometers. (U.S. Environmental Protection Agency 2022)

Under the current requirements, most projects are either installing balanced ventilation without compartmentalization, or exhaust only with compartmentalization. Either of these paths present the risk of PM2.5 infiltration from the outdoors, or from neighboring units:

- Balanced ventilation with MERV 13 filtration should remove most PM2.5 in the ventilation air. But without compartmentalization, ambient PM2.5 can infiltrate through the exterior wall, or PM2.5 may be transferred from adjacent units.
- Exhaust-only ventilation with compartmentalization provides some protection against ambient PM2.5 and PM2.5 transfer from neighboring units. However, two of the three interviewees that reported using (designers) or verifying (raters) an exhaust-only strategy reported the use of passive vents (such as trickle vents or z-ducts) for bringing in fresh air. Passive vents do not filter outdoor air, so they would increase the outdoor PM2.5 entering the dwelling unit.

A study found that “Multi-unit housing residents are particularly at risk for secondhand smoke exposure, because of higher tobacco use and air exchange between units [i.e., the movement of air from one dwelling unit to another]”, and based on a review of other studies found that “substantial proportions of multi-unit residents reporting secondhand smoke incursions, ranging from 26 to 64 percent” (Hernández, et al. 2019). (Hernández, et al. 2019) Although many buildings have moved to banning smoking indoors, one study of a multifamily building that banned smoking found that residents reported a reduction, but not an elimination, in secondhand smoke transfer (Hernández, et al. 2019). For example, one study found that 17 percent of residents reported frequent exposure to secondhand smoke 16 months after a no-smoking policy was adopted (Hernández, et al. 2019). While the details of the buildings in this study are not known, including the presence or absence of patios, or the presence or absence of outdoor smoking areas, compartmentalization would help address secondhand smoke transfer in all these scenarios, since it would reduce penetration of secondhand smoke from both adjoining interior spaces and nearby outdoor areas.

3.2.3 Background Information for Compartmentalization

Compartmentalization refers to air sealing each dwelling unit to reduce air exchange with the exterior (to reduce infiltration, for energy reasons) and with adjacent spaces such as other dwelling units, the corridor, or other interior spaces (e.g., elevator shaft, parking garage, etc.) for IAQ reasons.

The proposed code change to require compartmentalization would result in multifamily project teams improving air sealing for dwelling units. This proposed code change would require architects or other design team members to specify how dwelling units would be sealed (where to seal and with what materials); general contractors and subcontractors, particularly drywall and waterproofing contractors, to follow these specifications during construction; and HERS Raters to test a sample of units to ensure that the maximum leakage of 0.3 $cfm50/ft^2$ is not exceeded. In addition, there would be more communication throughout the process within the project team to ensure the compartmentalization target is met. Section 4.2.2 provides more detail on how project teams have met a compartmentalization target for 2019 Title 24, Part 6 or as part of a program such as Leadership in Energy and Environmental Design (LEED).

As described in Section 3.4.1, air sealing for compartmentalization has some overlap with existing air sealing requirements:

- At the exterior for waterproofing or quality insulation installation (QII).
- At the interior for fire proofing and acoustical sealing.

Consequently, even project teams that are not pursuing compartmentalization currently are practicing many of the air sealing techniques that are required for other purposes.

3.2.4 Justification for Compartmentalization

The primary purpose for requiring compartmentalization is IAQ benefits.

Air sealing between units reduces pollutant transfer between units. In particular, compartmentalization should reduce the transfer of cooking-related pollution (PM2.5, NO_2, formaldehyde, benzene, etc.), second-hand smoke from cigarettes (PM2.5, benzene, and other pollutants) and cannabis, and odors. A recent study by UC Davis for the California Air Resources Board investigated the impact of different levels of compartmentalization on air transfer and IAQ using field measurements and modeling (Modera, et al. 2023). The study found:

- No measurable transfer of PM2.5 micrometers or smaller in dwelling units compartmentalized to an average of 0.16 $cfm50/ft^2$ based on field measurements.
- Reduced transfer of NO_2 for units compartmentalized at 0.3 $cfm50/ft^2$ compared to 0.45 $cfm50/ft^2$, although the resulting pollutant concentration from the transferred NO_2 was low (one to two ppb).
- Reduced transfer of benzene (C_6H_6) released from cigarettes at tighter levels of compartmentalization. In the study, benzene concentrations in units next to smokers were compared to a concentration of 0.04 ppm, the concentration associated with a cancer risk of one-in-a-million (EPA 2003). At a unit leakage level of 0.15 $cfm50/ft^2$, about 90 percent of units neighboring a smoker had benzene levels below the one-in-a-million cancer risk level, whereas at a leakage level of 0.45 $cfm50/ft^2$, about 50 percent of units neighboring a smoker had benzene levels below the one-in-a-million cancer risk level. While it is possible that the relationship between unit tightness and benzene transfer is non-linear, a ballpark estimate based on interpolation is that at a unit sealed to 0.3 $cfm50/ft^2$, about 70 percent of units neighboring a smoker had benzene levels below the one-in-a-million cancer risk level.

These results illustrate how compartmentalization can protect occupants from the transfer of several pollutants between units.

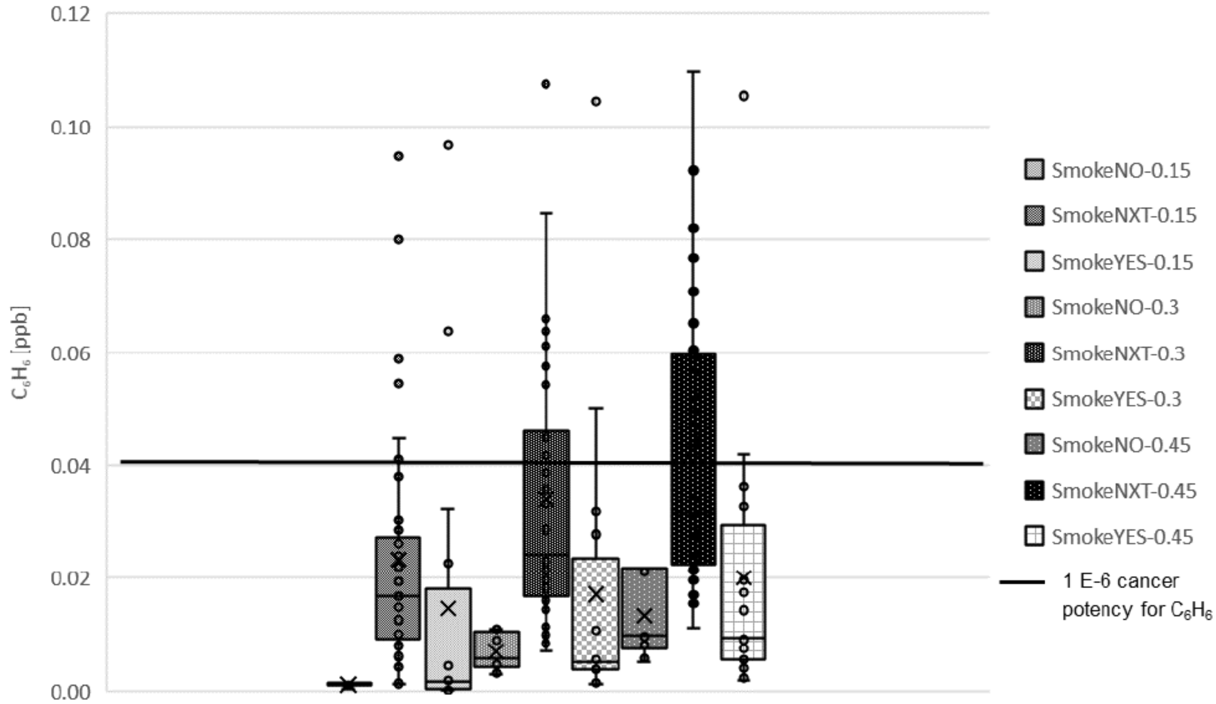

Figure 5: Concentration of C_6H_6 transferred from other units compared to the cancer potency exposure limit for units with a smoker (SmokeYES), next to a smoker (SmokeNXT) and, without a smoker and not next to a smoker (SmokeNO) for a balanced building using Sacramento weather data.

Source: (Modera, et al. 2023)

Figure 5 shows C_6H_6 concentrations compared to the exposure cancer potency (1 E-6) of 0.04 ppm for units next to a smoker ("SmokeNXT") and not next to a smoker ("SmokeNO") at three different leakage levels: 0.15 cfm50/ft^2, 0.3 cfm50/ft^2, and 0.45 cfm50/ft^2 for a balanced building using Sacramento weather data (Modera, et al. 2023). For all modeled units, there was no smoking within the dwelling unit, so all benzene transfer came from secondhand smoke from other dwelling units.[11]

Studies indicate that a tight dwelling unit envelope can serve as an effective filter for outdoor PM2.5. A field study of multifamily dwelling units sealed to very tight levels: 0.13 to 0.18 cfm50/ft^2, equivalent to three to four ACH50, found significant outdoor PM2.5 removal, and no measurable PM2.5 transfer from neighboring units (Modera, et al. 2023). This field study also measured a reduction in the indoor to outdoor ratio of PM2.5 from units that had tighter levels of compartmentalization units (Modera, et al.

[11] For units not next to a smoker: "SmokeNO", there was a small amount of benzene transfer from dwelling units with a smoker that were in other parts of the building, but not directly adjoining the modeled unit.

2023). Another field study found that in a single-family home with an air leakage rate of 5.0 ACH50, the envelope filtered ambient PM2.5 equivalent to a MERV 13 level (Singer, et al. 2016). The proposed measure calls for a compartmentalization level at 0.3 cfm50/ft^2, equivalent to 6 to 7 ACH50, so a value that is leakier than the dwelling units in these studies. Unfortunately, the Statewide CASE Team is not aware of studies that have measured PM2.5 transfer in dwelling units compartmentalized to 0.3 cfm50/ft^2 or to uncompartmentalized dwelling units. Logically, compartmentalizing to 0.3 cfm50/ft^2 should reduce PM2.5 transfer compared to uncompartmentalized units.

The figure below shows adjustments in disability-adjusted life years (DALY) from different air pollutants; the DALY represents one year of healthy life lost due to exposure from the pollutant. As shown in this figure, PM2.5 has a high DALY compared to other pollutants typically found in residences (Logue, Klepeis, et al. 2014). PM2.5 can travel into the lungs and bloodstream, causing respiratory and cardiovascular impacts. NO_2 is associated with respiratory problems such as chest tightness, shortness of breath, and wheezing (EPA n.d.). The proposed measure should reduce:

- PM2.5, formaldehyde, and acrolein that could be transferred from other units from cooking, regardless of the stove's fuel type.
- Secondhand smoke that could be transferred from other units.
- NO_2 transfer from other units that could be transferred from cooking over a gas stove.

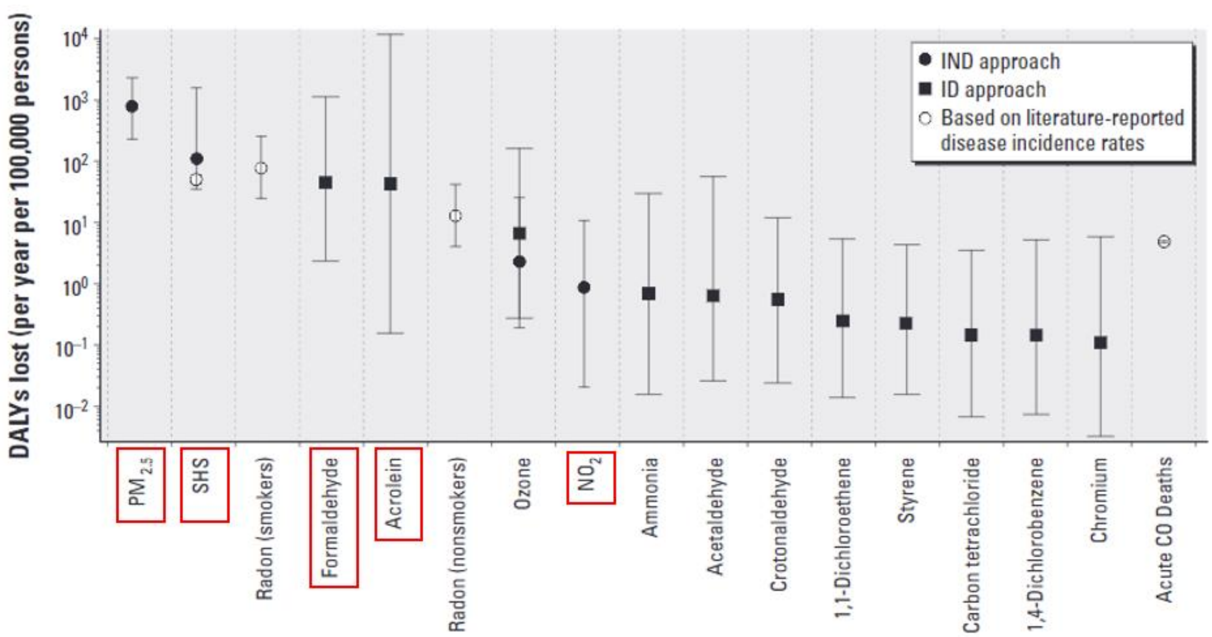

Figure 6: Estimated population averaged annual cost, in disability adjusted life years.

Source: (J. M. Logue, P. N. Price, et al. 2011)

Children may also be more susceptible to illnesses associated with poor IAQ than adults. Children are more prone to respiratory illnesses due to less acquired immunity. They also intake a relatively larger volume of air per body weight compared to adults due to having smaller bodies and being more physically active (Zhu, et al. 2020, Seals and Krasner 2020).

Other studies supporting the need for compartmentalization include the following:

- A field study of six existing multifamily buildings in Minnesota that underwent compartmentalization (air sealing between units) and ventilation upgrades found that before any air sealing or ventilation work was performed, all six buildings had at least one unit for which more than 10 percent of the air entering the unit came from another unit (Bohac and Hewett 2004). The study found, based on tracer gas testing, that the effective contaminant transfer (ECT) - a proxy for environmental tobacco smoke transfer, was reduced by an average of 41 percent post-treatment.[12] This indicates that compartmentalization and ventilation improvements can reduce environmental tobacco smoke transfer.
- A 2016 study (Center for Energy and Environment 2016) developed airflow models using three different tightness levels (9.5, 3 and 0.6 ACH50, which depending on unit geometry roughly correspond to 0.50, 0.16, and 0.03 cfm50/ft2) based on compartmentalization field measurement data in six new and existing multifamily buildings in Minnesota and four different ventilation strategies (exhaust only, exhaust & half supply, balanced, and no mechanical ventilation). The study found, "For the leakiest units (9.5 ACH50), the average inter-unit airflow rate for all four ventilation strategies is 22.3 cfm, and all four values are within 4 percent of the average. For the units with mechanical ventilation, the inter-unit air flow is about 25 percent of the ventilation flow. This indicates that there is significant air and contaminant transfer between units with about 20 percent of the air that enters the units coming from neighboring units.... Reduced envelope leakage significantly reduces inter-unit airflow. The 65 percent leakage reduction from 9.5 to 3.0 ACH50 results in an average reduction in inter-unit airflow of 86 percent."

There are also energy savings from reduced leakage through the exterior envelope. While there is considerable scatter in exterior leakage value compared to total leakage, there is a significant ($p<0.01$) correlation in CEE 2020 data between a tighter dwelling unit envelope and a tighter exterior wall. Section 5.1 provides more details on estimating energy impacts from the measure, including compartmentalization.

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[12] The six buildings had pre-treatment unit average ECT values of 82.2, 52.8, 59.3, 59.5, 25.5, and 16.4 μh/ft2 (Avg: 45.6 μh/ft2) and post-treatment unit average ECT values of 67.2, 53.6, 27.9, 20.3, 3.2, and 9.4 μh/ft2 (Avg: 27.1 μh/ft2) respectively. (Bohac, Fitzgerald, et al. 2007)

In addition to the IAQ improvements and energy savings, compartmentalization provides other benefits.

- **It reduces noise transfer** between units and with the exterior. Field measurements found significant sound attenuation improvement for frequencies above 500 Hz due to compartmentalization via aerosol sealing (Center for Energy and Environment 2016). In interviews, several market actors also pointed to noise reduction as a benefit of compartmentalization. One interviewee noted that in addition to noise from neighbors, multifamily projects are typically located in noisy, urban areas and “to be able to close your door and have quiet in your unit is huge.” A quiet environment is also important for sleep and mental health.
- **Two interviewees also identified pest control as an additional benefit.** Compartmentalization reduces holes between units and holes with the exterior, which could serve as a path of travel for cockroaches and other pests.

The proposed code change follows the requirements of ASHRAE Standard 62.2-2019 and is less stringent than the requirements of ASHRAE 62.2-2022. ASHRAE Standard 62.2 is for Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, and it has served as the precedent for Title 24, Part 6 ventilation and IAQ requirements since the 2008 version of Title 24. For the 2025 Title 24, Part 6, the Statewide CASE Team proposes 0.3 cfm50/square foot—the value from ASHRAE Standard 62.2-2019, instead of 0.2 cfm50/ft^2, for two primary reasons:

1) This would be the first cycle that compartmentalization is required, and interviewees strongly recommended requiring a higher, less stringent, tightness level.
2) Interviews indicated there is a significant cost increase meeting 0.2 compared with 0.3 cfm50/ft^2, as described in Section 6.3.

Figure 7 shows existing codes and program requirements for compartmentalization, (discussed in Section 3.4.3) and IAQ data supporting compartmentalization.

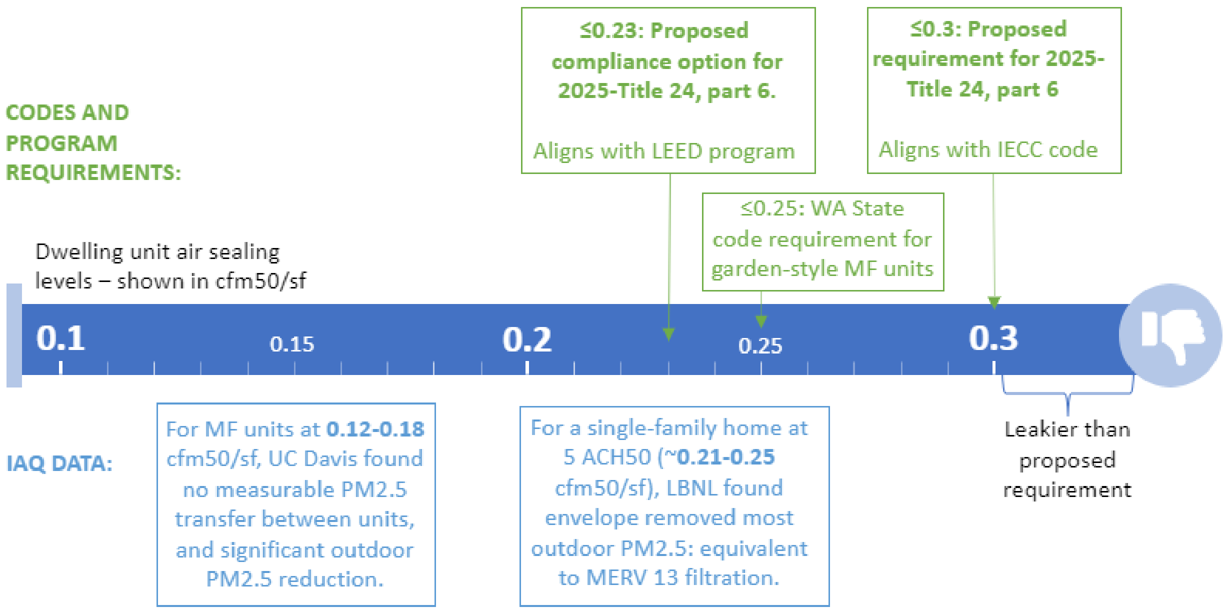

Figure 7: Overview of code requirements and IAQ data supporting compartmentalization.

The Statewide CASE team also proposes a minor change to the Reference Appendix to allow a HERS Rater or ATT to conduct a multi-point blower door test, instead of the single-point test that is currently allowed. A multi-point test is conducted at multiple pressure points, which the blower door software uses to develop a custom regression analysis for the unit, and then identifies what the leakage would be at 50 Pa based on this regression. The Statewide CASE Team proposes to allow this multi-point test for conducting the enclosure leakage test in Reference Appendices sections RA3.8.3 and NA2.3.3. The current Reference Appendices only allow a single-point test, which is conducted only at 50 Pa. Airflow determined using a one-point test is required to be adjusted following the procedure given in RESNET 380 Section 4.5.1 where the adjusted air flow used for compliance determination is 10 percent higher than the measured (and altitude and temperature corrected) flow rate. Multipoint testing does not require this correction. In addition, a research study (Walker, et al. 2013) found that multipoint test results are more accurate than the single point test results in most testing conditions. The Statewide CASE Team proposes to continue to allow a single-point test, since it is faster than a multi-point test, so the HERS Rater or ATT could choose a single-point or multi-point test.

3.2.5 Background and Justification for IAQ System Component Accessibility and FID Requirements

This section provides the background and justification for IAQ system component accessibility and the FID requirements for both the single-family and multifamily proposed requirements. In general, this proposal shifts these requirements out of the ACM and into the Standards.

The 2022-Title 24 Part 6 ACM states that “to receive compliance credit relative to the standard design, balanced and supply-only systems must have accessible supply air filters, outside air inlets, and heat/energy recovery cores (if applicable). For systems not meeting these requirements, compliance credit would be neutralized”. In practice, this means that if the proposed design has IAQ fans with higher efficacy, the modeling software would not account for savings from the higher efficacy unless the system components are accessible. Similarly for sensible recovery efficiency (SRE) of an HRV/ERV, this means that the modeling software would not account for additional heating or cooling savings for an HRV/ERV with a higher SRE than the standard design, unless the system components are accessible.

IAQ system component accessibility is important to ensure that the resident or building owner can maintain the system.

- Because filters should be replaced at least twice per year, the Statewide CASE Team proposed a mandatory requirement that the filter be accessible. This language is based on a current requirement for ventilation system filter accessibility in the 2022-Title 24 Part 6 ACM.
- The Statewide CASE Team also proposes a requirement that HRV/ERV heat / energy recovery cores be accessible, based on a current requirement for ventilation system filter accessibility in the 2022-Title 24 Part 6 ACM. HRVs/ERVs with an FID are exempt from this requirement.
- For single-family homes only, the Statewide CASE Team included a requirement that outdoor air intakes be accessible, based on language from the 2022-Title 24 Part 6 ACM. This requirement is not proposed for multifamily units, since it is challenging to meet unless the upper units have balconies. HRVs/ERVs in single-family homes with an FID are exempt from this requirement.

In addition to IAQ system component accessibility requirements, the Statewide CASE Team proposes a prescriptive requirement for an FID that meets a set of criteria listed in the Joint Appendix. The FID would respond if the filter should be replaced, if the supply airflow is low, or if exhaust airflow is low (in balanced systems only). This list of criteria is based on current requirements in the 2022-Title 24 Part 6 ACM, which has the same FID requirements for single-family and multifamily units. Projects without an FID can follow the performance path and incur a fan efficacy penalty (increase of 10 percent) and, for projects with an HRV/ERV, incur an SRE penalty (decrease of 10 percent).

The need for these requirements for IAQ system component accessibility, and the utility of an FID, are illustrated in Table 6. This table summarizes findings from several field studies of existing, single-family homes, which show that more than half of ventilation systems deliver less air than code requirements. These ventilation systems included a range of types: HRVs, exhaust-only, central-fan integrated HVAC ("CFI HVAC"), and others. The studies compare measured airflow rates of ventilation systems against the expected flow based on code requirements. While they identified maintenance deficiencies, such as clogged filters or clogged outdoor air (OA) intakes, they do ***not*** isolate the impacts of poor maintenance over time. Consequently, it is possible that other ventilation design or installation deficiencies contributed to reduced airflow compared to code requirements, such as disconnected ducts, undersized ventilation fans, or a lack of commissioning of dampers or other components. The Statewide CASE Team did not find similar studies of multifamily units, but anticipates similar outcomes if systems are not properly installed or maintained.

In general, these studies highlight the importance of proper commissioning and maintenance, including replacement of the filter and cleaning of outdoor air intakes, to ensure good performance of ventilation systems. The Standards already include a requirement for measuring ventilation airflow for newly constructed residential buildings in Section 150.0(o)1H in single-family homes and Section 160.2(b)2Avii in multifamily dwelling units. The proposed requirements for IAQ system component accessibility and an FID are proposed to reduce maintenance issues.

Table 6: Summary of field study data of ventilation system faults and impact

Study	Site stock age	Type of faults	No. of tested sites and measured performance compared to expected	Ventilation system	No. of tested sites	Percentage of sites with issues
(Martin, et al. 2020) (Chan, et al. 2020)	2-9 yrs.	Ventilation system not operational as found. Clogged filters (47 of 128 filters), insufficient flow, excess flow, damper not opening.	70 (CA); 74% of all sites not operational as found	Exhaust system	64	77%
				CFI HVAC	6	50%
			25 (Southeast); 48% of all sites not operational as found	ERV	6	17%
				Exhaust System	4	75%
				CFI HVAC	15	53%
			55 (West); 36% of all sites not operational as found	HRV/ERV	7	23%
				Exhaust System	22	23%
				CFI HVAC	25	36%
(Hill 1998)	3-14 yrs.	Of occupants who reported maintaining their systems (81%), inspections found 42% with dirty filters or cores, and 17% with blocked OA intakes	69 (Ottawa); 4 out of 69 units (6%) not operational, 27 units (39%) provide 10% to 56% less airflow than code requirement	HRV	69	64%
(Sonne, Withers and Vierira 2015)	1-10 yrs.	Dirty filters/dirty OA intake (2 of 6 ERV), nonfunctioning dampers, duct constriction	21 (FL); 86% of houses had 16-80% airflow deficit compared to expected flow (based on system type)	ERV	6	86% across all 21 sites
				Run time ventilation with min flow	11	86% across all 21 sites
				Run time ventilation without min flow	4	86% across all 21 sites
(Lubliner, et al. 2002)	Existing	Mechanical dampers not functioning (18%), flow rate less than WA state code	31 (WA); 48% did not meet WA ventilation code requirements.	Exhaust System with Inlet Vents	14	48% across all 31 sites
				Passive Integrated Exhaust System, CFI HVAC	11	48% across all 31 sites
				CFI HVAC	6	48% across all 31 sites

3.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, Compliance Manuals, and compliance documents would be modified by the proposed change.[13] See Section 8 of this report for detailed proposed revisions to code language.

3.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 1 and Part 6 as well as the Reference Appendices to Part 6 are described below. See Section 8.2 of this report for marked-up code language.

Section 100.1 (Definitions)

Specific Purpose: The specific purpose is to slightly modify the definitions for "Ventilation system, balanced" and "Ventilation system, supply" from "a mechanical device" to "one or more mechanical devices," since many buildings provide ventilation systems, particularly balanced ventilation systems, through two separate continuously operating fans.

Necessity: These changes provide clarity for the proposed changes to multifamily ventilation and compartmentalization requirements.

Section 150.0(o)1C

Specific Purpose: The current language does not require access to IAQ system components in single-family homes. The specific purpose is to require IAQ system component accessibility, including access to air filters and outdoor air intakes.

Necessity: These changes are necessary to encourage proper maintenance of ventilation systems.

Section 150.1(c)

Specific Purpose: The current language does not require a Fault Indicator Display (FID) for ventilation systems in single family homes. The specific purpose is to add a prescriptive requirement for an FID for ventilation systems, which meet criteria such as alerting the resident if the filter must be replaced or if the ventilation system has low airflow.

[13] Visit EnergyCodeAce.com for trainings, tools, and resources to help people understand existing code requirements.

Necessity: These changes are necessary so that residents are aware of ventilation system maintenance needs.

Section 160.2(b)2Aiv

Specific Purpose: The current language allows new multifamily dwelling units to either provide balanced ventilation or meet a compartmentalization (dwelling unit air sealing) limit. The specific purpose is to require both balanced ventilation and compartmentalization, although supply-only ventilation could be used in lieu of balanced ventilation.

Necessity: These changes ensure good IAQ as building envelopes become tighter,[14] increasing the need for a dedicated outside air and for a reduction in pollutant transfer between dwelling units through compartmentalization. The compartmentalization measure would also result in energy savings in all climate zones. While these energy savings would not be cost effective in all climate zones, they are necessary for ensuring good IAQ.

Section 160.2(b)2Axi

Specific Purpose: The current language does not require access to IAQ system components in multifamily dwelling units. The specific purpose is to require IAQ system component accessibility, including access to air filters.

Necessity: These changes are necessary to encourage proper maintenance of ventilation systems.

Section 170.2(c)3Biii

Specific Purpose: The current language does not require a Fault Indicator Display (FID) for ventilation systems in multifamily dwelling units. The specific purpose is to add a prescriptive requirement for an FID for ventilation systems, which meet criteria such as alerting the resident or building manager if the filter must be replaced or if the ventilation system has low airflow.

Necessity: These changes are necessary so that residents are aware of ventilation system maintenance needs.

[14] While compartmentalization is one measure leading to tighter building envelopes, other measures like QII and industry practices to improve sealing around windows and balconies would reduce air leakage from the outdoors. Both components of the proposed mandatory measure—compartmentalization with supply-only or balanced ventilation—are needed to control where ventilation air comes from. In a compartmentalized unit with exhaust ventilation, you could have more air coming from neighbors and corridors, which can be sources of contamination transfer between units, than from the outside.

Section 170.2(c)3Biv

Specific Purpose: The specific purpose is, for multifamily dwelling units in Climate Zones 1, 2, 4, 11 through14, and 16, to prescriptively require balanced ventilation with an HRV or ERV.

Necessity: The proposed change is cost effective in Climate Zones 1, 2, 4, 11 through 14, and 16 compared to supply-only ventilation or balanced ventilation without an HRV or ERV.

3.3.2 Specific Purpose and Necessity of Changes to the Nonresidential and Multifamily ACM Reference Manual

The purpose and necessity of proposed changes to the Nonresidential and Multifamily ACM Reference Manual are described below. See Section 8.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual. The changes would not affect common use areas and the existing language would remain the same for those spaces.

ACM Reference Manual—Section 6.6 Air Leakage and Infiltration

Specific Purpose: The purpose of the proposed change is to update the default leakage value, so it more accurately reflects air leakage with compartmentalized dwelling units.

Necessity: Because compartmentalization (i.e., dwelling unit air sealing) would reduce leakage from all surfaces, including the exterior, the software must be updated to reflect reduced air leakage due to compartmentalization.

For the compartmentalization requirements, Section 6.6 would be revised to reflect a lower ACH50 for the Standard Design that aligns with the proposed mandatory leakage requirement. For the Proposed Design, the language would be revised to default the ACH50 to the same value as the Standard Design. The language would clarify that HERS verification is required.

ACM Reference Manual—Section 6.8.6 IAQ System Type

Specific Purpose: The purpose is to update the software to reflect the ventilation systems that would be allowed under the proposed code change and remove prohibited systems.

Necessity: These changes are necessary, so the software allows users to only choose systems that comply with the proposed change.

IAQ System Type: Currently, the user selects one of the following ventilation system types for the proposed design: exhaust-only, supply-only, or balanced, and the software assumes the same ventilation system type in the standard design. Under the proposed changes, the reference to an exhaust-only option would be removed from this section, and there would no longer be an option to select exhaust-only. For the proposed design, the user would be able to select between a supply-only or balanced system.

- In Climate Zones 3, 5 through 10, and 15, the software would continue to assume the same standard design as the proposed design. For example, if the user selected supply-only for proposed design, the software would assume supply-only for the standard design. If the user selected balanced for proposed Design, the standard design would be balanced.
- In Climate Zones 1, 2, 4, 11 through 14, and 16, the software would assume balanced with HRV for the standard design, because of the proposed change to the prescriptive requirement. For the proposed design, the user could select a supply-only system or balanced system without an HRV, which would generate negative energy savings, or they can select a balanced system with HRV (same as standard design).

Table updates:

- Table 38: Add a column for Supply Only and qualify that the exhaust only option is for common use areas only.
- Table 39: Qualify that the exhaust only option is for common use areas only.

This section would also be modified to remove the specific criteria for the FID and reference those criteria in Joint Appendix 15.

ACM Reference Manual—Section 6.6.1 Building Air Leakage and Infiltration

Specific Purpose: The specific purpose is to change the infiltration value in the ACM Reference manual for residential zones (which primarily include dwelling units) from 7 ACH50 to 2.3 ACH50 to reflect the reduced infiltration due to compartmentalization.

Necessity: These changes are necessary to provide project teams with an option for claiming energy savings for tightening the dwelling unit envelope beyond the mandatory requirement.

3.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Changes to the Nonresidential and Multifamily Compliance Manual would include the following:

- **Section 11.4.2.1 Dwelling Unit Mandatory Requirements**, would need to be revised to show that both balanced or supply-only ventilation and compartmentalization are required for dwelling units.

- **Section 11.4.2.3 Differences between Energy Code and ASHRAE Standard 62.2**, would need to be revised to show that the California Energy Code requires balanced or supply-only ventilation for all multifamily dwelling units (no exemption for garden-style), and to state that the California Energy Code requires 0.3 cfm50/ft^2 instead of 0.2 cfm50/ft^2 in ASHRAE Standard 62.2-2022. This should also call out that the California Energy Code prescriptively requires an FID for balanced or supply-only ventilation.
- **Section 11.4.2.4 Dwelling Unit Ventilation Strategies** and **11.4.2.8 Dwelling Unit Ventilation Airflow Measurement** would need to be revised to describe that only balanced or supply-only ventilation can be used for multifamily dwelling units.
- **Section 11.4.2.11 Dwelling Unit Compartmentalization, Adjacent Spaces and Transfer Air** would need to be revised to indicate that compartmentalization is mandatory.
- **Section 11.4.2.12 Dwelling Unit Prescriptive Requirements**, **A. Balanced Ventilation** would need to be revised to reflect the updated prescriptive HRV/ERV requirements in Climate Zones 1, 2, 4, 11 through 14, and 16.

3.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. While the requirements for this proposal are not different for multifamily dwelling units in low-rise (buildings with three or fewer habitable stories) and high-rise buildings, the compliance documents are different for low-rise vs. high-rise buildings.

Examples of the revised forms are presented in Section 8.5.

In effect as of January 1, 2023, the 2022 California Energy Code has introduced new requirements for low-rise multifamily, three stories or less, and it includes new compliance documentation. For low-rise multifamily buildings only, there would be no approved data registry capable of registering compliance documentation for this building type until one of the two certified HERS Data Registry Providers is approved for low-rise multifamily. Until then, fillable forms can be used to document compliancy.

For multifamily buildings with three or fewer habitable stories, the compliance documents that would be updated include:

Certificates of Compliance

- **LMCC-MCH-01-E Mechanical Systems**: Supply and balanced ventilation approaches are already covered in these forms. The forms would need to be revised so that exhaust ventilation is not allowed. The forms would also need to be revised to provide a field on the presence of an FID and the FID model number.

Certificates of Installation

- **LMCI-MCH-27b-H Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method:** Compliance document for verifying ventilation strategy. The forms would need to be revised so that exhaust ventilation is not allowed. The forms would also need to be revised to provide a field on the presence of an FID and the FID model number, and to provide a field to confirm the ventilation system accessibility.
- **LMCI-MCH-24a Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter**, and **LMCI-MCH-24b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Automatic Meter**: These forms already provide fields for compartmentalization. The forms would be revised to remove the question on whether HERS verification of compartmentalization is required, since it would be required for all multifamily dwelling units.

Certificates of Verification

- **LMCV-MCH-27b Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method**: Compliance document for verifying ventilation strategy. The forms would need to be revised so that exhaust ventilation is not allowed. The forms would also need to be revised to provide a field on the presence of an FID and the FID model number, and to provide a field to confirm the ventilation system accessibility.
- **LMCV-MCH-24a Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter** and **LMCV-MCH-24b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures——Automatic Meter**: These forms already provide fields for compartmentalization. The forms would be revised to remove the question on whether HERS verification of compartmentalization is required, since it would be required for all multifamily dwelling units.

Nonresidential Compliance Certificates are used for multifamily buildings with four or more habitable stories. These documents are used to demonstrate compliance with acceptance testing requirements for the 2022 California Energy Code. These documents must be completed by a field technician or certified Acceptance Test Technician (ATT) and submitted to the building inspector.

For multifamily buildings with four or more habitable stories, the Compliance Documents that can be used include:

Certificates of Compliance

- **NRCC-MCH-01-E Mechanical Systems:** Supply and balanced ventilation approaches are already covered in these forms. The forms would need to be revised so that exhaust ventilation is not allowed. The forms would also need to be revised to provide a field on the presence of an FID and the FID model number.

Certificates of Installation

- **2022-NRCI-MCH-E Mechanical Systems:** Supply and balanced ventilation approaches are already covered in these forms. The forms would need to be revised so that exhaust ventilation is not allowed. The forms would be revised to provide a field on the presence of an FID and the FID model number. The forms would also be revised to provide a field to confirm the ventilation system accessibility.

Certificates of Verification and Acceptance

The following forms already provide fields for compartmentalization. The forms would be revised to remove the question on whether HERS verification of compartmentalization is required, since it would be required for all multifamily dwelling units.

- **2022-NRCV-MCH-24a Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Manual Meter**
- and **2022-NRCV-MCH-24b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Automatic Meter**

The following forms would be revised so that exhaust ventilation is not allowed:

- **NRCA-MCH-20a-H MF Dwelling Ventilation**
- **NRCA-MCH-20c-H MF IAQ Ventilation System**
- **NRCA-MCH-20d-H MF Dwelling Ventilation—HRV-ERV**
- **NRCA-MCH-23-A HRV-ERV Verification**

The following form would be revised to provide a field on the presence of an FID and the FID model number, as well as to confirm the ventilation system accessibility:

- **NRCA-MCH-20a-H MF Dwelling Ventilation**

3.4 Regulatory Context

3.4.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

The proposed changes to Title 24, Part 6 for balanced or supply-only ventilation do not conflict with other federal, state, or local laws and regulations, with the exception of Title 24, Part 11 (CALGreen), as described below.

Title 24, Part 11 Section 4.506.1 specifies bathroom exhaust fan requirements. One of these is for bathroom fans to be ENERGY STAR® compliant. The Statewide CASE Team recommends that the language be revised to allow an exception for bathroom exhaust systems that incorporate heat or energy recovery ventilation (HRV/ERV). This is because a common strategy to reduce costs for an HRV/ERV is to have the HRV/ERV exhaust pull directly from the bathroom, and there are no ENERGY STAR-rated HRV/ERVs.[15] The Statewide CASE Team proposes that the following exception be added:

4.506.1 Bathroom exhaust fans

Each bathroom fan shall be mechanically ventilated and shall comply with the following:

1. Fans shall be ENERGY STAR compliant and be ducted to terminate outside the building.

   Exception: Bathroom exhaust that is ducted to a heat or energy recovery ventilator does not need to be ENERGY STAR compliant.

2. Unless functioning as a component of a whole house ventilation system, fans must be controlled by a humidity control.

The proposed mandatory requirement for compartmentalization calls for air sealing each dwelling unit with the exterior and with adjacent spaces such as other dwelling units, the corridor, or other interior spaces. The requirement does not specify how compartmentalization must be achieved, but it specifies a maximum leakage target that must be met.

The requirement would not conflict with other requirements outside of Title 24, Part 6, but it does overlap with other requirements. These overlapping requirements include:

1.. Title 24, Part 9 fire code requirements for air sealing between dwelling units.

2.. Title 24, Part 2 building code requirements for water proofing.

[15] The Canadian ENERGY STAR® program rates HRV/ERVs, but to the Statewide CASE Team's knowledge, the U.S. ENERGY STAR program currently does not.

These existing requirements would make it easier for project teams to meet compartmentalization, because the same air sealing would serve two (or more) purposes: for fire code or water proofing, as well as contributing to compartmentalization.

The proposed requirements for IAQ system component accessibility overlap with some California Mechanical Code (the "CMC", or Title 24 Part 4) requirements. The Statewide CASE Team included a reference to the CMC, rather creating new requirements that would potentially conflict. The proposed language requires that IAQ equipment comply with California Mechanical Code Section 304.0 Accessibility for Service. That language requires that "all appliances shall be located with respect to building construction and other equipment so as to permit access to the appliance. Sufficient clearance shall be maintained to permit cleaning of heating surfaces; the replacement of filters, blowers, motors, burners, controls, and vent connections; the lubrication of moving parts where necessary; the adjustment and cleaning of burners and pilots; and the proper functioning of explosion vents, if provided. For attic installation, the passageway and servicing area adjacent to the appliance shall be floored." The proposed language for the accessibility of the IAQ filter, HRV/ERV heat/energy recovery core, and (for single-family homes) outdoor air intake do not conflict with the CMC.

3.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

3.4.3 Difference From Existing Model Codes and Industry Standards

The proposed measure for balanced or supply-only ventilation aligns with ASHRAE Standard 62.2-2022, which requires balanced ventilation or supply-only ventilation for dwelling units that open directly to an enclosed corridor. ASHRAE Standard 62.2-2022 does not impose restrictions on the ventilation system type for garden-style dwelling units, but this proposed measure would apply to all multifamily dwelling units, including those that open directly to the exterior.

For compartmentalization, the Energy Standard is generally less stringent than other standards. While the 2022 Title 24, Part 6 provides an optional path for compartmentalization, other standards, including the 2021 International Energy Conservation Code (2021-IECC), require air leakage testing for multifamily buildings. As shown below, the IECC allows the option for either a whole building test or a compartmentalization test. This section provides more detail.

There are different levels of compartmentalization—i.e., different degrees of dwelling unit tightness. The proposed mandatory requirement of 0.3 cfm50/ft^2 is moderately tight, and it corresponds to approximately 6 to 7 ACH50 depending on unit geometry.

The proposed mandatory requirement for compartmentalization aligns with some other requirements and is less stringent than others.

- The 2021-IECC C402.5.2 requires all dwelling units in high-rise multifamily buildings to meet 0.3 cfm50/ft^2—so it aligns with the mandatory code change proposed here. A proposed change to IECC, IECC-C 2024 PCD1, has a compartmentalization dwelling unit leakage limit of 0.27 cfm50/ft2. Thus, it is likely that the 2024 IECC would have a tighter limit than the 2021 IECC.
- ASHRAE Standard 62.2-2022 requires all dwelling units in multifamily buildings to meet a compartmentalization limit of 0.2 cfm50/ft^2, so it is tighter than the proposed requirement. An earlier version, ASHRAE Standard 62.2-2019, required 0.3 cfm50/ft^2. As illustrated in the discussion of incremental costs in Section 6.3, there is a significant incremental cost of compartmentalizing to 0.2 cfm50/ft^2 compared to 0.3 cfm50/ft^2. In interviews, market actors recommended that 2025 Title 24, Part 6 require 0.3 cfm50/ft^2 for feasibility and cost reasons, particularly because this would be the first cycle that the Standards require compartmentalization.
- The LEED for Homes Midrise program, a voluntary program for above code buildings, sets a prerequisite for compartmentalization of 0.23 cfm50/ft^2 and provides credit in the form of points for sealing to 0.15 cfm50/ft^2. As of November 2022, there were at least 186 multifamily buildings in California certified since 2018 under the LEED for the Homes Midrise Program. That program does allow dwelling units smaller than 1,200 ft^2 to meet a compartmentalization limit of ≤0.3 cfm50/ft^2.

Table 7: Summary of Compartmentalization Requirements in other Codes, Standards, or Above-Code Programs

Code or Program	Compartmentalization Requirement
2021 IECC	0.3 cfm50/ft^2
Proposal for 2024 IECC	0.27 cfm50/ft^2
ASHRAE Standard 62.2-2022	0.2 cfm50/ft^2
LEED for Homes Midrise	0.23 cfm50/ ft^2 [16]
U.S. Environmental Protection Agency ENERGY STAR for Highrise Multifamily	0.3 cfm50/ft^2

3.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. This

[16] LEED Interpretation Request 10645 allows smaller multifamily dwelling units, defined by the interpretation request as those <1,200 ft^2, to meet a compartmentalization limit of ≤0.3 cfm50/ft^2.

section describes how to comply with the proposed code change. It also describes the compliance verification process. Note that this section describes HERS Raters performing field verifications and diagnostic testing. An Acceptance Test Technician (ATT) may instead verify HERS measures, per Nonresidential Appendix 1.9.1. Appendix E presents how the proposed changes could impact various market actors.

The compliance verification activities related to this measure that need to occur during each phase of the project are described below.

While the two components of the mandatory measure (balanced or supply-only ventilation and compartmentalization) work together to improve IAQ, the compliance and enforcement of these components are independent. Consequently, this section provides separate descriptions of how market actors would comply with each component.

3.5.1 Balanced or Supply-only Ventilation

3.5.1.1 Design Phase

- **Existing process**: In the design phase, the mechanical designer identifies a whole dwelling unit ventilation strategy, which can be exhaust-only or supply-only (both require compartmentalization), or balanced ventilation, and they select either central or individual dwelling unit ventilation systems. The mechanical designer specifies equipment, and in coordination with the architect, locates equipment, including duct routing and duct exterior terminations, and checks that location of equipment and filters is consistent with California Mechanical Code 304.0. The mechanical designer specifies fan airflow rates and control methods. The design team submits plans and specifications, including the following forms to the enforcement agency: LMCC-MCH-01-E for three or fewer stories or NRCC-MCH-01-E Mechanical Systems for four or more stories.
- **Changes:** The proposed mandatory measure to require balanced or supply-only ventilation would have minimal impact on the existing building design phase process, with no change in workflow. The mechanical designer would no longer be able to design an exhaust-only system for new construction multifamily buildings and would specify a supply-only or balanced ventilation system with an FID. The mechanical designer and architect would locate the equipment such that there is unobstructed access for servicing supply air filters.

3.5.1.2 Permit Application Phase

- **Existing process**: In the permit application phase, the design team applies for a building permit with design drawings, specifications, and the following forms: LMCC-MCH-01-E for three or fewer stories or NRCC-MCH-01-E Mechanical Systems for four or more stories. The plans examiner verifies the ventilation strategy, verifying that the dwelling units have either continuous balanced ventilation or compartmentalization.

- **Changes**: The plans examiner would verify the ventilation strategy, verifying that the dwelling units have continuous balanced ventilation or supply-only ventilation, along with compartmentalization. Design teams using the prescriptive path would indicate the presence of an FID in the prescriptive compliance document. Design teams using the performance path would select the presence of the FID and the FID model from the CEC certified list of FIDs in the compliance software. The software would be linked to the online certified equipment list. The plans examiner would confirm the presence of an FID and that the FID is on the certified list. The plans examiner would confirm unobstructed access to the equipment. This measure would have minimal impact on the existing building permit application phase process.

3.5.1.3 Construction Phase

- **Existing process**: In the construction phase, the general contractor works with subcontractors to ensure design documents are carried out in construction, including duct terminations at the exterior. The mechanical contractor installs the ventilation systems. The mechanical contractor conducts commissioning and startup to ensure that the equipment provides continuous ventilation and runs as designed. The general or mechanical contractor completes the following forms: LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet – Building Enclosures and Dwelling Unit Enclosures for (three or fewer stories) or 2022-NRCI-MCH-E Mechanical Systems for four or more stories.
- **Changes:** There would be different acceptable inputs for Certificate of Installation forms, including those previously named LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCI-MCH-E Mechanical Systems for four or more stories. The mechanical contractor would install the ventilation system with an FID and would ensure, coordinating with other trades as needed, that there was unobstructed access for servicing supply air filters. This measure would have minimal impact on the existing building construction phase process, with no change in workflow.

3.5.1.4 Inspection Phase

- **Existing process:** In the inspection phase, the inspector verifies that the type of ventilation system in the permit (balanced or unbalanced) is installed. The HERS Rater field verifies the ventilation system per RA3.7.4.1: Continuous Whole-Building Mechanical Ventilation Airflow and confirms that the installation is consistent with the certificate of installation and certificate of compliance documents. The HERS Rater measures whole dwelling unit ventilation in a sampling of dwelling units.

- **Changes:** There would be different acceptable inputs for the ventilation strategy in the certificate of installation on the following forms: LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCC-MCH-E Mechanical Systems for four or more stories and verification forms LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet for four or more stories. The inspector would verify that the ventilation system meets the accessibility requirements. The HERS Rater would confirm the presence of an FID. This measure would have minimal impact on the existing building inspection phase process, with no change in workflow.

3.5.2 Compartmentalization

3.5.2.1 Design Phase

- **Existing process**: In the design phase, the design team does not always specify compartmentalization. The design team, primarily the architect and the mechanical designer, chooses between compartmentalization and balanced ventilation. If the designer chooses to do compartmentalization, then the architect, working with the energy consultant, identifies target sealing level for the dwelling units in the building. The architect, working with the energy consultant, may specify the air barrier and how it would be sealed. Aside from specifying it for compartmentalization, architects may specify air sealing for other reasons, including exterior air sealing for waterproofing and QII and interior air sealing for fire code and acoustics. The architect may also not specify the air barrier and air sealing, leaving it up to the general contractor to determine the best approach. The energy consultant or HERS Rater (often the same person) may also provide recommendations to the architect on how to achieve compartmentalization. The design team submits plans and specifications, including LMCC-MCH-01-E Mechanical Systems for three or fewer stories or NRCC-MCH-01-E Mechanical Systems for four or more stories forms, to the enforcement agency.
- **Changes**: There is no change in workflow when compartmentalization is done as part of the existing process. The main difference is that all projects would need to meet the compartmentalization requirement, as the current alternative for projects with balanced ventilation systems would no longer exist. Compared to the existing process, there would be no change for project teams already

meeting a compartmentalization target. For project teams that are not already meeting a compartmentalization target, project teams would need to strategize on how to meet compartmentalization targets. This measure would have moderate impact on the existing building design phase process.

3.5.2.2 Permit Application Phase

- **Existing process:** In the permit application phase, the design team applies for a building permit with design drawings, specifications, and LMCC-MCH-01-E Mechanical Systems for three or fewer stories or NRCC MCH-01-E Mechanical Systems for four or more stories forms. If the design specifies compartmentalization, then the plans examiner verifies the target sealing level.
- **Changes:** There is no change in workflow to when compartmentalization is done in the existing process. The plans examiner would need to be familiar with changes to compartmentalization requirements. The plans examiner would ensure that the design documents identify the target compartmentalization level and specify air sealing. This measure would have minimal impact on the existing building permit application phase process.

3.5.2.3 Construction Phase

- **Existing process:** In the construction phase, the general contractor works with subcontractors to ensure design documents are carried out in construction, including executing all air sealing specified at each construction stage. While not required by code, best practice is that before completing the air sealing process, the contractor or their HERS Rater does a mock-up to test the compartmentalization at one dwelling unit to ensure that it meets the requirement, which allows the contractor to adjust the air sealing process as-needed before completing the remaining dwelling units. The HERS Rater may provide guidance on how to meet air sealing specifications during construction. If needed to meet compartmentalization limits, the general contractor may work with subcontractors to improve air sealing during the construction process. The general or mechanical contractor completes forms LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCC-MCH-E Mechanical Systems for four or more stories.
- **Changes:** Because of the compartmentalization requirement, the general contractor and subcontractors, such as mechanical, drywall, electrical, plumbing, fire sprinkler, and other contractors, would coordinate as required to closely follow all air sealing design specifications. The contractors would be more likely to do a mock-up to test the compartmentalization of a dwelling unit before completing the remaining units. There would be different acceptable inputs for

forms LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCI-MCH-E Mechanical for four our more stories. This measure would have a moderate impact on the existing building construction phase process.

3.5.2.4 Inspection Phase

- **Existing process:** During the inspection phase, if the design includes compartmentalization, the HERS Rater[17] field verifies the compartmentalization according to RA3.8 Field Verification and Diagnostic Testing of Air Leakage of Building Enclosures and Dwelling Unit Enclosures. The HERS Rater develops a sample of dwelling units and measures air leakage of each unit in that sample. The HERS Rater confirms that the air leakage rate complies with the requirement. If a unit fails, the contractors take corrective action to improve the sealing, then the HERS Rater retests the unit to verify that the corrective action was successful. The contractors and HERS Rater repeat this process until the unit passes. Additionally, the HERS Rater conducts resampling and tests another dwelling unit in the group to determine whether the first failure in the group is unique or if the rest of the dwelling units in the group are likely to have similar failings. The HERS Rater completes forms LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet for four or more stories. As per NA1.2.1.1.1 pertaining to multifamily buildings with four or more habitable stories and RA2.3.1.2 pertaining to multifamily buildings with three or fewer habitable stories, a HERS Rater is required to submit these completed Certificate of Verification documents to an approved Residential Data Registry. The inspector verifies the enclosure air leakage by accepting the LMCV and NRCV forms.
- **Changes:** There would be different acceptable inputs for LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet for four or more stories.

Overall, there would be some changes to the compliance and enforcement process of the proposed measure compared to the existing process. The workflow would not change, but due to the tighter compartmentalization requirement during construction, the general contractor and subcontractors would have to coordinate to meet all air sealing requirements. The compartmentalization requirement would also result in a

[17] An ATT may instead conduct the field verification and diagnostic test for compartmentalization.

higher number of compartmentalization tests conducted by HERS Raters (or ATTs). There would be minor revisions to the acceptable inputs to the compliance forms:

- LMCC-MCH-01-E Mechanical Systems for three or fewer stories or NRCC-MCH-01-E Mechanical Systems for four or more stories.
- LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCI-MCH-E Mechanical Systems for four or more stories.
- LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures for three or fewer stories or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet for four or more stories.

This measure would have minimal impact on the existing building inspection phase process, with no change in workflow.

4. Market Analysis

4.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during a public stakeholder meeting that the Statewide CASE Team held on February 21, 2023.

As part of data gathering, the Statewide CASE Team interviewed multifamily practitioners and asked about their typical ventilation strategies. The majority of interviewees were in the San Francisco Bay Area. Interviewees also included several from Southern California and the Central Valley. They represent a mix of affordable and market-rate buildings, primarily buildings four to seven stories, with a smaller representation of buildings less than four stories and buildings over seven stories.

4.1.1 Balanced or Supply-only Ventilation

Table 8 shows the percent of market actors currently using balanced, exhaust-only, or supply-only ventilation, based on 14 interviews. These interviewees work at different firms. There was some overlap in projects; for example, a general contractor that was interviewed constructed many multifamily projects, and some (but not all) were the same projects that an architect that was interviewed had designed. However, all of these stakeholders work for a variety of clients, so there was no complete overlap of multifamily projects among interviewees.

As shown, most market actors are currently using balanced ventilation, although a few report using exhaust-only sometimes, and one affordable developer reported using mostly exhaust-only. Across all market actors interviewed, 80 percent reported using balanced ventilation, 20 percent reported using exhaust-only ventilation, and none reported using supply-only ventilation. Multiple interviewees noted that, since bathroom fans are always needed for local exhaust, the primary cost of balanced ventilation is the supply air fan, so there is no incremental cost difference between balanced and supply-only ventilation. One HERS Rater reported, “Supply-only is pretty rare. If they’re going to go through that effort, they’re going to go balanced.”

Table 8: Percent of Stakeholders that Reported Designing, Constructing, or Verifying Building Multibuilding Using Balanced, Exhaust-only, and Supply-only Ventilation

Ventilation Type	Architect (n=3)	Rater (n=3)	General Contractor (n=3)	Mechanical Engineer (n=2)	Developer (n=3)	Total (n=14)
% of market actors using balanced	100%	38%	100%	65%	77.5%	80%
% of market actors using exhaust-only	0%	62%	0%	35%	22.5%	20%
% of market actors using supply-only	0%	0%	0%	0%	0%	0%

The Statewide CASE Team reviewed plans for six multifamily buildings under the 2019 Title 24, Part 6 code and found that five used balanced and one used exhaust-only ventilation.

Table 9 summarizes multifamily dwelling unit ventilation practices for multifamily buildings that are four or more habitable stories, based on interviews (with stakeholders who primarily work on buildings of four or more habitable stories) and plan-reviews (of buildings with four or more habitable stories). The poll results from the public stakeholder meeting are also shown for comparison. As shown, balanced ventilation is clearly the most common practice, although exhaust-only ventilation is occasionally used.

Table 9: Dwelling Unit Ventilation Strategies, Primarily Reflecting Multifamily Buildings with Four or More Habitable Stories

Data Source (n-value)	Balanced Ventilation (%)	Exhaust-only Ventilation (%)	Supply-only Ventilation (%)	Comments
Interviews with multifamily stakeholders (n=14)	80%	20%	0%	Majority Bay Area and some Central Valley and Southern California interviewees
Plan review of multifamily new construction projects in above-code programs (n=6)	83%	17%	0%	While these buildings exceeded the energy code for energy efficiency measures, the program did not incentivize specific ventilation strategies
Poll result of stakeholders during public stakeholder meeting (n=11)	63%	36%	0%	Results do not add to 100% due to rounding

Table 10 summarizes multifamily dwelling unit ventilation practices for multifamily buildings that are three or fewer habitable stories, based on CalCERTS data. The poll results from the public stakeholder meeting are also shown for comparison.

Table 10: Dwelling Unit Ventilation Strategies, Reflecting Multifamily Buildings with Three or Fewer Habitable Stories

Data Source (n-value)	Balanced Ventilation (%)	Exhaust-only Ventilation (%)	Supply-only Ventilation (%)	Comments
CalCERTS data (n=2,559 units)	42%	58%	0%	May include some townhomes
Poll result of stakeholders during public stakeholder meeting (n=13)	38%	62%	0%	-

The data indicates that balanced ventilation is the dominant ventilation strategy for multifamily buildings with four or more habitable stories, and exhaust-only is the dominant strategy for multifamily buildings with three or fewer habitable stories. The data for low-rise buildings does not distinguish between low-rise dwelling units in buildings with common corridors vs. garden-style multifamily buildings, which may have different ventilation practices.

Some interviewees indicated that their approach for providing the supply air component of a balanced ventilation system may vary by number of stories.

- Individual vs central: Seven of eight interviewees reported that their typical approach for providing a supply fan in a balanced ventilation system is to use individual "throughwall" ventilation, where each dwelling unit has its own air intake, exhaust terminations, and ventilation ductwork.
  - One interviewee reported primarily using central ventilation, and two reported using it occasionally, such as in taller buildings or affordable projects to centralize maintenance (including air filter replacement). Central ventilation includes dedicated outdoor air systems (DOAS): typically rooftop fans that bring in outside air, filter it, and duct it to dwelling units (often a vertical stack of dwelling units below).
- Heat recovery versus no heat recovery: Four of eight interviewees reported they typically incorporate heat recovery through an HRV or ERV—typically in individual, throughwall systems and occasionally central (rooftop) systems.
- For exhaust only approaches, four of five interviewees reported they use continuously operating bathroom exhaust. The fifth reported using continuously operating exhaust either from the bathroom or kitchen.

Figure 8 provides an illustration of a balanced system that uses individual, throughwall ventilation without heat recovery.

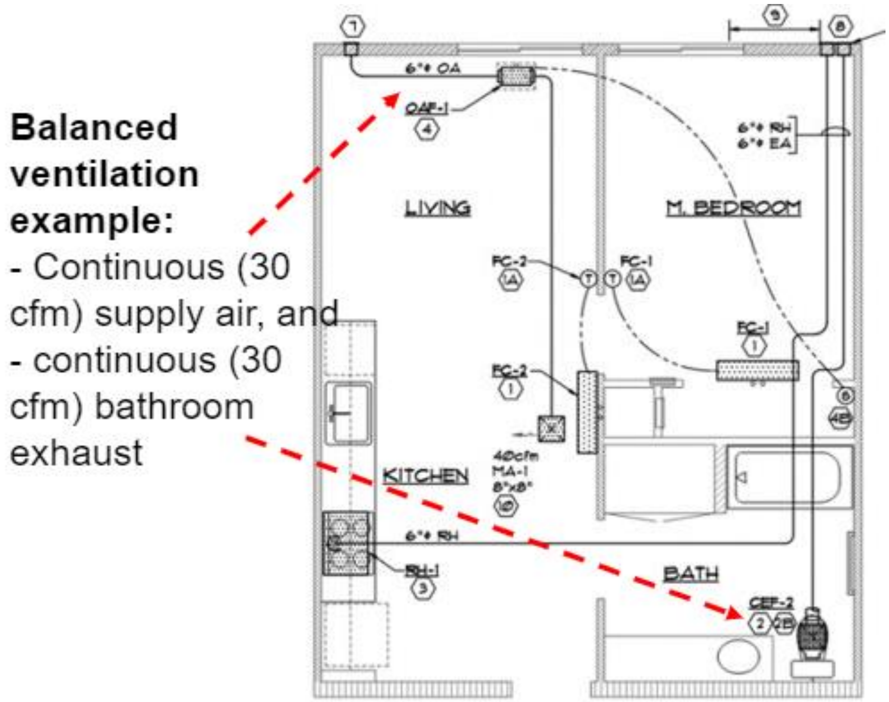

Figure 8: Example of balanced ventilation without heat recovery

Figure 9 is a schematic for an HRV and its main components. An HRV works through passive heat transfer:

- Conditioned air that is being exhausted preheats colder outdoor supply air, typically during the heating season, thereby preheating ventilation air.
- Conditioned air that is being exhausted precools warmer outdoor supply air, typically during most of the cooling season. However, there can be times during the cooling season when the outdoor supply air is cooler than exhausted air; during these times, the HRV traps heat and results in a cooling penalty.

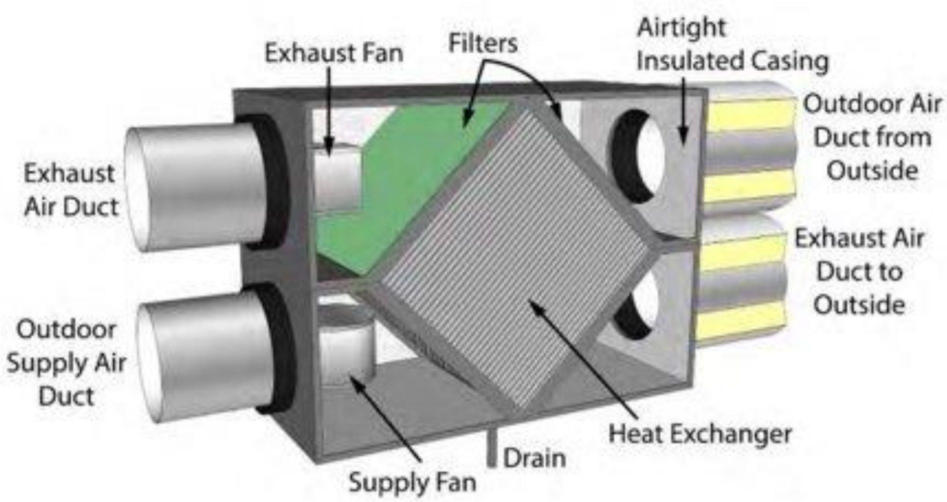

Figure 9: Diagram of an HRV

Source: (City of Vancouver 2015)

4.1.2 Compartmentalization

4.1.2.1 Description of Compartmentalization Processes

Compartmentalization typically involves several members of the project team. The following describes the compartmentalization process based on interviews with architects, general contractors, developers, and HERS Raters that have done it:

- An architect specifies the target compartmentalization value and specifies through plans and specifications the seams or gaps to seal. Several interviewees reported they typically have a meeting early in the construction process to discuss the overall sealing goal, discuss the air sealing that is needed, and review specifications. This meeting typically includes the general contractor, architect, HERS Rater or ATT, and any subcontractors the general contractor identifies for conducting air sealing. These subcontractors may include the insulation subcontractor, waterproofing subcontractor, drywall subcontractor, or others.
- The contractors seal according to the specifications. Interviewees reported that, in addition to the general contractor who is responsible for all quality control, key contractors involved in compartmentalization include the waterproofing and drywall subcontractors, and, to a lesser degree, mechanical, electrical, and plumbing contractors, since they may also make holes in the dwelling unit envelope that they need to seal.
- While not required, many interviewees reported it is beneficial to have a mock-up unit where the project team seals according to specifications before proceeding with all units. The HERS Rater can inspect the air sealing in this unit and test its tightness and recommend changes in air sealing if needed. The Statewide CASE

Team considered requiring a mock-up test, but decided against requiring an intermediate step towards compartmentalization and instead allowing project teams flexibility with how they ultimately meet the 0.3 cfm50/sf limit.

- After the drywall is installed, the HERS Rater conducts blower door testing to ensure all sampled units are at or below the maximum leakage level.

Figure 10 provides an example of a compartmentalization sheet that an architect includes in their designs.

Location	Treatment	Detail		Products	Spec
		WD Frame	MTL Frame		
FRAMING FOR INSULATION					
Partition intersections with exterior walls	all stud cavities are accessible during insulation stage				
Insulated metal headers (Level 1 Block 17)	exterior headers are to provide cavities for insulation			Thermal Insulation	07 21 00
Non-Load-Bearing Headers	headers to be sized for load; no insulation is displaced				
EXTERIOR SHELL					
Windows And Glazed Doors Rough Opening, Interior	Fill gaps, voids between window and wall frame with minimal expanding sealant compatible with window. Architectural sealant at frame to drywall			Exterior Sealant	07 92 00
Windows And Glazed Doors Rough Opening, Exterior	Flashing sequence as detailed. Place continuous bead of min. 20-year sealant compatible with all surfaces			Flashing Accessories	07 62 00
Ground Level Storefront Windows and Doors	Set threshold in bed of sealant at concrete slab		SHEET A564	exterior sealant	07 92 00
Water resistant barrier (WRB)	Continuous taped and sealed air and weather barrier applied over exterior sheathing	SHEET A500	SHEET A500	sheet applied membrane	07 13 26 07 14 13
Insulation continuity at wall intersections	Extend insulation at podium slab edge, concrete soffits and parapet connections			thermal insulation	07 21 00
Roof penetrations	Apply membrane as specified at curbs, vent penetrations, and small pipe penetrations	SHEET A550		roofing membrane	07 51 13 07 52 16
Underslab insulation	Extend under slab insulation 2'-0" min. beyond extents of conditioned area above.			Thermal insulation	07 21 00
DWELLING UNIT SHELL					
Plumbing penetrations through demising and corridor walls	Maintain ¼" gap. Apply acoustic sealant or fire rated sealant as required			fire rated sealant	07 92 00
Wall recess (Elec., J-boxes, medicine cabinets, etc.)	At all exterior demising and corridor walls, seal J box with sheet caulking pads and fill 1/4" perimeter gap with acoustic sealant.	SHEET A580		acoustical non hardening caulk	07 92 00
Interior drywall	Mud and tape all seams	SHEET A501	SHEET A501	tape	06 16 43
Interior demising walls to exterior and corridor walls	Extend demising wall gypsum board through adjoining wall cavity. Hold back top layer of gypsum board ½" and place backer rod and fire-rated sealant.	SHEET A580	SHEET A581	fire rated sealant	07 92 00
Interior partition walls to concrete slab (top and bottom)	Hold back top layer of gypsum board ¼" and place continuous bead of acoustic sealant			acoustic sealant	07 92 00
Unit exhaust soffit	Hold back top layer of gypsum board ¼" and place continuous bead of acoustic sealant			acoustic sealant	07 92 00
Unit exhaust duct penetration	Place continuous minimally expanding foam sealant on interior side of wall. Sealant, backer rod, and tape on exterior side of wall			exterior sealant	07 92 00
CORRIDORS					
Unit corridor doors	Fully-gasketed door seal. Fill steel door frame with mineral wood and fill gap between frame and drywall with continuous bead of acoustic sealant.	SHEET A568	SHEET A568	acoustic sealant	07 92 00
Unit corridor thresholds	Set threshold in bed of sealant at concrete slab.	SHEET A568	SHEET A568	threshold	08 11 13

Figure 10: Example of compartmentalization sheet in architectural designs

Source: Courtesy of David Baker Architects

4.1.2.2 Air Sealing in Projects Not Meeting a Compartmentalization Target

Projects not meeting a compartmentalization requirement still have some air sealing of the exterior for waterproofing and with adjacent interior spaces for fire proofing and acoustical reasons. However, interviewees reported that while there is overlap with other requirements, compartmentalization may not be achieved. Subcontractors may create holes that do not get sealed, or if a subcontractor believes another subcontractor is following them, they may not seal it. For this reason, a blower door test to measure compartmentalization is critical for identifying major air leakage and for ensuring that contractors are more aware of (and therefore careful of) air sealing.

Because project teams do not test dwelling unit air sealing unless they are pursuing a compartmentalization target, the Statewide CASE Team does not have comprehensive data regarding leakage in dwelling units not targeting compartmentalization. However, the California Code Readiness team measured air leakage in three multifamily buildings in California that were not targeting compartmentalization, and the leakage values were 0.13 cfm50/ft^2, 0.21 cfm50/ft^2, and 0.30 cfm50/ft^2 (Staller, et al. 2023). This indicates that a mandatory compartmentalization value of 0.30 cfm50/ft^2 is feasible. The California Building Energy Code Compliance (CBECC) software makes assumptions for baseline exterior leakage, which are discussed in Section 5.1.

4.1.2.3 Current Prevalence of Compartmentalization

Data from the CalCERTS database based on approximately 3,000 low-rise dwelling units indicates that approximately 30 percent of those units were tested for compartmentalization, and 99.8 percent met a target of 0.3 cfm50/ft^2 or lower. The CalCERTS data had less representation of high-rise dwelling units with approximately 640 total dwelling units.[18] Among the high-rise dwelling units, 3 percent of dwelling units tested for compartmentalization, all of which met a target of 0.3 cfm50/ft^2 or lower. Section 4.2.2 provides results of this analysis.

Based on interviews with market actors, a minority of projects, approximately one-third in the current market, meet a compartmentalization target. Based on the 13 market actors interviewed that provided an estimate of the prevalence of compartmentalization in their projects, 35 percent of projects meet a compartmentalization target—primarily 0.23 cfm50/ft^2 for the LEED prerequisite. One energy consultant estimated that 20 percent of multifamily projects meet compartmentalization, because it is required for LEED, and they noted that another popular above-code rating program (GreenPoint Rated) provides a credit for the measure but does not require it. A HERS rater

[18] The CalCERTS data reported the ventilation strategy for multifamily high-rise projects in only two of California's sixteen climate zones, so the Statewide CASE Team did not use these data for determining the baseline for high-rise multifamily ventilation strategy.

concurred: “LEED is the big driver. Green Point Rated gives you credit for compartmentalization, but it’s not a main driver since it’s not a requirement.”

Several of the 14 interviewees reported they are just now, as of fall 2022, seeing their multifamily projects in design or construction shift from the 2016 to the 2019 version of Title 24.[19] While this is a relatively small sample, it indicates the impact of the 2019 Title 24, Part 6 requirement for balanced ventilation or compartmentalization may not have fully impacted the market. However, the general consensus from all interviewees is that projects are typically meeting the 2019 Title 24, Part 6 requirement using balanced ventilation, rather than compartmentalization. An architect reported that she has not yet done compartmentalization but is considering the measure to meet 2019 Title 24, Part 6 requirements if it is lower cost than balanced ventilation or if there is only space on the building façade for one penetration (i.e., the project would install exhaust-only ventilation, because there is not space on the exterior wall for both the exhaust termination and an air inlet). A general contractor that has met compartmentalization for various projects for LEED reported he is working on a 2019 Title 24, Part 6 project that is *not* pursuing LEED, but they may meet code requirements using compartmentalization, because the developer believes it may be cheaper for that project than balanced ventilation. Section 4.2.2 further discusses the rationale for project teams typically choosing balanced ventilation over compartmentalization to meet 2019 Title 24, Part 6.

4.2 Technical Feasibility and Market Availability

4.2.1 Balanced or Supply-only Ventilation

As described in Section 4.1.1, balanced ventilation is a relatively common practice in the current market, and there are various strategies that project teams have developed to provide balanced ventilation. Based on interviews and plan reviews, providing balanced ventilation is technically feasible.

The market actors interviewed identified relatively few barriers to balanced ventilation. They identified an additional cost compared to exhaust-only ventilation, because of the supply fan and associated ductwork, filter, filter box, and other components. One affordable developer that regularly pursues compartmentalization for LEED, said they provide exhaust-only ventilation 90 percent of the time. They felt that, in their circumstances, being required to install supply-side ventilation would be prohibitively expensive. Section 6 describes cost estimates for this measure.

[19] While projects permitted on or after January 1, 2020, needed to follow the 2019 Title 24, many projects under design or construction in 2020, 2021, and early 2022 were permitted prior to this cut-off date.

One additional expense of balanced or supply-only ventilation is they require periodic replacement of air filters for the outside air supply. This is one reason why some project teams choose to provide centralized outside air, instead of individual dwelling unit systems for supply air. One architect reported that another disadvantage to balanced ventilation is it adds complexity compared to an exhaust-only system. Another architect that sometimes uses exhaust-only ventilation believes that exhaust-only ventilation with operable windows is a preferred strategy for small units. However, since this does not allow for the opportunity to filter outside air, this strategy could result in high concentrations of PM2.5 within dwelling units if residents regularly open windows to provide fresh (outside) air.

The proposed requirement should not significantly impact occupant comfort in most projects. As noted in Section 4.1, four of eight interviewees reported they typically use an HRV or ERV, which would temper incoming air. Two other interviewees reported tempering the air: one uses a central DOAS and tempers air at the rooftop, while the other uses a small electric resistance heater to warm air that is delivered from the ventilation system – an individual dwelling unit inline fan. The last interviewee reported delivering outdoor air without heat recovery and without tempering but ducting it to a location, such as above the entry way or above the refrigerator, to reduce drafts felt by occupants. The 2022 Title 24, Part 6 prescriptive requirements specify an HRV or ERV for projects choosing balanced ventilation in Climate Zones 1, 2, and 11 through 16, and the proposed revisions to the prescriptive measure requiring balanced ventilation with an HRV/ERV in climate zones 1, 2, 4, 11 through14, and 16 would further reduce comfort impacts.

A few stakeholders called out that one challenge with providing balanced ventilation is meeting the requirement for 10 feet of separation distance between an air inlet and exhaust termination, particularly for small dwelling units.

Supply-only is an uncommon strategy, but the Statewide CASE Team proposes to allow it as an option, since it provides a dedicated source of filtered outside air and has lower fan energy use compared to a balanced system. One affordable developer indicated that they would leverage the supply-only option if the proposed measure went into effect. A mechanical designer noted that supply-only ventilation may reduce maintenance compared to balanced ventilation, since there are fewer moving parts.

4.2.2 Compartmentalization

Compartmentalizing to a value of 0.3 cfm50/ft^2 is technically feasible. Interviewees reported that both 0.3 cfm50/ft^2 and 0.23 cfm50/ft^2 can be achieved using traditional and easily obtained sealing materials such as caulk, putty, and expanding foam. Several interviewees with experience with compartmentalization reported that 0.3 cfm50/ft^2 is fairly loose and easy to meet, but it is a good level for a mandatory measure, since it would be new to some project teams. For example:

- One program manager reported that 0.3 cfm50/ft^2 might not even require changes to specifications, but simply sealing big penetrations such as plumbing penetrations, but that sealing below 0.25 cfm50/ft^2 would take changes to specifications.
- One rater reported "0.3 is not a huge burden to project teams, while also ensuring you don't have a massive problem in the envelope."
- One mechanical engineer reported, "0.3 is easy. 0.23 could be done. Contractors complaining about 0.3 need to join the modern world."
- One developer reported challenges meeting 0.23 cfm50/ft^2 (for a LEED project).

Table 11 provides CalCERTS data for reported compartmentalization. These data are based on compliance forms for multifamily dwelling units for compliance with 2019 Title 24, Part 6, and it primarily captures low-rise multifamily dwelling units. As shown, 75 percent of low-rise dwelling units met a compartmentalization value of 0.27 cfm50/ft^2. Only two units that reported results (or 0.2 percent of units) exceeded the 0.3 cfm50/ft^2 limit. However, only 3 percent of high-rise and 30 percent of low-rise dwelling units in the CalCERTS data reported compartmentalization measurements.

Table 11: Multifamily Dwelling Units Meeting Compartmentalization Limit from CalCERTS 2019 Title 24 Part 6 Compliance Data

Dwelling Unit Type	Number of Dwelling Units	25th percentile	50th percentile	75th percentile	99th percentile	100th percentile
High-rise	20	Not avail.	0.19	0.24	0.29	0.29
Low-rise	919	0.19	0.24	0.27	0.30	0.51

Table 12 provides a comparison of studies from UC Davis (Modera, et al 2023) and the Code Readiness team (Staller, 2023) with and without a targeted compartmentalization value. Within the research data (UC Davis and Code Readiness): the average tightness is not much leakier for units *not* targeting compartmentalization compared to those that are targeting compartmentalization. However, the variability of results shows there is a much wider range in results for units *not* targeting compartmentalization.

Table 12: Multifamily Dwelling Units with and without Target Compartmentalization Comparison

Data Set	Low-rise or high-rise	Cmprt Value Targeted	Number of Dwelling Units	Median (50th perc.) or Average Compartmentalization Value	Variability of Results
CalCERTS Low-rise	Low-rise	Varies: 0.23 to 0.3 cfm50/sf	919	0.24 (Median)	25th to 99th percentile: 0.19 to 0.30
CalCERTS Highrise	High-rise	Varies: 0.23 to 0.3 cfm50/sf	20	0.19 (Median)	Not Available
Research Data (UC Davis + Code Readiness): Units Targeting Compartmentalization	High-rise	0.3 cfm50/sf	84	0.17 (Average); Building averages 0.16, 0.17, 0.17, and 0.17	Std Dev within each building: 0.02 to 0.03 cfm50/sf
Research Data (UC Davis + Code Readiness): Units Not Targeting Compartmentalization	Mix	None	84	0.18 (Average); Building averages 0.13, 0.14, 0.21, and 0.28, 0.14	Std Dev within each building: 0.01 to 0.08 cfm50/sf
RESNET data for U.S.	High-rise	Varies: 0.03 to 0.3 cfm50/sf	2,181	0.17 (Median)	25th to 99th percentile: 0.08 to 0.30

The ASHRAE Standard 62.2 committee changed its requirement from 0.3 cfm50/ft^2 in its 2019 standard to 0.2 cfm50/ft^2 in its 2022 standard. One justification was Residential Energy Services Network (i.e., RESNET) data of U.S. multifamily dwelling unit (analyzed by Steven Winter and Associates) showing that one-third of units were able to meet a compartmentalization value of 0.2 cfm50/ft^2 or lower. This figure also illustrates that over 2,000 U.S. multifamily dwelling units met a compartmentalization value of 0.3 cfm50/ft^2 or lower.

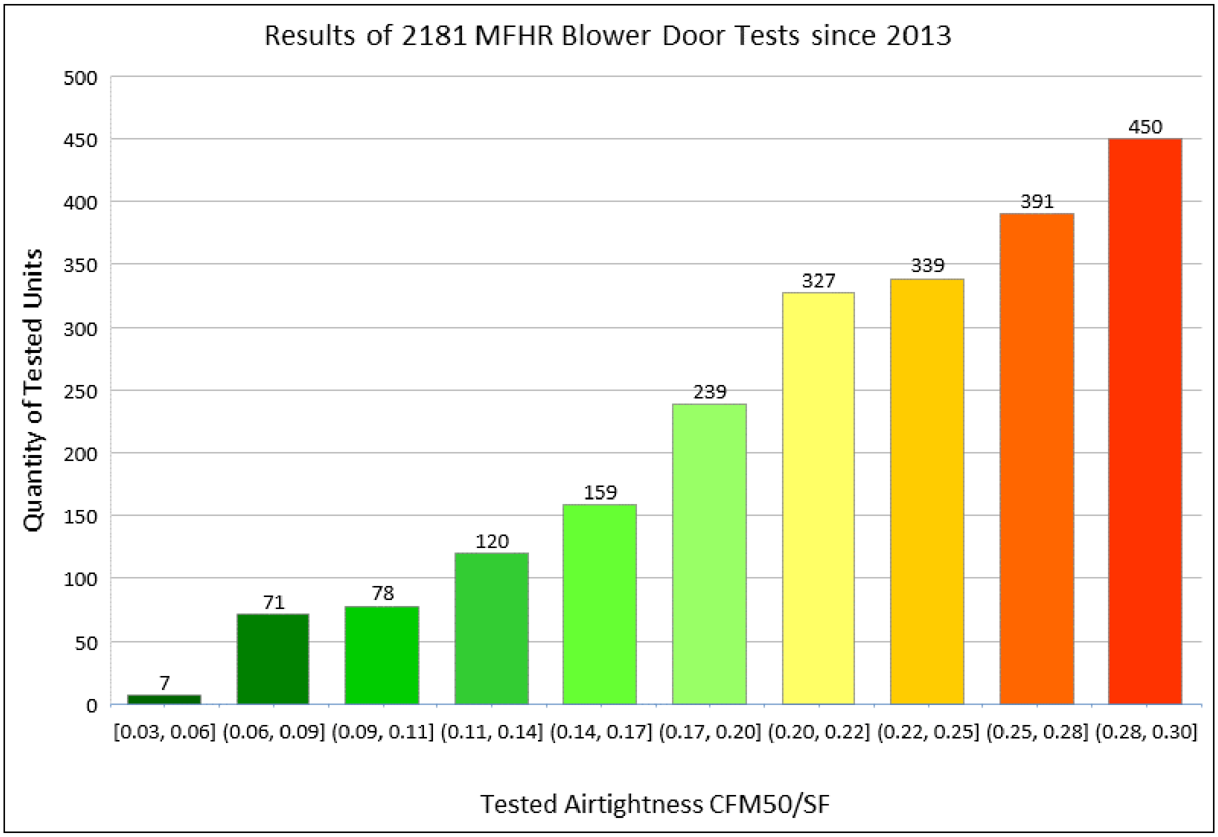

Figure 11: Results of over 2,000 U.S. multifamily dwelling unit blower door tests from 2013 to 2019

Source: (Vijayakumar 2016)

Several interviewees reported the main key to compartmentalization is communication within the project team and awareness of the project team of air sealing goals. Four interviewees reported that compartmentalization is more challenging for projects with metal studs, because of the holes in the studs. Two reported this is easily overcome by sealing the holes in the studs. Another interviewee reported meeting 0.3 cfm50/ft^2 in metal-framed buildings without sealing holes in the studs.

While interviewees with compartmentalization experience reported that compartmentalization is very feasible, particularly to the value of 0.3 cfm50/ft^2, they reported many developers choose balanced ventilation instead of compartmentalization because they believe balanced ventilation is cheaper or less risky. Balanced ventilation requires installation of an appliance whereas compartmentalization is not a widget but improved work quality. Also, there is no *back door* for projects that do not achieve the compartmentalization target, and it is more challenging to air seal once drywall is installed. All interviewees reported that compartmentalization increases cost due to increased labor, coordination (including meetings), and HERS Rater costs. Section 6.3 describes cost estimates.

Compartmentalization should have persistent impacts. According to one subject matter expert with air sealing expertise, air sealing materials often last well more than 15 years. For example, polyurethane has a lifetime of beyond 20 years (Platz 2016).

4.2.3 IAQ System Component Accessibility and FIDs

The IAQ system component accessibility requirements should be technically feasible to meet. These include locating the IAQ filter and HRV/ERV heat / energy recovery core so that it can be accessed easily, such as in occupiable space, garages, basements, on a balcony, or on an accessible roof. Filters and heat / energy recovery cores behind access panels, access doors, or grilles that are no more than 10 ft above a walking surface comply. It is standard practice to locate ventilation air filters and HRVs/ERVs in these locations. For example, multifamily ventilation equipment and filters are often located above the ceiling, behind access panels. These would be within 10 ft of a walking surface. Others are located in mechanical closets or (particularly in multifamily units) in mechanical equipment located on balconies. The allowance for locating filter access on an accessible roof should accommodate central ventilation systems serving multifamily dwelling units in multifamily buildings, including dedicated outdoor air systems (DOAS).

For single-family homes, another part of the requirement is locating the outdoor air (OA) intake so that it is accessible for cleaning. An OA intake located no more than 10 feet above a walking surface complies. There is an exception for systems with an FID, since the FID would alert occupants to a problem such as a clogged OA intake. This is a mandatory requirement for single-family homes but is not required for multifamily dwelling units. This is because it is nearly impossible for multifamily units to have OA intakes within 10 feet above a walking surface without balconies. Multifamily property owners could maintain OA intakes through other strategies. For example, they could periodically rent scaffolding and clean all OA intakes in the building.

The FID requirements should also be feasible to meet, although incorporating an FID is not standard practice. The proposed prescriptive requirement for the FID, including the list of criteria for qualifying FIDs, follows the current requirement in the ACM. There are already several FIDs from three manufacturers that have been certified to meet the proposed requirements and are listed in the Energy Commission database.[20] These FIDs are for HRVs/ ERVs, but manufacturers could create products for supply fans without heat recovery. In email communications with the Statewide CASE Team, two manufacturers reported that it is feasible to create FIDs for balanced or supply-only ventilation with heat recovery, but that they would need to see customer demand for these products before developing them. One manufacturer predicted that customer demand for FIDs for systems without heat recovery may be low, since the proposed fan energy penalty for not including one is low, and contractors may be reluctant to install

[20] Residential_Fault_Indicator_Display_Certification_List_ADA | California Energy Commission

FIDs due to possible maintenance calls. The other manufacturer noted they may see an increase in demand for FIDs for systems without heat recovery, since many climate zones in California do not have the prescriptive HRV requirement.

Both the IAQ system component accessibility and FID requirements are already in the single-family and multifamily ACM. Based on analysis of the CalCERTS database, 99 percent of single-family and multifamily units follow the performance path, so would be subject to the ACM. However, projects using an exhaust-only ventilation strategy would not need to meet these requirements, because they do not have supply filters nor outdoor air intakes, and they are not subject to the FID requirement. Consequently, the main impact on the market would be that all multifamily projects would be subject to the requirements, not just projects following the balanced ventilation compliance path, because exhaust-only ventilation would no longer be permissible.

4.3 Market Impacts and Economic Assessments

This section includes important information that the CEC uses in the economic analysis that is required by statutes. The CEC uses the information to complete Form STD. 399 (Economic and Fiscal Impact Statement), including identifying whether the proposed update would be greater than $50 million, triggering the requirement for the CEC to complete a Standardized Regulatory Impact Assessment.

4.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the measures proposed by the Statewide CASE Team for the 2025 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California’s construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 13). For 2022, total estimated payroll would be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector.

Table 13: California Residential Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Residential Construction Sectors	Establishments	Employment	Annual Payroll (Billions $)
All	**71,889**	**472,974**	**31.2**
Building Construction Contractors	27,948	130,580	9.8
Foundation, Structure, & Building Exterior	7,891	83,575	5.0
Building Equipment Contractors	18,108	125,559	8.5
Building Finishing Contractors	17,942	133,260	8.0

Source: (State of California n.d.)

The proposed change to multifamily IAQ would likely affect residential builders, but it would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential building industry would not be felt by all firms and workers, but rather, it would be concentrated in specific industry subsectors. Table 14 shows the residential building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Builders are responsible for understanding the design requirements and ensuring that all subcontractors are aware of these requirements for proper installation. They would need to incorporate either a balanced or supply ventilation system. Builders would also need to install the appropriate air sealing material, such as sealants and caulk, for compartmentalization within each multifamily dwelling unit. There are energy consultants and engineers who can support builders in identifying the appropriate solutions to their project needs. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 4.4 Economic Impacts.

4.3.2 Impact on Residential Building Industry

Table 14: Specific Subsectors of the California Residential Building Industry by Subsector in 2022 (Estimated)

Residential Building Subsector	Establishments	Employment	Annual Payroll (Billions $)
New multifamily general contractors	421	6,344	0.7
New housing for-sale builders	189	3,969	0.5
Residential Framing Contractors	741	25,028	1.3
Residential Siding Contractors	242	2,081	0.1
Other Residential Exterior Contractors	628	2,875	0.2
Residential plumbing and HVAC contractors	9,852	75,404	5.1
Other Residential Equipment Contractors	399	1,789	0.1
Residential Drywall Contractors	1,901	32,631	2.0

Source: (State of California n.d.)

4.3.3 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle, and building designers and energy consultants engage in continuing education and training to remain compliant with changes to design practices and building codes.

Building designers and energy consultants would need to identify the best strategies for implementing a balanced or supply-only ventilation system and compartmentalization for multifamily projects in the climate zones in which the requirements apply. Designers would need to consider the details of the project, such as whether to install an ERV, HRV, or supply-only fan; location of the ventilation system; type of sealants and materials for air sealing; and first costs. They must understand the rules and industry standards to ensure safety and compliance. Energy consultants would need to advise their clients on how to improve the building's energy performance through ventilation and compartmentalization, while complying with code and being cost effective.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 15 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for multifamily IAQ to affect firms that focus on multifamily construction.

There is not a North American Industry Classification System (NAICS)[21] code specific to energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[22] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy

[21] NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[22] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

efficiency consulting. The information shown in Table 15 provides an upper bound indication of the size of this sector in California.

Table 15: California Building Designer and Energy Consultant Sectors in 2022 (Estimated)

Sector	Establishments	Employment	Annual Payroll (Millions $)
Architectural Services [a]	4,134	31,478	3,623.3
Building Inspection Services [b]	1,035	3,567	280.7

Source: (State of California n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures.

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

4.3.4 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health. All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

4.3.5 Impact on Building Owners and Occupants (Including Homeowners and Potential First-Time Homeowners)

4.3.5.1 Residential Buildings

According to data from the U.S. Census, American Community Survey, there were more than 14.5 million housing units in California in 2021 and nearly 13.3 million were occupied (see Table 16). Most housing units (nearly 9.42 million) were single family homes (either detached or attached), approximately 2 million homes were in buildings containing two to nine units, and 2.5 million homes were in multifamily buildings containing 10 or more units. The California Department of Revenue estimated that building permits for 67,300 single family and 54,900 multifamily homes would be issued in 2022, up from 66,000 single family and 53,500 multifamily permits issued in 2021.

Table 16: California Housing Characteristics in 2021[a]

Housing Measure	Estimate
Total housing units	14,512,281
Occupied housing units	13,291,541
Vacant housing units	1,220,740
Homeowner vacancy rate	0.7%
Rental vacancy rate	4.3%
Number of 1-unit, detached structures	8,388,099
Number of 1-unit, attached structures	1,030,372
Number of 2-unit structures	348,295
Number of 3- or 4-unit structures	783,663
Number of 5- to 9-unit structures	856,225
Number of 10- to 19-unit structures	740,126
Number of 20+ unit structures	1,828,547
Mobile home, RV, etc.	522,442

Sources: (United States Census Bureau n.d.), (Federal Reserve Economic Data (FRED) n.d.)

a. Total housing units as reported for 2021; all other housing measures estimated based on historical relationships.

Table 17 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes—59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there was no California Energy Code (Kenney, Bird and Rosales 2019).

Table 17: Distribution of California Housing by Vintage in 2021 (Estimated)

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	348,296	2.4	2.4
Built 2010 to 2013	261,221	1.8	4.2
Built 2000 to 2009	1,581,839	10.9	15.1
Built 1990 to 1999	1,596,351	11.0	26.1
Built 1980 to 1989	2,191,354	15.1	41.2
Built 1970 to 1979	2,539,649	17.5	58.7
Built 1960 to 1969	1,915,621	13.2	71.9
Built 1950 to 1959	1,930,133	13.3	85.2
Built 1940 to 1949	841,712	5.8	91.0
Built 1939 or earlier	1,306,105	9.0	100.0
Total housing units	**14,512,281**	**100.0**	**–**

Sources: (United States Census Bureau n.d.)

Table 18 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with an income below $50,000 is only 37 percent, whereas the owner occupancy rate is 71 percent for households earning $100,000 or more.

Table 18: Owner- and Renter-Occupied Housing Units in California by Income in 2021 (Estimated)

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	353,493	113,315	240,178
$5,000 to $9,999	254,304	74,939	179,366
$10,000 to $14,999	495,287	134,633	360,654
$15,000 to $19,999	412,498	144,064	268,435
$20,000 to $24,999	467,694	169,431	298,264
$25,000 to $34,999	906,996	355,968	551,028
$35,000 to $49,999	1,319,892	560,453	759,438
$50,000 to $74,999	2,036,560	990,769	1,045,791
$75,000 to $99,999	1,662,032	920,607	741,425
$100,000 to $149,999	2,307,889	1,490,247	817,642
$150,000 or more	3,074,895	2,337,651	737,244
Total Housing Units	**13,291,541**	**7,292,076**	**5,999,465**

Source: (United States Census Bureau n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single family or multifamily residences and so the counts of housing units by building type shown in Table 16 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 17 and Table 18.

4.3.5.2 Estimating Impacts

For California residents, the proposed code changes would result in lower energy bills. The Statewide CASE Team estimates that on average the proposed change to Title 24, Part 6 would increase construction cost by about $1,486 per multifamily dwelling unit. The increased construction cost is roughly equivalent to an $8 per month increase in payments for a 30-year mortgage (assuming a 5 percent interest rate). But the measure would also result in LSC Savings of $75 to $916 per year, depending on climate zone, or a $6 to $76 per month reduction (depending on climate zone) in LSCs. Subtracting the estimated increase in mortgage from the estimated energy savings, the Statewide CASE Team expects the 2025 Title 24, Part 6 Standards to save homeowners negative $1 (i.e., to approximately break even) to $68 per month, relative to homeowners whose multifamily residences are minimally compliant with the 2022 Title 24, Part 6 requirements.

When homeowners or building occupants save on energy bills, they tend to spend it elsewhere thereby creating jobs and economic growth for the California economy. LSC Savings can be particularly beneficial to low-income homeowners who typically spend a higher portion of their income on energy bills, often have trouble paying energy bills, and sometimes go without other necessities to save money for energy bills (Association, National Energy Assistance Directors 2011).

4.3.6 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The proposed measure would impact manufacturers developing heating, ventilation, and air conditioning (HVAC) equipment and materials for balanced and supply-only ventilation systems and compartmentalization, distributors selling these products to retailers, and these retailers selling directly to consumers. Various brands and models would be available on the market. The demand for installing ERV or HRV would increase slightly, as the market already includes multifamily dwelling units using balanced ventilation systems with ERV or HRV. Sales of air sealing materials would increase, since the measure requires compartmentalization, and most projects are not doing compartmentalization. As the demand for balanced and supply-only ventilation increases, there would be less demand for other ventilation systems. However, with the price of ERV and HRV units being higher and the need for compartmentalization, manufacturers, distributors, and retailers are likely to have slightly higher sales revenues.

4.3.7 Impact on Building Inspectors

Table 19 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 19: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Govt.	Establishments	Employment	Annual Payroll (Million $)
Administration of Housing Programs[a]	State	18	265	29.0
	Local	38	3,060	248.6
Urban and Rural Development Admin[b]	State	38	764	71.3
	Local	52	2,481	211.5

Source: (State of California, Employment Development Department n.d.)

Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

4.3.8 Impact on Statewide Employment

As described in Sections 4.3.1 through 4.3.7, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in multifamily IAQ would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

4.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software,[23] along with economic information from published sources, and professional judgement to develop estimates of the economic impacts associated with each of the proposed code changes. Conceptually, IMPLAN estimates jobs created as a function of incoming cash flow in different sectors of the economy, due to implementing a code or a standard. The jobs created are typically categorized into direct, indirect, and induced employment. For example, cash flow into a manufacturing plant captures direct employment (jobs created in the manufacturing plant), indirect employment (jobs created in the sectors that provide raw materials to the manufacturing plant) and induced employment (jobs created in the larger economy due to purchasing habits of people newly employed in the manufacturing plant). Eventually, IMPLAN computes the

[23] IMPLAN employs economic data and advanced economic impact modeling to estimate economic impacts for interventions like changes to the California Title 24, Part 6 code. For more information on the IMPLAN modeling process, see www.IMPLAN.com.

total number of jobs created due to a code change. The assumptions of IMPLAN include constant returns to scale, fixed input structure, industry homogeneity, no supply constraints, fixed technology, and constant byproduct coefficients. The model is also static in nature and is a simplification of how jobs are created in the macro-economy.

The economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. The IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that the direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspects of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the economic impacts presented below represent lower bound estimates of the actual benefits associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the residential building industry, architects, energy consultants, and building inspectors, as well as indirectly as residents spend all or some of the money saved through lower utility bills on other economic activities.[24] There may also be some nonresidential customers that are impacted by this proposed code change; however, the Statewide CASE Team does not anticipate such impacts to be materially important to the building owner and would have measurable economic impacts.

The annual economic impact is based on the estimated first-year incremental, replacement, and maintenance costs of the proposed code change per dwelling unit. These costs are weighted by building prototypes and climate zones.

[24] For example, for the lowest income group, the Statewide CASE Team assumes 100 percent of money saved through lower energy bills would be spent, while for the highest income group, the Statewide CASE Team assumes only 64 percent of additional income would be spent.

Table 20: Estimated Annual Impact that Adoption of the Proposed Measure would have on the California Residential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Residential Builders)	194.9	$15,445,144	$20,431,448	$24,916,897
Indirect Effect (Additional spending by firms supporting Residential Builders)	23.4	$1,762,390	$2,870,454	$4,950,220
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	72.5	$4,945,150	$8,853,532	$14,091,448
Total Economic Impacts	**290.8**	**$22,152,684**	**$32,155,434**	**$43,958,564**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[25]

Table 21: Estimated Annual Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultants Sectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Designers & Energy Consultants)	14.4	$1,577,649	$1,561,854	$2,468,657
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	5.8	$469,746	$652,853	$1,050,959
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	8.6	$588,721	$1,054,273	$1,678,029
Total Economic Impacts	**28.8**	**$2,636,116**	**$3,268,980**	**$5,197,645**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

Table 22: Estimated Annual Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Inspectors)	3.5	$397,962	$471,935	$573,495
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.4	$36,856	$57,403	$99,977
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	1.8	$125,171	$224,222	$356,889
Total Economic Impacts	**5.8**	**$559,990**	**$753,560**	**$1,030,361**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

[25] IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

4.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the proposed measure would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. Rather, the proposed measure would lead to modest changes in employment of existing jobs.

4.4.2 Creation or Elimination of Businesses in California

As stated in Section 4.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to the use of specific products, which would not excessively burden or competitively disadvantage California businesses—nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

4.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state.[26] Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

4.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[27] As Table 23 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020, due to the worldwide economic slowdowns associated with the COVID 19 pandemic, to a high of 35 percent in 2019, with an average of 26 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE

[26] Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

[27] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

Table 23: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2017	518.473	1882.460	28
2018	636.846	1977.478	32
2019	690.865	1952.432	35
2020	343.620	1908.433	18
2021	506.331	2619.977	19
5-Year Average	**539.227**	**2068.156**	**26**

Source: (Federal Reserve Economic Data (FRED) n.d.)

The Statewide CASE Team estimates that the sum of proposed code changes in this report would increase in investment in California:

- $7,611,004 x 0.26 = $2,016,357
- Change in proprietor Income: $7,611,004
- Proportion of total proprietor income used for net capital investment: 26 percent
- Total estimated net private investment: $2,016,357

4.4.5 Incentives for Innovation in Products, Materials, or Processes

The Statewide CASE Team does not anticipate an impact on innovation as a result of the proposed code change. The market is already using balanced ventilation, some with HRVs. For the level of compartmentalization proposed, the project team can use the existing air sealing materials.

4.4.6 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team does not expect the proposed code changes would have a measurable impact on California's General Fund, any state special funds, or local government funds.

4.4.6.1 Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

This measure would not impact state buildings because it is a residential measure.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the investor-owned utility (IOU) codes and standards program (such as Energy Code Ace). As noted in Section 3.5 and Appendix E, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

4.4.7 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences.

The proposed code changes are not expected to have an impact on specific persons. It is likely to impact the Disproportionately Impacted Populations (DIPs) as discussed in Section 2.

4.5 Fiscal Impacts

4.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to school districts, because this only impacts multifamily buildings. There are also no mandates for local agencies, because the requirements would be specified at the Statewide level through Title 24, Part 6.

4.5.2 Costs to Local Agencies or School Districts

There are no costs to school districts, because this only impacts multifamily buildings. For local agencies, there would be minor increases in work for building inspectors because they (along with HERS Raters and ATTs) would enforce the measure. Section 4.3.7 describes the impact on building inspectors.

4.5.3 Costs or Savings to Any State Agency

There are no costs or savings to state agencies because they would not be involved in enforcement of the measure.

4.5.4 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies.

4.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state due to the measure. The proposed measure is a relatively small cost, which the market would bear. The state would not require federal funding to implement the proposed measure.

5. Energy Savings

This section provides the combined energy savings of the two components of this measure: supply or balanced ventilation, and compartmentalization. As described in Section 5.1, the Statewide CASE Team used plan reviews and interviews with stakeholders to estimate the fraction of projects that use each ventilation strategy currently (fraction using supply-only, exhaust only, or balanced), and it used interviews to estimate how that might change under the proposed measure (fraction using supply-only or balanced) and to estimate the fraction of projects pursuing compartmentalization. The Statewide CASE Team assumed that there would be a reduction in air leakage—characterized in energy simulations as the ACH at 50 Pascals—from compartmentalization based on published studies that have measured dwelling unit and multifamily building air leakage. The sections below provide more detail on these assumptions.

The Statewide CASE Team proposes this measure as a mandatory requirement in all climate zones because of its IAQ benefits. These include ensuring a reliable source of filtered, outdoor air through supply-only or balanced ventilation, and reducing pollutant transfer from neighboring units from compartmentalization. The two components of this measure work hand-in-hand, since compartmentalization reduces air leakage from the exterior and pollutant transfer from units, but tightening the dwelling unit envelope increases the need for mechanically supplied outdoor air. In addition to improved IAQ, the measures also provide non-energy benefits such as reduced noise transmission and pest control (both from the exterior and with neighboring units).

Energy savings benefits may have potential to disproportionately impact DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

5.1 Energy Savings Methodology

The Statewide CASE Team modeled the proposed measure in all multifamily building prototypes: low-rise loaded corridor, garden-style, midrise, and high-rise.

As an overview, the Statewide CASE Team conducted energy simulations for different ventilation strategies and compartmentalization scenarios that project teams could use to meet the existing requirements and proposed requirements. The Statewide CASE Team then weighted these results based on the expected prevalence of each scenario under existing requirements (baseline) and proposed requirements (proposed).

The Statewide CASE Team:

1. Conducted energy simulations of different compliance scenarios for the *base* case. The Statewide CASE Team ran simulations of the following: (a) Balanced

ventilation without compartmentalization, in which the infiltration was assumed to be 7 ACH50, the default leakage value in CBECC; and (b) exhaust-only ventilation with compartmentalization to 0.3 cfm50/ft^2, in which infiltration was assumed to be 2.4 to 3.2 ACH50, depending on the prototype. For Climate Zones 1, 2, and 11-16, the energy models included an HRV because 2022 Title 24, Part 6 prescriptively requires it. The Statewide CASE Team weighted these results as described in step 3.

2. Conducted energy simulations of different compliance scenarios for the *proposed* case. The Statewide CASE Team ran simulations of the following: (a) Balanced ventilation with compartmentalization to 0.3 cfm50/ft^2, assuming infiltration of 2.4 to 3.2 ACH50, depending on the prototype. The Estimate of Compartmentalization's Impact on ACH50 section below describes how the Statewide CASE Team developed this assumption. For Climate Zones 1, 2, 4, 11-14, and 16, the energy models included an HRV; and (b) Supply-only ventilation with compartmentalization to 0.3 cfm50/ft2, assuming infiltration of 2.4 to 3.2 ACH50, depending on the prototype. The Statewide CASE Team weighted these results as described in step 4.
3. Assumed that for multifamily buildings with four or more habitable stories, the base case was a weighted average of 75 percent balanced ventilation without compartmentalization, and 25 percent was exhaust-only with compartmentalization, based on market research (interviews, plan reviews, and stakeholder input during public stakeholder meeting). The Statewide CASE Team assumed that for multifamily buildings with three or fewer habitable stories, the base case has a weighted average of 42 percent balanced ventilation without compartmentalization, and 58 percent was exhaust-only with compartmentalization, based on market research (CalCERTS data and stakeholder input during public stakeholder meeting).
4. Assumed the proposed case would be a weighted average of 85 percent balanced ventilation with compartmentalization and 15 percent supply-only ventilation with compartmentalization, based on interviews with market actors.

All scenarios including balanced or supply-only ventilation include FIDs. This is true for both the base case, since the 2022 Title 24 Part 6 ACM requires FIDs, and the proposed case, since the Statewide CASE Team proposes it as a prescriptive requirement.

Table 24 summarizes these assumptions.

Table 24: Weighting of Scenarios in Energy Modeling

Case	Climate Zone (CZ)	Assumed Scenario for Ventilation Strategy and Infiltration (ACH50) for Energy Modeling and Incremental Costs
Base	CZs 1, 2, 11-16	Three or fewer habitable stores: • 42% balanced with HRV and 7 ACH50 • 58% exhaust only and 2.4 to 3.2 ACH50,[28] depending on prototype Four or more habitable stores: • 75% balanced with HRV and 7 ACH50 • 25% exhaust only and 2.4 to 3.2 ACH50, depending on prototype
Base	CZs 3-10	Three or fewer habitable stores: • 42% balanced and 7 ACH50 • 58% exhaust only and 2.4 to 3.2 ACH50, depending on prototype Four or more habitable stores: • 85% balanced and 7 ACH50 • 15% exhaust only and 2.4 to 3.2 ACH50, depending on prototype
Proposed	CZs 1, 2, 4, 11–16	100% balanced with HRV, and 2.4 to 3.2 ACH50, depending on prototype
Proposed	CZs 3, 5-10, and 15	85% balanced with HRV and 2.4 to 3.2 ACH50, depending on prototype 15% supply-only and 2.4 to 3.2 ACH50, depending on prototype

The Statewide CASE Team calculated the difference between the base and proposed case as energy savings.

5.1.1 Key Assumptions for Energy Savings Analysis

5.1.1.1 Estimate of Compartmentalization's Impact on ACH50

The Nonresidential and Multifamily Alternative Calculation Method (NRMF-ACM) Reference Manual defines the standard design building air leakage and infiltration values that should be used in CBECC. The 2022 NRMF-ACM specifies a value of 7 ACH50 as the standard design infiltration rate for multifamily buildings with three or fewer habitable stories, and 0.2352 cfm/ft^2 for multifamily buildings with four or more habitable stories. However, the 2022-CBECC software applies the 7 ACH50 infiltration rate to all multifamily spaces, irrespective of the number of habitable stories. This

[28] The Statewide CASE Team assumed the default infiltration value in CBECC of 7 ACH50 for dwelling units not targeting compartmentalization. We estimated that a compartmentalization rate of 0.3 cfm50/sf roughly translated to an infiltration value of 2.4 to 3.2 ACH50, depending on the prototype. The assumptions behind this crosswalk is described in Section 5.1.1.

follows the precedent in the 2019-CBECC-Res software, which also assumes 7 ACH50 infiltration rate for all multifamily spaces.

Because compartmentalization requires air sealing each dwelling unit around the entire dwelling unit enclosure, including with the exterior, there are energy savings from the measure due to reduced infiltration. Reduced infiltration generally translates to reduced heating and cooling needs with energy savings varying by climate zone, as shown in Section 5.2.1. Compartmentalization is measured by a blower door test conducted at the dwelling unit level, which does not distinguish between air from the outside (infiltration air that would need to be conditioned) and air from adjacent units or the corridor (which would likely have less need for conditioning).

To estimate the energy savings from this measure, the Statewide CASE Team needed to adjust the infiltration assumption in CBECC for the proposed design to account for compartmentalization, compared to the CBECC default in the standard design of 7 ACH50. The Statewide CASE Team used the following approach to estimate a reduced infiltration rate because of compartmentalization in the proposed measure:

1. **Translated the compartmentalization limit from cfm50/ft^2 to ACH50 for total leakage through the dwelling unit envelope,** based on the average of a few different unit geometries, **the Statewide CASE Team assumed that 0.3 cfm50/ft^2 is roughly equivalent to 6.2 ACH50**.
    a. For an example dwelling unit of 1,080 ft^2 (32 ft x 33.75 ft), and 8.5 ft ceiling:

       Dwelling unit enclosure area = 2x (32 ft x 8.5 ft) + 2x (33.8 ft x 8.5 ft) + 2x (32 ft x 33.75 ft) = 3,278 ft^2.

       *Allowing 0.3 cfm50/*ft^2*: 0.3 cfm50/*ft^2 *x 3,278* ft^2 *= 983 cfm50*

       To calculate ACH50: 983 cfm50 x 60 minutes/hr x 1 air exchange / (32 ft x 33.75 ft x 8.5 ft) = 6.4 ACH50

       This is the total leakage from all sides of the dwelling unit: both from the exterior and interior spaces (adjacent units and corridors)

       *The Statewide CASE Team calculated this calculation for dwelling units of other sizes and varying the ceiling height (at 8 ft, 8.5 ft, and 9 ft), and found on average that 0.3 cfm50/*ft^2 *converted to 6.2 ACH50.*
2. **Assumed 37 percent of dwelling unit leakage would be from the exterior, based on a field study that measured air leakage in multifamily buildings**. Because of the considerable variability that was found among units for this percentage, the Statewide CASE Team chose a value that would result in a conservative estimate of energy savings:

a. A field study found that, based on a measurement of 20 low-rise, common-entry multifamily buildings in six states,[29] 75 percent of units had 37 percent or less of their total leakage coming from the exterior, as shown in Figure 12. The Statewide CASE Team used the 75th percentile, rather than the median (50th percentile), to be conservative with energy savings estimates.[30]

   Multiplying 37 percent by the estimated total leakage value of 6.2 ACH50: 37 percent x 6.2 ACH50 = 2.3 ACH50.

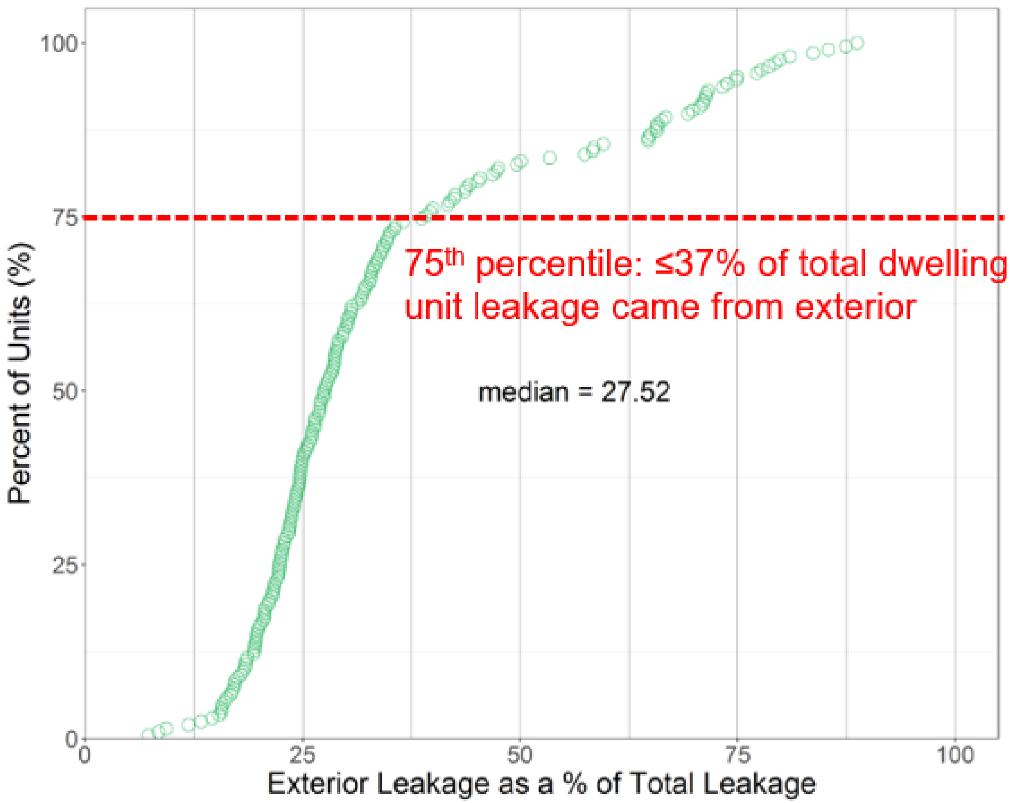

Figure 12: Cumulative distribution of dwelling unit exterior leakage as percent of total dwelling unit leakage in common-entry multifamily buildings

Source: (Bohac, et al. 2020)

For garden-style units, the same field study (David Bohac; Lauren Sweeney; Robert Davis; Collin Olson; Gary Nelson 2020) found that approximately 50 percent of leakage came from the exterior. So for the garden-style prototype, this analysis

[29] The tested buildings were located in Illinois, Iowa, Michigan, Minnesota, Oregon, and Washington.

[30] Using the 75th percentile instead of the median results in an assumption of a greater fraction of air that comes from the exterior, which translates into a higher infiltration value, and less savings compared to the standard design.

assumed 3.1 ACH50 leakage after compartmentalization, based on 50 percent x 6.2 ACH50 = 3.1 ACH50

Increased the infiltration assumption (i.e., reduced savings from the compartmentalization measure) to account for nonresidential spaces in the residential zones. Some of the residential zones in CBECC included nonresidential spaces, such as corridors and common areas used by residents. The Statewide CASE Team assumed the leakage in the proposed case would be 2.8, 3.2, 2.5, and 2.4 ACH50 in the garden-style, low-rise loaded corridor (LRLC), midrise, and high-rise prototype buildings, respectively, depending on the relative fraction of nonresidential spaces in the residential zones. Table 25 shows the supporting calculations. Note that the 2022-CBECC software has a different leakage assumption for nonresidential floors in multifamily buildings (0.2352 cfm/ft2), which the Statewide CASE Team did not adjust, since they would not be impacted by this measure.

Some of the residential zones in the prototype multifamily buildings include small areas of nonresidential spaces. The Statewide CASE Team addressed this by applying a weighted average for the leakage assumption in the proposed model, where the residential spaces (impacted by the proposed compartmentalization measure) have a leakage assumption of 2.3 ACH50, the nonresidential spaces (not impacted by the measure) have the baseline leakage assumption of 7 ACH50, and the weighting is based on the conditioned floor area of residential and nonresidential space in the residential zones of the building. The Statewide CASE Team used the values in Table 25 as the leakage assumption in the proposed model due to compartmentalization to 0.3 cfm50/ft^2. The low-rise loaded corridor (LRLC) prototype has the largest fraction of nonresidential spaces in the residential zones, because (in contrast to the mid-rise and high-rise prototypes) it does not have a floor dedicated as a nonresidential zone. The garden-style building does not have any nonresidential space.

Table 25: Infiltration Assumptions for Compartmentalization Measure, Accounting for Residential and Nonresidential Spaces in Building

Input	Garden Style	LRLC	Midrise	Highrise
Nonresidential space in residential zones (ft^2)[31]	0	6,492	4,900	3,000
Residential space in residential zones (ft^2)	7,680	32,988	90,600	112,900
Percent of nonresidential space in residential zones	100%	19.7%	5%	3%
Leakage estimate for nonresidential space in residential zone (ACH50)	7	7	7	7
Leakage estimate for residential space in residential zone, for compartmentalization at 0.3 cfm50/ft^2 (ACH50)	3.1	2.3	2.3	2.3
Weighted ACH50 for residential zone: Input for "proposed model" for 0.3 cfm50/ft^2	3.1	3.2	2.5	2.4

5.1.1.2 Energy Modeling Assumptions

Once the Statewide CASE Team had estimated the infiltration rate for the proposed case to account for infiltration, we were able to conduct energy modeling to estimate the energy savings from the proposed measure compared to the base case.

- In the base case,
    - For the mid-rise and high-rise prototypes, the Statewide CASE Team assumed that 75 percent of multifamily dwelling units use balanced ventilation in these climate zones, and 25 percent would use exhaust-only ventilation with compartmentalization, based on market research. Per the current prescriptive requirement, the Statewide CASE Team assumed that dwelling units with balanced ventilation in Climate Zones 1, 2, and 11-16 would have an HRV.
    - For the low-rise garden-style and low-rise loaded corridor prototypes, the Statewide CASE Team assumed that 42 percent of multifamily dwelling units use balanced ventilation in these climate zones, and 58 percent would use exhaust-only ventilation with compartmentalization, based on market research. Per the current prescriptive requirement, the Statewide CASE Team assumed that dwelling units with balanced ventilation in Climate Zones 1, 2, and 11-16 would have an HRV.
- In the proposed case, for all prototypes, the Statewide CASE Team assumed that 85 percent of multifamily dwelling units use balanced ventilation in Climate Zones 3,

[31] In addition to the nonresidential spaces that the CBECC software includes in residential zones, the mid-rise and high-rise prototypes include one to two floors that are entirely nonresidential space. The CBECC software models these nonresidential floors using a different infiltration assumption: 0.2352 cfm/ft2, which the Statewide CASE Team did not adjust.

5 through 10, and 15, and that 15 percent use supply-only ventilation. The Statewide CASE Team assumed 100 percent would use balanced ventilation with an HRV in Climate Zones 1, 2, 4, 11 through 14, and 16. For all of the proposed cases, the Statewide CASE Team assumed the units were compartmentalized (had an infiltration rate of 2.4 to 3.2 ACH50, depending on prototype).

5.1.2 Energy Modeling Assumptions Specific to the Prescriptive HRV Requirement

While Section 5.1.1 describes the energy savings analysis for the entire measure package, including the mandatory requirements, this section describes the energy modeling assumptions specific to the prescriptive HRV requirement.

Under the current prescriptive requirements, multifamily dwelling units in Climate Zones 1, 2, and 11 through 16 that use balanced ventilation must install an HRV or ERV. If the proposed change to the mandatory requirements moves forward, the Statewide CASE Team proposes to revise the prescriptive requirement so that all multifamily dwelling units in Climate Zones 1, 2, 4, 11 through 14, and 16 must use balanced ventilation with an HRV or ERV. Project teams following the performance path could install supply-only or balanced ventilation without HRV, but the base case would use balanced with HRV. Consequently, the project team would need to exceed the requirements of the energy code in another measure(s).

This proposed change to the prescriptive requirement is for energy reasons, so it must be cost effective. To investigate the energy impacts and cost effectiveness, the Statewide CASE Team modeled by climate zone:

- **Base case:** 85 percent balanced ventilation without an HRV/ERV and 15 percent with supply-only ventilation. All units are compartmentalized to 0.3 cfm50/ft^2. The base case assumes all units meet the proposed mandatory requirement.
- **Proposed case:** balanced ventilation with an HRV. All units compartmentalized to 0.3 cfm50/ft^2.
- **FID assumption for Base and Proposed cases:** The Statewide CASE Team checked the box in modeling software to indicate that an FID was used for all balanced and supply-only cases, in both the base case and proposed case. Our cost analysis includes the cost of an FID. We applied it to the base case (not just the proposed case) because almost all projects follow the performance path, and the ACM already requires the FID.

For illustrative purposes, Table 26 shows the impact in the CBECC energy model if the ventilation system does not have an FID – i.e., if the FID box is not checked in the model. The Statewide CASE Team ran this scenario in the mid-rise prototype in both Climate Zones 3, where the base case does not include heat recovery, and Climate

Zone 12, where the base case does include an HRV. As shown, in both climate zones, this results in a -0.6 percent LSC savings penalty compared to the base case (with an FID).

Table 26: Energy Impacts of No FID in the MidRise Mixed-Use Prototype.

Scenario	LSC (%) savings compared to Base Case: CZ 3	LSC (%) savings compared to Base Case: CZ 12
No FID	-0.6%	-0.6%

5.1.3 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team estimated per-unit energy savings expected from the proposed code changes in several ways to quantify key impacts. First, savings are calculated by fuel type. Electricity savings are measured in terms of both energy usage and peak demand reduction. Natural gas savings are quantified in terms of energy usage. Second, the Statewide CASE Team calculated Source Energy Savings. Source Energy Savings represents the total amount of raw fuel required to operate a building. In addition to all energy used from on-site production, source energy incorporates all transmission, delivery, and production losses. The hourly Source Energy values provided by the CEC are strongly correlated with greenhouse gas (GHG) emissions. Finally, the Statewide CASE Team calculated Long-term Systemwide (LSC) Cost Savings, formerly known as Time Dependent Valuation (TDV) LSC Savings. LSC Savings are calculated using hourly LSC factors for both electricity and natural gas provided by the CEC. These LSC hourly factors are projected over the 30-year life of the building and incorporate the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions. The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings (California Energy Commission 2022). The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 27.

Table 27: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
LowRiseGarden	2	7,680	2-story, 8-unit apartment building. Average dwelling unit size: 960 ft2.
LoadedCorridor	3	40,000	3-story, 36-unit apartment building. Average dwelling unit size: 960 ft2.
MidRiseMixedUse	5	113,100	4-story (3-story residential, 1-story commercial), 88-unit building. Avg dwelling unit size: 870 ft2.
HighRiseMixedUse	10	125,400	10-story (9-story residential, 1-story commercial), 117-unit building. Avg dwelling unit size: 850 ft2.

The Statewide CASE Team estimated LSC, Source Energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change in CBECC 2025 RV using the prototypical building models summarized above (California Energy Commission n.d.).

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[32] The Standard Design represents the geometry of the prototypical building and a design that uses a set of features that result in a LSC budget and Source Energy budget that is minimally compliant with 2022 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2022 Nonresidential and Multifamily ACM Reference Manual. The Proposed Design represents the same geometry as the Standard Design, but it assumes the energy features that the software user describes with user inputs. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design and Proposed Design for each prototypical building, with the Standard Design representing compliance with 2022 code and the Proposed Design representing compliance with the proposed requirements. Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2022 Title 24, Part 6 requirements, which follows industry typical practices.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 28 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, instead of assuming the default air leakage value of 7 ACH50, the proposed conditions assume lower air leakage values (around 3 ACH50, with the exact value dependent on the prototype) to represent the reduced air leakage from compartmentalization. Section 5.1.1 provides the derivation of this estimate.

Both the Standard and Proposed Designs assumed an electric space heating heat pump in all climate zones except Climate Zone 16, where it assumes a gas furnace.

[32] CBECC-Res creates a third model, the Reference Design, which represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 IECC. The Statewide CASE Team did not use the Reference Design for energy impacts evaluations.

Table 28: Modifications Made to Standard Design in Each Prototype to Simulate Measure

Prototype ID	Climate Zone	Parameter Name	Standard Design Parameter Value	Baseline Design Parameter Value: 42% or 75%[a]	Baseline Design Parameter Value: 58% or 25%[b]	Proposed Design Parameter Value: 85%	Proposed Design Parameter Value: 15%
Low-Rise Garden	1, 2, 4, 11–14, 16	Residential Air Leakage (ACH50)	7	3.5	3.5	3.5	3.5
		IAQ Fan Type	Balanced (with HRV)	Balanced (with HRV)	Exhaust	Balanced (with HRV)	Balanced (with HRV)
	3, 5–10, 15	Residential Air Leakage (ACH50)	7	3.5	3.5	3.5	3.5
		IAQ Fan Type	Balanced	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Supply
Low-Rise Loaded Corridor (LRLC)	1, 2, 4, 11–14, 16	Residential Air Leakage (ACH50)	7	3.2	3.2	3.2	3.2
		IAQ Fan Type	Balanced (No HRV)	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Balanced (No HRV)
	3, 5–10, 15	Residential Air Leakage (ACH50)	7	3.2	3.2	3.2	3.2
		IAQ Fan Type	Balanced	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Supply
Mid-Rise Mixed Use	1, 2, 4, 11–14, 16	Residential Air Leakage (ACH50)	7	2.5	2.5	2.5	2.5
		IAQ Fan Type	Balanced (No HRV)	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Balanced (No HRV)
	3, 5–10, 15	Residential Air Leakage (ACH50)	7	2.5	2.5	2.5	2.5
		IAQ Fan Type	Balanced	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Supply
High-Rise Mixed Use	1, 2, 4, 11–14, 16	Residential Air Leakage (ACH50)	7	2.4	2.4	2.4	2.4
		IAQ Fan Type	Balanced (No HRV)	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Balanced (No HRV)
	3, 5–10, 15	Residential Air Leakage (ACH50)	7	2.4	2.4	2.4	2.4
		IAQ Fan Type	Balanced	Balanced (No HRV)	Exhaust	Balanced (with HRV)	Supply

a. 42% for Low-Rise Garden and Low-Rise Loaded Corridor, 75% for Mid-Rise and High-Rise prototypes.

b. 58% for Low-Rise Garden and Low-Rise Loaded Corridor, 25% for Mid-Rise and High-Rise prototypes.

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/year) and therms per year (therms/year). It then applies the 2025 LSC hourly factors to calculate LSC in 2026 present value dollars (2026 PV$), Source Energy hourly factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/year), and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions equivalent. CBECC also calculates annual peak electricity demand measured in kilowatts (kW).

The energy impacts of the proposed code change vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific LSC hourly factors when calculating energy and LSC impacts.

Per-unit energy impacts for multifamily buildings are presented in savings per residential unit. Annual energy and peak demand impacts for each prototype building were translated into impacts per dwelling unit by dividing by the number of dwelling units in the prototype building. This step enables a calculation of statewide savings using the construction forecast that is published in terms of number of multifamily dwelling units by climate zone.

5.1.4 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. The Statewide Construction Forecasts estimate new construction/additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect (California Energy Commission 2022). The construction forecast provides construction by building type and climate zone, as shown in Appendix A.

Appendix A presents additional information about the methodology and assumptions used to calculate statewide energy impacts.

5.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 30 through Table 33. These results are only for new construction, because the measure does not affect additions or alterations.

5.2.1 Entire Measure Package

This section first provides results from compartmentalization for the high-rise prototype compared to another study in savings Table 29. While this analysis used savings from the entire measure (compartmentalization and balanced/ supply-only ventilation, with HRV where prescriptively required), the Statewide CASE Team provides this interim result of savings from just compartmentalization compared with another study as a sanity check. The savings from compartmentalization was challenging to estimate, since there is no established crosswalk between a compartmentalization value and infiltration. The Statewide CASE Team describes the approach used in Section 5.1.1. Table 29 compares our results with those from a different modeling effort conducted by the California Code Readiness Team (Boranian, Torvestad and Staller 2023).

- The Code Readiness Team estimated savings for compartmentalization at 0.3 cfm50/sf compared to the default ACM software of 7 ACH50 for the high-rise prototype.
- The Statewide CASE Team also estimated using modeling of 0.3 cfm50/sf compared to 7 ACH50 for the same building.

Because the Code Readiness Team used a different approach for estimating exterior leakage (i.e., infiltration) associated with compartmentalization, it is not surprising that results are not identical. However, results were similar as shown in the Table 29, which provides support that the savings by the Statewide CASE Team are reasonable.

Table 29: Energy Savings from Compartmentalization in High-Rise Prototype Compared to Code Readiness Estimate

Climate Zone	Space Heating [%kWh/year], from Code Readiness Team	Space Cooling [%kWh/year], from Code Readiness Team	Code Readiness Team modeling: Total Building savings (% LSC/sf)	Statewide CASE Team modeling: Total Building savings (% LSC)
CZ03	20.2%	-8.0%	0.9%	2.1%
CZ07	13.5%	-8.0%	-0.5%	0.2%
CZ12	31.2%	-1.3%	2.2%	2.5%
CZ15	15.0%	6.7%	2.7%	2.6%

Source for Code Readiness Results: (Boranian, Torvestad and Staller 2023)

The following tables show impacts by dwelling unit by climate zone for the entire measure package that is proposed. This assumes:

Base case:

- Mid-rise and High-rise prototypes:
  - Climate Zones 1, 2, and 11-16: 75 percent balanced with HRV and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
  - Climate Zones 3-10: 75 percent balanced and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
- Low-rise prototypes:

- Climate Zones 1, 2, and 11-16: 42 percent balanced with HRV and without compartmentalization, and 58 percent cent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
- Climate Zones 3-10: 42 percent balanced and without compartmentalization, and 58 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.

Proposed case:

- Climate Zones 1, 2, 4, 11 through 14 and 16: 100 percent balanced with HRV and with compartmentalization to 0.3 cfm50/ft^2.
- Climate Zones 3, 5-10, and 15: 85 percent balanced with compartmentalization to 0.3 cfm50/ft2, and 15 percent supply-only with compartmentalization to 0.3 cfm50/ft^2.

The tables below show results for the four prototype multifamily buildings. As shown, energy savings vary by prototype and by climate zone for the following reasons:

- For climate zones without the prescriptive HRV requirement: Energy savings are higher for the mid-rise and high-rise prototypes than for the two low-rise prototypes. This is because compartmentalization results in energy savings (due to reduced air leakage) but switching from exhaust-only ventilation to balanced without HRV does not, and this analysis assumes the majority of low-rise units switch from exhaust-only to balanced ventilation. In contrast, this analysis assumes the majority of mid- and high-rise units switch from balanced ventilation without compartmentalization to balanced ventilation with compartmentalization. The low-rise prototypes in climate zones with the prescriptive HRV requirement have more savings than the climate zones without the HRV requirement, because moving from exhaust to balanced ventilation with HRV saves energy.
- Within each prototype, energy savings vary significantly by climate zone because compartmentalization results in more energy savings from reduced heating and cooling needs in non-mild climates. Climate Zone 16 has high gas and low electricity savings, because the prototypes assume natural gas heat for that climate zone.

Table 30: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction—Ventilation + Compartmentalization—Low-Rise Garden Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	1121	0	1121
CZ02	787	0	787
CZ03	-332	0	-332
CZ04	-329	0	-329
CZ05	-377	0	-377
CZ06	40	0	40
CZ07	158	0	158
CZ08	307	0	307
CZ09	145	0	145
CZ10	94	0	94
CZ11	997	0	997
CZ12	903	0	903
CZ13	915	0	915
CZ14	925	0	925
CZ15	503	0	503
CZ16	38	1624	1662

Table 31: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction—Ventilation + Compartmentalization—Loaded Corridor Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	590	0	590
CZ02	481	0	481
CZ03	-208	0	-208
CZ04	-317	0	-317
CZ05	-124	0	-124
CZ06	86	0	86
CZ07	172	0	172
CZ08	257	0	257
CZ09	52	0	52
CZ10	70	0	70
CZ11	563	0	563
CZ12	461	0	461
CZ13	436	0	436
CZ14	585	0	585
CZ15	324	0	324
CZ16	-1	993	991

Table 32: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction—Ventilation + Compartmentalization—Mid-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	323	76	399
CZ02	352	0	352
CZ03	255	0	255
CZ04	502	0	502
CZ05	293	0	293
CZ06	83	0	83
CZ07	79	0	79
CZ08	220	0	220
CZ09	221	0	221
CZ10	293	0	293
CZ11	599	0	599
CZ12	416	0	416
CZ13	493	0	493
CZ14	619	0	619
CZ15	560	0	560
CZ16	384	434	818

Table 33: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction—Ventilation + Compartmentalization—High-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	353	102	455
CZ02	440	0	440
CZ03	188	0	188
CZ04	273	0	273
CZ05	210	0	210
CZ06	50	0	50
CZ07	37	0	37
CZ08	139	0	139
CZ09	156	0	156
CZ10	207	0	207
CZ11	593	0	593
CZ12	454	0	454
CZ13	481	0	481
CZ14	652	0	652
CZ15	364	0	364
CZ16	406	548	954

5.2.2 Prescriptive HRV Measure Only

The following tables show impacts by dwelling unit by climate zone for the proposed prescriptive requirement of an HRV in Climate Zones 1, 2, 4, 11 through 14, and 16. This assumes:

- **Base case:** 15 percent supply-only, and 85 percent balanced ventilation (no HRV). This assumption aligns with the proposed mandatory requirement.
- **Proposed case:** Balanced with HRV

For both the base and proposed case, this analysis assumed compartmentalization to 0.3 cfm50/ft2 so that the impact of the HRV could be separated from the impact of compartmentalization.

The Statewide CASE Team presents results for all climate zones for comprehensiveness, even though the measure is only proposed for Climate Zones 1, 2, 4, 11 through 14, and 16. Climate Zones 3, 5 through 10, and 15 are labeled as “not proposed”. As shown, the savings vary by climate zone.

Table 34: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction—Prescriptive HRV—Low-Rise Garden Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	2967	523	3490
CZ02	2444	0	2444
CZ03 (not proposed)	1402	0	1402
CZ04	2125	0	2125
CZ05 (not proposed)	1283	0	1283
CZ06 (not proposed)	-184	0	-184
CZ07 (not proposed)	-378	0	-378
CZ08 (not proposed)	-365	0	-365
CZ09 (not proposed)	157	0	157
CZ10 (not proposed)	283	0	283
CZ11	2142	0	2142
CZ12	1964	0	1964
CZ13	1862	0	1862
CZ14	2414	0	2414
CZ15 (not proposed)	622	0	622
CZ16	-42	5287	5246

Table 35: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction— Prescriptive HRV —Loaded Corridor Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	2168	498	2666
CZ02	1770	0	1770
CZ03 (not proposed)	730	0	730
CZ04	1416	0	1416
CZ05 (not proposed)	508	0	508
CZ06 (not proposed)	-495	0	-495
CZ07 (not proposed)	-634	0	-634
CZ08 (not proposed)	-625	0	-625
CZ09 (not proposed)	-115	0	-115
CZ10 (not proposed)	-44	0	-44
CZ11 (not proposed)	1830	0	1830
CZ12	1503	0	1503
CZ13	1537	0	1537
CZ14	1991	0	1991
CZ15 (not proposed)	715	0	715
CZ16	-255	4656	4401

Table 36: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction— Prescriptive HRV —Mid-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	798	476	1274
CZ02	629	0	629
CZ03 (not proposed)	208	0	208
CZ04	403	0	403
CZ05 (not proposed)	-2	0	-2
CZ06 (not proposed)	-919	0	-919
CZ07 (not proposed)	-1042	0	-1042
CZ08 (not proposed)	-916	0	-916
CZ09 (not proposed)	-573	0	-573
CZ10 (not proposed)	-464	0	-464
CZ11	1164	0	1164
CZ12	651	0	651
CZ13	903	0	903
CZ14	1273	0	1273
CZ15 (not proposed)	597	0	597
CZ16	455	2368	2823

Table 37: 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction— Prescriptive HRV —High-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	782	426	1208
CZ02	933	0	933
CZ03 (not proposed)	375	0	375
CZ04	653	0	653
CZ05 (not proposed)	125	0	125
CZ06 (not proposed)	-325	0	-325
CZ07 (not proposed)	-435	0	-435
CZ08 (not proposed)	-609	0	-609
CZ09 (not proposed)	-273	0	-273
CZ10 (not proposed)	-221	0	-221
CZ11	1318	0	1318
CZ12	963	0	963
CZ13	1096	0	1096
CZ14	1333	0	1333
CZ15 (not proposed)	745	0	745
CZ16	711	2453	3164

6. Cost and Cost Effectiveness

This section describes the methodology and results for estimating LSC Savings from the measure—i.e., the monetized energy savings from the proposed measure, the incremental cost for the proposed measure, and the cost effectiveness of the measure.

6.1 LSC Savings Methodology

LSC Savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 5.1. LSC hourly factors are a normalized metric to calculate LSC Savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with how costs are expected to change over the period of analysis. In this case, the period of analysis used is 30 years. As described in Section 6.4, the Statewide CASE Team assumed the ventilation system would be replaced at year 15.

The CEC requested LSC savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$. Costs and cost effectiveness using 2026 PV$ are presented in Section 6.5 of this report. The CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (From 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars. The measure applies to new construction only, not additions or alterations.

The Statewide CASE Team analyzed LSC Savings for the entire measure package, so assuming:

Base case:

- Climate Zones 1, 2, and 11-16:
  - Mid-rise and high-rise prototypes: 75 percent balanced with HRV and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft2.
  - Low-rise garden style and low-rise loaded corridor prototypes: 42 percent balanced with HRV and without compartmentalization, and 58 percent exhaust-only with compartmentalization to 0.3 cfm50/ft2.
- Climate Zones 3-10:
  - Mid-rise and high-rise prototypes: 75 percent balanced and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft2.
  - Low-rise garden style and low-rise loaded corridor prototypes: 42 percent balanced and without compartmentalization, and 58 percent exhaust-only with compartmentalization to 0.3 cfm50/ft2.

Proposed case:

- Climate Zones 1, 2, 4, 11 through 14, and 16: 100 percent balanced with HRV and with compartmentalization to 0.3 cfm50/ft2.
- Climate Zones 3, 5-10, and 15: 85 percent balanced with compartmentalization to 0.3 cfm50/ft2, and 15 percent supply-only with compartmentalization to 0.3 cfm50/ft2.

The Statewide CASE Team also analyzed LSC Savings for the prescriptive measure only. To isolate the impacts of the prescriptive HRV, the Statewide CASE Team assumed that the proposed mandatory measure would be the base case for the prescriptive HRV measure. The prescriptive HRV cost analysis assumed:

- **Base case:** 85 percent balanced with HRV, and 15 percent supply-only with compartmentalization, both with compartmentalization to 0.3 cfm50/ft^2.
- **Proposed case:** 100 percent balanced with HRV and with compartmentalization to 0.3 cfm50/ft^2.

6.2 LSC Savings Results

Peak demand savings and per-unit LSC Savings for newly constructed buildings in terms of LSC savings realized over the 30-year period of analysis are presented 2026 present value dollars (2026 PV$) in Table 38 through Table 40. Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

6.2.1 Entire Measure Package

Table 38: Average 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction —Ventilation + Compartmentalization—All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	445	49	494
CZ02	416	0	416
CZ03	75	0	75
CZ04	187	0	187
CZ05	124	0	124
CZ06	80	0	80
CZ07	111	0	111
CZ08	232	0	232
CZ09	159	0	159
CZ10	207	0	207
CZ11	603	0	603
CZ12	452	0	452
CZ13	490	0	490
CZ14	622	0	622
CZ15	470	0	470
CZ16	244	672	916

The LSC hourly factors methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. This analysis found little change in peak savings from the proposed measure. The peak savings were slightly positive for most climate zones. The reason why the proposed measure does not generate significant peak savings is because, during the cooling season, compartmentalization decreases cooling energy when the outdoor temperature is warmer than the indoor temperature, but it increases cooling energy when the outdoor temperature is cooler than the indoor temperature. Compartmentalization reduces overall air exchange, so cooler outdoor air infiltrates a dwelling unit at a lower rate. Stated differently, when the outdoor air temperature cools down in the early evening hours of a summer day, compartmentalization results in negative savings because less of the cool air enters the home. To reduce this impact at times during the cooling season when it is cooler outdoors, occupants could open windows. This analysis does not account for window opening, because some occupants may not open windows due to noise, safety considerations, or other reasons.

Table 39: Peak Demand Savings by Climate Zone—New Construction—Ventilation + Compartmentalization—All Prototypes

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 *(Dwelling Units)*	First-Year[a] Peak Electrical Demand Reduction *(W / Dwelling Unit)*
CZ01	144	12.67
CZ02	1391	15.22
CZ03	7699	(0.21)
CZ04	3417	(1.85)
CZ05	285	1.37
CZ06	2243	1.20
CZ07	5156	1.64
CZ08	8600	3.96
CZ09	10302	2.10
CZ10	4306	3.13
CZ11	1173	18.65
CZ12	5537	17.63
CZ13	1009	14.73
CZ14	1446	20.15
CZ15	373	5.39
CZ16	187	7.15

6.2.2 Prescriptive HRV Measure Only

Table 40 shows lifecycle cost analysis for the prescriptive HRV measure for the climate zones where it is proposed.

Table 40: Average 2026 Present Value Systemwide Lifecycle Cost Savings Per Dwelling Unit Over 30-Year Period of Analysis—New Construction —Prescriptive HRV—All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2026 PV $)	30-Year LSC Gas Savings (2026 PV $)	Total 30-Year LSC Savings (2026 PV $)
CZ01	1336	482	1818
CZ02	1093	0	1093
CZ04	819	0	819
CZ11	1431	0	1431
CZ12	1000	0	1000
CZ13	1160	0	1160
CZ14	1558	0	1558
CZ16	214	3244	3458

6.3 Incremental First Cost

The following section describes how the Statewide CASE Team estimated the cost of the proposed measure and the cost savings results. In general, there are two components of the measures: 1) balanced or supply-only ventilation, and 2) compartmentalization to ≤0.3 cfm50/ft^2. The costs of these two components are independent, so as a first step, the Statewide CASE Team estimated the costs independently. However, the existing code requires that multifamily buildings use either 1) balanced ventilation or 2) compartmentalization to ≤0.3 cfm50/ft^2. Consequently, the Statewide CASE Team weighted the results of different scenarios (e.g., balanced ventilation without compartmentalization, and exhaust-only with compartmentalization) in both the base and proposed case to develop cost estimates. The Statewide CASE Team used the same scenario weightings as for the energy methodology, described in Section 5.1. The following subsections provide more detail.

6.3.1 Dwelling Unit Ventilation Cost

For both the baseline and proposed systems, the Statewide CASE Team estimated costs for the ventilation system as described below. The difference between the baseline and proposed system cost is the incremental cost.

The Statewide CASE Team reviewed design drawings from recent new construction multifamily buildings in California. Based on this review, the Statewide CASE Team developed a basis of design for each multifamily building prototype and worked with two mechanical contractors to get cost estimates. The basis of design includes a description of the exhaust-only, supply-only, balanced, and balanced with HRV ventilation strategies. The Statewide CASE Team considered individual dwelling-unit ventilation, a common approach as-described in Section 3.2.1. Central ventilation systems that serve multiple dwelling units may be used to comply with the standard, but the review found that this strategy is less common in multifamily buildings than individual dwelling-unit ventilation systems. From the drawing review, the Statewide CASE Team identified representative designs for each ventilation strategy. The Statewide CASE Team provided examples of these designs, including mechanical floor plans and equipment schedules to the contractors. The Statewide CASE Team requested that the contractors select and locate equipment based on the examples and based on their experience.

The contractors provided material and labor cost estimates for the ventilation system, including the whole dwelling unit ventilation system and local bathroom fans. Kitchen exhaust costs are not included. The contractors disaggregated costs by equipment type and accessories (fans, grilles, controls, access panels, air intake and discharge terminations, ductwork, filters, HRVs), commissioning and startup; and contractor markups (general conditions and overhead; design and engineering; permit, testing, and inspection; and a contractor profit or market factor). The Statewide CASE Team used the average of the costs from the two contractors.

To account for the prescriptive FID requirement, the Statewide CASE Team added the cost of an FID to all cases that included balanced or supply-only ventilation, in both the base case and proposed case. This analysis included the cost of the FID in the base case because almost all multifamily projects use a performance approach,[33] and an FID is required in the ACM. The Statewide CASE Team included a material cost of $172.50 (based on two HVAC suppliers) plus 0.25 hours for labor for purchasing and installing an FID for the applicable systems. This labor estimate aligns with an estimate provided by an FID manufacturer. A HERS Rater would verify the FID in the field, but the time to verify the FID would be minimal, so the Statewide CASE Team did not include an additional cost. These costs are based on FIDs for an HRV. The Statewide CASE Team did not identify an FID for a balanced or supply-only ventilation system without heat recovery. However, one manufacturer estimated that the cost for such a system would be on par with an FID for an HRV, and a second manufacturer estimated that the cost for an FID for a balanced system without heat recovery – where both airflows are integrated in the same assembly system – would be on par with an FID for an HRV. Consequently, the Statewide CASE Team applied the same cost estimate for FIDs for balanced and supply-only ventilation systems without heat recovery.

The Statewide CASE Team did not assume an increase in cost to meet the mandatory requirement for filter accessibility, or the prescriptive requirement for outdoor air intake accessibility. These are achieved through correctly locating equipment and should not result in increased construction costs.

Table 41 shows the cost of the whole dwelling unit ventilation, excluding the cost of the local bathroom fans. The local bathroom fans must be installed regardless of this proposed measure (i.e., is included in the base case), so the local bathroom fans were removed to calculate the incremental cost. The cost of the ventilation system increases with dwelling unit size because the number of bathrooms increases, as does the size of the ductwork and length of the ductwork. The cost for the two-bedroom unit is almost twice as much as the cost for the one-bedroom unit, because the two-bedroom (and three-bedroom) units typically have two bathrooms while the one-bedroom (and studio) units have one bathroom.

[33] CalCERTS data indicates that 99 percent of new construction multifamily units use the performance path, and the remaining 1 percent use the prescriptive path.

Table 41: Ventilation Cost by Dwelling Unit Size - Excluding Local Exhaust

	Studio	One-bedroom	Two-bedroom	Three-bedroom
Exhaust-only	$0	$0	$0	$0
Supply-only	$1,427	$1,518	$1,427	$1,518
Balanced	$1,427	$1,518	$1,427	$1,518
Balanced, with HRV	$1,879	$1,970	$1,784	$1,876

These results also indicate that the incremental first cost between a supply-only and balanced with HRV system is approximately $400. (This does not include maintenance and replacement costs, which Section 6.4 describes.) The Statewide CASE Team used the sum of the first cost and the present value of the maintenance/replacement cost discussed in Section 6.4 as the incremental cost when evaluating the cost effectiveness of the prescriptive HRV measure.

In addition, the Statewide CASE Team gathered qualitative cost data through stakeholder interviews. The interview findings generally support the contractor costs.

- When asked about the cost difference between an exhaust-only strategy compared to a supply-only strategy, multiple interviewees noted the additional components, and therefore, additional expense that would be required of supply-only systems compared to exhaust-only systems, including intake fans, MERV filters, and ductwork.
- Two interviewees commented that supply-only ventilation system would be the same cost as the balanced ventilation system, since the primary cost for the supply system is adding a supply fan, and dwelling units would always have exhaust for local exhaust requirements.
- When asked about the cost difference between an exhaust-only ventilation system compared to a balanced ventilation system, the responses were similar to the comparison between exhaust-only and supply-only.

6.3.2 Compartmentalization Cost

The Statewide CASE Team gathered cost data through stakeholder interviews. When asked how long the air sealing process takes on average per dwelling unit for compartmentalization compared to a building without compartmentalization, stakeholders provided a range of responses, which are described below.

When asked for the average cost, including labor and materials, of compartmentalization to 0.3 cfm50/ft^2 per dwelling unit, one general contractor commented that compartmentalization was $400 per dwelling unit, noting that overall compartmentalization was not a big cost. One mechanical engineer commented that the cost of compartmentalization is $800, including verification. One HERS Rater commented that most air sealing was done to meet fire code requirements for wood-framed buildings, and that metal-framed buildings leak more and require more attention to sealing. The HERS Rater estimated labor hours for each step in the compartmentalization process, providing separate estimates for wood-framed and metal-framed buildings. The Statewide CASE Team assumed a labor rate of $75 based on the average labor rate of a carpenter, a sheet metal worker, and an electrician (Gordian 2023). Based on the estimates from the HERS Rater, the Statewide CASE Team calculated that the average compartmentalization cost was $187 per dwelling unit for wood-framed buildings and $261 per dwelling unit for metal-framed buildings. One architect commented that there is no difference in cost compared to no compartmentalization. The Statewide CASE Team based the 0.3 cfm50/ft^2 cost on the average of the input from the general contractor, mechanical engineer, and HERS Rater.

Based on the interview results, the Statewide CASE Team calculated costs for compartmentalization. For compartmentalizing to 0.3 cfm50/ft^2, the Statewide CASE Team subtracted the average verification cost (see below) from the mechanical engineer interview which included verification, resulting in a sealing cost of $728. The Statewide CASE Team took the average of the three estimates from the three different interviewees, resulting in a sealing cost per dwelling unit of **$450** for wood-framed buildings (Low-rise Garden Style, Low-rise Loaded Corridor, and Mid-rise prototypes) and **$475** for metal-framed buildings (High-rise prototype)**.**

The Statewide CASE Team also estimated the cost to compartmentalize to 0.23 cfm50/ft^2, since this tighter value (from LEED) was originally considered as a proposed requirement. The general contractor and HERS Rater had experience with this level of compartmentalization and provided estimates. Their estimates (when averaged) were a sealing cost per dwelling unit of $894 for wood-framed buildings (Low-rise Garden Style, Low-rise Loaded Corridor, and Mid-rise prototypes) and $950 for metal-framed buildings (High-rise prototype)**.** The Statewide CASE Team did not use these estimates in the analysis, since the proposed compartmentalization value is 0.3 cfm50/sf, instead of 0.23 cfm50/sf. But this significantly higher cost – more than double the cost to reach 0.3 cfm50/sf – was the primary reason why the Statewide CASE Team proposes a limit of 0.3 instead of 0.2 cfm50/ft^2.

The Statewide CASE Team calculated the cost of verification separately. Based on a follow-up interview with one HERS Rater that focused on estimating compartmentalization costs, the Statewide CASE Team assumed that HERS Raters can verify three dwelling units per hour. Based on the sampling requirements in the Reference Appendices, the Statewide CASE Team assumed that one in five units would be selected for verification, for an average labor estimate of 0.07 hours per unit (after sampling). The 2025 Statewide CASE Team assumed that for compartmentalization to 0.3 cfm50/ft^2 there would be 8 hours of meetings per building. The 2025 Statewide CASE Team also assumed there would be one mock-up test per building. The Statewide CASE Team assumed a labor rate of $90 and that each mock-up test is one labor hour, based on an interview with a HERS Rater.

For compartmentalization to 0.23 cfm50/ft^2, the Statewide CASE Team assumed there would be 12 hours of meetings, because the tighter compartmentalization would require additional coordination, and one mock-up compared to 0.3 cfm50/ft^2 assumption. Table 42 summarizes the verification costs by prototype building.

Table 42: Compartmentalization Verification Costs by Prototype Building

Cost Unit	Compartmentalization Parameters	Low-rise Garden Style	Low-Rise Loaded Corridor	Mid-rise	High-Rise
Verification cost per dwelling unit	**Compartmentalization to 0.3 cfm50/ft^2**	$107	$29	$15	$13
	Compartmentalization to 0.23 cfm50/ft^2	$254	$61	$29	$23
Verification cost for whole building	**Compartmentalization to 0.3 cfm50/ft^2**	$858	$1,026	$1,338	$1,512
	Compartmentalization to 0.23 cfm50/ft^2	$2,028	$2,196	$2,508	$2,682

Table 43 summarizes the total compartmentalization costs, including the labor and material cost of sealing and verification, by prototype building.

Table 43: Total Compartmentalization Cost by Prototype Building

Compartmentalization Parameters	Low-rise Garden Style	Low-Rise Loaded Corridor	Mid-rise	High-Rise
Compartmentalization to 0.3 cfm50/ft^2	$4,456	$17,218	$40,918	$57,034
Compartmentalization to 0.23 cfm50/ft^2	$9,183	$34,392	$81,210	$113,872

6.3.3 Combined Costs for Proposed Measure: Supply or Balanced Ventilation and Compartmentalization

The Statewide CASE Team applied the costs described in Sections 6.3.1 and 6.3.2 to the baseline and proposed designs for each prototype building, per the weighting factors described in Section 5.1. As an example of results, Table 44 shows the base case cost, proposed cost, and incremental cost for the low-rise loaded corridor prototype. The presence of an HRV varies by climate zone, based on the 2022 prescriptive requirement for the base case and the proposed 2025 prescriptive requirement for the proposed case. As described in Section 6.3.2, the Statewide CASE Team gathered costs for compartmentalization through stakeholder interviews, where most stakeholders provided round-value costs without much precision, and without differentiating between multifamily building type or dwelling unit size. Because of the lack of precision in the compartmentalization cost estimates, the Statewide CASE Team did not adjust costs between climate zones to account for regional differences between material and labor costs.

Table 44: Baseline and Proposed Measure Costs for Low-Rise Loaded Corridor Building Type

Climate zone	Baseline w/ HRV?	Proposed w/ HRV?	Baseline	Proposed	Incremental
1	Y	Y	$93,169	$139,595	$46,426
2	Y	Y	$93,169	$139,595	$46,426
3	N	N	$87,055	$125,038	$37,983
4	N	Y	$87,055	$139,595	$52,540
5	N	N	$87,055	$125,038	$37,983
6	N	N	$87,055	$125,038	$37,983
7	N	N	$87,055	$125,038	$37,983
8	N	N	$87,055	$125,038	$37,983
9	N	N	$87,055	$125,038	$37,983
10	N	N	$87,055	$125,038	$37,983
11	Y	Y	$93,169	$139,595	$46,426
12	Y	Y	$93,169	$139,595	$46,426
13	Y	Y	$93,169	$139,595	$46,426
14	Y	Y	$93,169	$139,595	$46,426
15	Y	N	$93,169	$125,038	$31,869
16	Y	Y	$93,169	$139,595	$46,426

6.4 Incremental Maintenance and Replacement Costs

Incremental maintenance and replacement costs are the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the 30-year period of analysis. The present value of equipment maintenance costs (or savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 Lifecycle Cost Hourly Factors. The present value of maintenance costs that occurs in the n^th^ year is calculated as follows:

$$Present\ Value\ of\ Maintenance\ Cost = Maintenance\ Cost \times \left\lfloor \frac{1}{1+d} \right\rfloor^{n}$$

For the ventilation strategy, the Statewide CASE Team assumed that the expected useful life of the ventilation system equipment is 15 years, and that after this time, the building owner replaces any fans, controls, FIDs, and HRV equipment, and recommissions the system. The Statewide CASE Team assumed that the supporting infrastructure such as ductwork would not need to be replaced. Table 45 summarizes the 15-year replacement costs, including labor and materials, by dwelling unit size.

Table 45: Ventilation System 15-year Replacement Cost – Excluding Local Exhaust

	Studio	One-bedroom	Two-bedroom	Three-bedroom
Exhaust-only	$0	$0	$0	$0
Supply-only	$684	$684	$684	$684
Balanced	$684	$684	$684	$684
Balanced, with HRV	$1,169	$1,169	$1,109	$1,109

In addition, for the ventilation strategy, the Statewide CASE Team assumes that the building owner replaces the MERV 13 filters in the supply-only system two times each year. Manufacturers recommend filter replacements two to twelve times per year. The Statewide CASE Team assumed the lower value (twice per year) because it seemed less realistic that building owners would replace them more often. Each filter replacement is $38, based on an HVAC supplier. The Statewide CASE Team assumes that the building owner uses MERV 13 filters that can be vacuumed in the HRV systems and replaces them once every five years, based on an HVAC supplier. Each HRV filter replacement is $43, based on an HVAC supplier.

For compartmentalization, the Statewide CASE Team assumes that no re-sealing would occur throughout the analysis period.

6.5 Cost Effectiveness

The CEC establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with CEC staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The LSC savings from electricity and natural gas were also included in the evaluation. Design costs were not included nor were the incremental costs of code compliance verification.

According to the CEC's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 30 years by the total incremental costs, which includes maintenance costs for 30 years. The B/C ratio was calculated using 2026 Present Value (PV) costs and cost savings.

6.5.1 Entire Measure Package

Because the Statewide CASE Team proposes the mandatory measure to ensure adequate IAQ, and not for energy savings, cost effectiveness is not required for the measure package.

6.5.2 Prescriptive HRV Measure Only

The following tables show cost effectiveness for the prescriptive HRV measure only. This analysis assumes that the mandatory measure would be adopted and uses cases that comply with the mandatory measure as the base case:

- **Base case:** 85 percent balanced ventilation (no HRV), and 15 percent supply-only
- **Proposed case:** Balanced with HRV

For both the base and proposed case, this analysis assumed compartmentalization to 0.3 cfm50/ft^2. This is so the Statewide CASE Team does not double-count the savings from compartmentalization, and to isolate just the impact of the HRV.

The incremental cost assumption is $400 for a supply-only or balanced (no HRV) ventilation system to a balanced with HRV ventilation system. This includes an incremental first cost for purchasing an HRV instead of a supply fan and an incremental replacement cost in 15 years for replacing the HRV (compared to replacement of a supply fan). As shown, based on initial cost-effectiveness analysis, the proposed prescriptive measure for an HRV is cost effective in all climate zones proposed (Climate Zones 1, 2, 4, 11 through 14, and 16). The proposed measure is not cost effective (B/C ratio < 1) in Climate Zones 3, 5 through 10, and 15.

Because these tables show results per dwelling unit, they are not impacted by different construction forecasts by climate zone. Section 7 provides statewide impacts, which does account for the different construction forecasts by climate zone.

Table 46: 30-Year Cost Effectiveness Summary Per Dwelling unit for Prescriptive HRV- New Construction, by Climate Zone

Climate Zone	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/dwelling unit)	Costs: Total Incremental PV Costs (2026 PV$/dwelling unit)	Benefit-to-Cost Ratio
CZ01	1818	679	2.7
CZ02	1093	679	1.6
CZ04	819	679	1.2
CZ11	1431	679	2.1
CZ12	1000	679	1.5
CZ13	1160	679	1.7
CZ14	1558	679	2.3
CZ16	3458	679	5.1

Table 47: 30-Year Cost Effectiveness Summary Per Dwelling Unit for Prescriptive HRV—New Construction, by Prototype

Building Prototype	Benefits: LSC Savings + Other PV Cost Savings (2026 PV$/dwelling unit)	Costs: Total Incremental PV Costs (2026 PV$/dwelling unit)	Benefit-to-Cost Ratio
LowRiseGarden	2160	676	3.2
LoadedCorridor	1636	676	2.4
MidRiseMixedUse	747	680	1.1
HighRiseMixedUse	993	687	1.4
Total	1109	679	1.6

Figure 13 shows results by climate zone. Dark green bars show the proposed climate zones, and light green bars show climates zones that are not proposed for the prescriptive HRV measure. All proposed climate zones are cost effective. Climate Zone 15 is close, but not quite cost effective, with a benefit-to-cost ratio of 0.9.

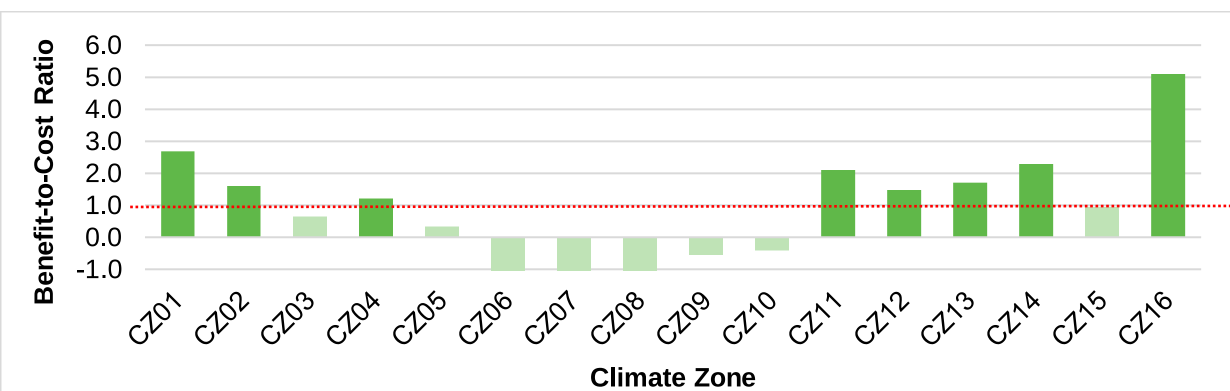

Figure 13. Benefit-to-cost Ratio of Prescriptive HRV Proposal by Climate Zone.

7. First-Year Statewide Impacts

This section provides first-year statewide impacts for energy, GHG emissions, materials use, and non-energy impacts including IAQ improvements. This section only includes results for the entire measure package, which includes impacts of both the mandatory and prescriptive requirements. These impacts follow the assumptions for the entire measure package used for energy and cost calculations described in Section 5.1.

Base case (under current code):

- Low-rise garden-style and low-rise loaded corridor prototypes:
  - Climate Zones 1, 2, and 11-16: 42 percent balanced with HRV and without compartmentalization, and 58 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
  - Climate Zones 3-10: 42 percent balanced and without compartmentalization, and 58 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
- Mid-rise and high-rise prototypes:
  - Climate Zones 1, 2, and 11-16: 75 percent balanced with HRV and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.
  - Climate Zones 3-10: 75 percent balanced and without compartmentalization, and 25 percent exhaust-only with compartmentalization to 0.3 cfm50/ft^2.

Proposed case:

- Climate Zones 1, 2, 4, 11 through 14, and 16: 100 percent balanced with HRV and with compartmentalization to 0.3 cfm50/ft^2.
- Climate Zones 3, 5 through 10, and 15: 85 percent balanced with compartmentalization to 0.3 cfm50/ft2, and 15 percent supply-only with compartmentalization to 0.3 cfm50/ ft^2.

These assumptions are based on market data described in Section 4.1.

7.1 Statewide Energy and LSC Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction by multiplying the per-unit savings, which are presented in Section 5.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. The statewide new construction forecast for 2026 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type). All (100 percent) of new construction multifamily buildings would be impacted by this measure.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2026. The 30-year LSC Savings represent the LSC Savings over the entire 30-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

The tables below present the first-year statewide energy and LSC Savings from newly constructed buildings by climate zone. Table 48 presents first-year statewide savings from new construction. Like previous results at the dwelling unit level, statewide results show that savings vary by climate zones. This is both because the number of forecasted dwelling units varies by climate zone, and because non-mild climate zones have more LSC Savings.

While a statewide analysis is crucial to understanding broader effects of code change proposals, there is potential to disproportionately impact DIPs that needs to be considered. Refer to Section 2 for more details addressing energy equity and environmental justice.

Table 48: Statewide Energy and LSC Impacts—New Construction

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2026 (dwelling units)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Value LSC Savings (Million 2026 PV$)
CZ01	144	0.01	0.00	0.00	0.03	$0.07
CZ02	1,391	0.07	0.02	-	0.23	$0.58
CZ03	7,699	0.09	(0.00)	-	0.08	$0.58
CZ04	3,417	0.11	(0.01)	-	(0.00)	$0.64
CZ05	285	0.01	0.00	-	0.01	$0.04
CZ06	2,243	0.03	0.00	-	0.05	$0.18
CZ07	5,156	0.08	0.01	-	0.14	$0.57
CZ08	8,600	0.29	0.03	-	0.53	$1.99
CZ09	10,302	0.25	0.02	0.00	0.37	$1.63
CZ10	4,306	0.14	0.01	0.00	0.21	$0.89
CZ11	1,173	0.09	0.02	-	0.24	$0.71
CZ12	5,537	0.32	0.10	-	0.97	$2.50
CZ13	1,009	0.06	0.01	-	0.16	$0.49
CZ14	1,446	0.12	0.03	-	0.31	$0.90
CZ15	373	0.03	0.00	-	0.03	$0.18
CZ16	187	0.01	0.00	0.00	0.11	$0.17
Total	53,268	1.70	0.26	0.00	3.45	$12.12

a. First-year savings from all buildings completed statewide in 2026.

Table 49 provides statewide energy savings, by aggregating results across the forecasted number of dwelling units by building type (low-rise garden style, low-rise loaded corridor, mid-rise, and high-rise) and the estimated energy savings by building type.

Table 49: Statewide Energy and LSC Impacts—New Construction

First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	First-Year Source Energy Savings (million therms)	30-Year Present Valued LSC Savings (PV$ million)
1.7	0.3	0.0	3.4	12

a. First-year savings from all alterations completed statewide in 2026.

7.2 Statewide GHG Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions associated with energy consumption using the hourly GHG emissions factors that the CEC developed along with the 2025 LSC hourly factors and an assumed cost of $123.15 per metric ton of carbon dioxide equivalent emissions (metric tons CO2e).

The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs).[34] The cost-effectiveness analysis presented in Section 6 of this report does not include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the other economic impacts.

Table 50 presents the estimated first-year avoided GHG emissions of the proposed code change.

Table 50: First-Year Statewide GHG Emissions Impacts

Avoided GHG Emissions	Monetary Value of Avoided GHG Emissions
185 MTCO2e/year	22,755 $/year

a. First-year savings from all applicable newly constructed buildings completed statewide in 2026.
b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the LSC hourly factors published by the CEC here: https://www.energy.ca.gov/files/2025-energy-code-hourly-factors
c. The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs) derived from the 2022 TDV Update Model published by the CEC here: https://www.energy.ca.gov/files/tdv-2022-update-model

[34] The permit cost of carbon is equivalent to the market value of a unit of GHG emissions in the California Cap-and-Trade program, while social cost of carbon is an estimate of the total economic value of damage done per unit of GHG emissions. Social costs tend to be greater than permit costs. See more on the Cap-and-Trade Program on the California Air Resources Board website: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

7.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

7.4 Statewide Material Impacts

The proposed measure to require both balanced or supply-only ventilation and compartmentalization would have an impact on the material use. There would be an increase in use of ERV, HRV, and supply fans as well as air sealing materials. Since ventilation has previously been required for multifamily dwelling units, only the equipment would be impacted with no significant changes to the duct design. Compartmentalization has not been previously required for all multifamily dwelling units.

ERV, HRV, and supply fans are not typically composed of heavy metals or other toxic materials, but they are primarily composed of steel and (for the ERV or HRV core) plastic. Air sealing materials include various types of sealants for the exterior and dwelling unit shells. Gaps and voids of the exterior walls and windows are sealed with sealant primarily composed of polyurethane foam, which provides a barrier to air and moisture. The gaps of the interior demising walls to the exterior and corridor are sealed with an acoustic sealant to reduce sound transmissions. Most acoustic sealants are latex-based composed of acrylic polymer; this makes them more flexible, preventing cracks and shrinkage. The interior drywall seams also are sealed with drywall tape. Most drywall installation uses paper or mesh tapes. Mesh tape is composed of fiberglass, which is mold resistant.

In order to estimate the First-Year Statewide Material Impacts, the Statewide CASE Team used manufacturer data for the equipment and materials involved for the base and proposed cases and used the same building prototype weighting scale based on climate zone as in the energy savings. Aligning with the energy savings and cost assumptions, the Statewide CASE Team assumed that:

For the base case:

- In Climate Zones 1, 2, and 11-16, where an HRV or ERV is prescriptively required if a project uses balanced ventilation:
    - Mid-Rise and High-Rise
        - 75 percent of dwelling units are using balanced ventilation with an HRV, without compartmentalization.
        - 25 percent of dwelling units are using exhaust-only ventilation and compartmentalization.
    - Low-Rise
        - 42 percent of dwelling units are using balanced ventilation with an HRV, without compartmentalization.

        - 58 percent of dwelling units are using exhaust-only ventilation and compartmentalization.
- In Climate Zones 3-10, where an HRV or HERV is not prescriptively required:
    - Mid-Rise and High-Rise
        - 75 percent of dwelling units are using balanced ventilation (no HRV), without compartmentalization.
        - 25 percent of dwelling units are using exhaust-only ventilation and compartmentalization.
    - Low-Rise
        - 42 percent of dwelling units are using balanced ventilation (no HRV) without compartmentalization.
        - 58 percent of dwelling units are using exhaust-only ventilation and compartmentalization.

For the proposed case:

- In Climate Zones 1, 2, 4, 11 through 14, and 16, where an HRV or ERV would be prescriptively required:
    - 100 percent of dwelling units would use balanced ventilation with an HRV, and with compartmentalization.
- In Climate Zones 3, 5 through 10, and 15, where an HRV or ERV would not be prescriptively required:
    - 85 percent would use balanced ventilation (no HRV), and with compartmentalization.
    - 15 percent of dwelling units would use supply-only ventilation and compartmentalization.

Table 51 shows the assumed mix of scenarios for the base and proposed cases.

Table 51: Assumed Compliance Scenarios for Materials Impacts

Case	Type of Ventilation and Compartmentalization	% of multifamily dwelling units
Base Case	Exhaust Only with Compartmentalization	30.9%
	Balanced Ventilation, no HRV, without Compartmentalization	54.5%
	Balanced Ventilation, with HRV, without Compartmentalization	14.6%
Proposed Case	Supply Only with Compartmentalization	11.8%
	Balanced Ventilation, no HRV, with Compartmentalization	67.0%
	Balanced Ventilation, with HRV, with Compartmentalization	21.1%

The assumed scenarios include the following materials estimates:

- **An exhaust-only ventilation system:** This analysis assumed an exhaust fan weight of zero, since all dwelling units must have exhaust fans (bathroom and kitchen) to meet local exhaust requirements.
- **A supply-only ventilation system, or the supply side of a balanced ventilation system:** The supply-only ventilation system would require a supply fan, which this analysis assumed to be 11 lbs, based on a product spec sheet. For the reasons described for the exhaust only system, the exhaust fan in the balanced system is assumed to be zero.
- **An HRV or ERV:** This analysis assumed it would weigh 56 lbs, based on the weight of a Panasonic Intellibalance-100 ERV product. Based on product spec sheets, the ERV has a polypropylene core and polystyrene insulation that weighs 17 lbs, while the remainder of the weight is steel at 39 lbs.
- **Compartmentalization:** This generally requires sealants and drywall tape. The Statewide CASE Team assumed a total of 7 lbs per dwelling unit, as detailed here. Based on the product spec sheet, a 20oz tube of exterior sealant can seal about eight 3'x5' windows. With the assumption that there are three windows in each multifamily residence, the Statewide CASE Team estimated that 0.47 lbs of exterior sealant would be used per residence. Acoustic sealant would be used to seal along the corners of the interior walls, as well as around the front door. According to the product sheet, a 28oz tube of acoustic sealant seals a ¼" gap per 85 linear feet. The Statewide CASE Team estimated that 6.03 lbs of acoustic sealant is needed for soundproofing a residence that is 30'x30' with a 9' ceiling and a typical 36"x80" front door with a 2" frame. The team also estimated that 0.52 lbs of a 1.875"x500' roll of mesh tape is needed to tape the seams of the drywalls.
- **Fault Indicator Displays (FID):** This analysis assumed an FID to consist of 5 lbs of metal and 1 lb of plastic based on product specifications.

For more information on the Statewide CASE Team's methodology and assumptions used to calculated embodied GHG emissions, see Appendix D.

Table 52: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per dwelling unit)	First-Year [b] Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Steel	Increased	8.7	461,476	(254)
Plastic	Increased	1.3	70,099	(59)
Polyurethane Foam	Increased	0.3	15,680	(17)
Acrylic Polymer	Increased	3.8	201,648	(169)
Fiberglass	Increased	0.4	19,135	(21)
TOTAL	-	-	768,038	(521)
Estimated GHG reductions per year from energy savings	-	-	-	185

a. First-year savings from all buildings completed statewide in 2026.

While this analysis did find an increase in GHG emissions due to a materials increase, of 521 MTCO2e, the GHG emissions reductions through reduced energy use in just one year is 185 MTCO2e/year, as shown in Section 7.2. Hence, over its lifetime, the measure would save far more GHG emissions than used for the materials impact.

7.5 Other Non-Energy Impacts

The primary purpose of the proposed measure is to protect IAQ. Section 3.2 details the IAQ impacts, and the health impacts associated with pollutants that should be reduced by this measure, including reductions in pollutants that have been shown to exacerbate asthma. As detailed Section 3.2, other non-energy benefits of the proposal include noise reduction from the exterior and from neighboring units, and reduction in pest transfer between units.

8. Proposed Revisions to Code Language

8.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2022 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

8.2 Standards

SECTION 100.1—DEFINITIONS AND RULES OF CONSTRUCTION

Section 100.1(b)—Definitions: Recommends new or revised definitions for the following terms:

VENTILATION SYSTEM, BALANCED is at least one mechanical device intended to remove air from buildings, and simultaneously replace it with outdoor air.

VENTILATION SYSTEM, EXHAUST is at least one mechanical device intended to remove air from buildings, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope.

VENTILATION SYSTEM, SUPPLY is at least one mechanical device intended to bring outdoor air into buildings, causing indoor air to flow out of the building through ventilation relief outlets or normal leakage paths through the building envelope.

….

150.0(o)1C Whole**-dwelling unit mechanical ventilation for single-family detached and townhouses.**

iv. Requirements for balanced and supply only ventilation systems

a. IAQ Filter and HRV/ERV Accessibility. System air filters and HRV/ERV heat / energy recovery cores shall be located such that they are accessible for regular service from within occupiable space, basements, garages, balconies, or accessible rooftops. Filters and heat / energy recovery cores behind access panels, access doors, or grilles located no more than 10 ft above a walking surface comply with this requirement.

Exception: IAQ filters and heat or energy recovery cores for ventilation systems located in an accessible attic and having an FID meeting the requirements of Reference Appendix JA15.

b. IAQ System Component Accessibility. Fans, motors, heat exchangers, and other serviceable components shall meet all applicable requirements of California Mechanical Code Section 304.0 Accessibility for Service.

c. Outdoor Air Intake Design. Outdoor air intakes shall comply with California Mechanical Code Section 402.4.1.

d. Outdoor Air Intake Location and Accessibility. To provide access for cleaning, outdoor air intakes shall be accessible. Air intakes located not more than 10 feet above a walking surface comply with this requirement. If located on roofs, they shall meet the requirements of California Mechanical Code Section 304.3.1.

Exception: Outdoor air intakes serving equipment with an FID meeting the requirements of Reference Appendix JA15.

150.1(c) Prescriptive **standards/component packages.**

15. **Ventilation system Fault Indicator Display (FID).** All balanced and supply ventilation systems serving individual dwelling units shall have a Fault Indicator Display (FID) that meets the requirements of Reference Appendix JA15, as confirmed by HERS field verification.

Table 150.1-A COMPONENT PACKAGE – Single-Family Standard Building Design

				Climate Zone															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HVAC System	Space Heating[9]		Electric-Resistance Allowed	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
HVAC System	Space Heating[9]		If gas, AFUE	MIN	MIN	NA	NA	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	NA	NA	MIN	MIN
HVAC System	Space Heating[9]		If Heat Pump, HSPF[7] /HSPF2	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
HVAC System	Space Cooling		SEER/SEER2	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
HVAC System	Space Cooling		Refrigerant Charge Verification or Fault Indicator Display	NR	REQ	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
HVAC System	Space Cooling		Whole house fan[8]	NR	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR	NR
HVAC System	Central System Air Handlers		Central Fan Integrated Ventilation System Fan Efficacy	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
HVAC System	Ducts[10]	Roof/Ceiling Options B	Duct Insulation	R-8	R-8	R- 6	R-8	R- 6	R- 6	R- 6	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
HVAC System	Ducts[10]	Roof/Ceiling Options B	§150.1(c)9A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HVAC System	Ducts[10]	Roof/Ceiling Option C	Duct Insulation	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R- 6	R-6	R-6	R- 6	R- 6	R- 6
HVAC System	Ducts[10]	Roof/Ceiling Option C	§150.1(c)9B	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
HVAC System	**Ventilation Systems**			System Shall meet Section 150.1(c)15															
Water Heating	**All Buildings**			System Shall meet Section 150.1(c)8															

Section 160.2(b)2A

iv. Whole-Dwelling Unit Mechanical Ventilation. Multifamily attached dwelling units shall comply with subsections a and b below.

a. Mechanical ventilation airflow shall be provided at rates greater than or equal to the value determined in accordance with Equation 160.2-B.

   Total Required Ventilation Rate [ASHRAE 62.2:4.1.1].

   $Qtot = 0.03Afloor + 7.5(Nbr + 1)$ (Equation 160.2-B)

   WHERE:

   Qtot = total required ventilation rate, cfm

   Afloor = dwelling-unit floor area, ft^2

   Nbr = number of bedrooms, (not to be less than 1)

b. All dwelling units in a multifamily building shall use the same whole-dwelling unit ventilation system type. ~~The system type installed throughout the building shall be only one of the following three types: supply, exhaust, or balanced~~. The dwelling unit shall comply with ~~one of the following~~ subsections 1 and~~or~~ 2 below.

   1. Balanced or supply ventilation. A balanced or supply ventilation system shall provide the required whole-dwelling unit ventilation airflow. Balanced ~~S~~systems with heat recovery or energy recovery that serve a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm. ~~or~~

   2. ~~Supply or Exhaust Ventilation with C~~Ccompartmentalization T~~t~~esting. ~~Continuously operating supply ventilation systems, or continuously operating exhaust ventilation systems shall be allowed to be used to provide the required whole-dwelling unit ventilation airflow only if t~~The dwelling unit envelope leakage shall be ~~is~~ less than or equal to 0.3 cubic feet per minute at 50 Pa (0.2 inch water) per ft^2 of dwelling unit envelope surface area as confirmed by HERS field verification and diagnostic testing in accordance with the procedures specified in Reference Appendix RA3.8 or NA2.3 as applicable.

…

xi. Balanced and supply ventilation component accessibility. Balanced and supply ventilation systems shall meet the following requirements for accessibility:

a. IAQ Filter and HRV/ERV Accessibility. All system air filters and HRV/ERV heat / energy recovery cores shall be located such that they are accessible for regular service from within occupiable space, basements, garages, balconies, or accessible rooftops. Filters and heat / energy recovery cores behind access panels, access doors, or grilles located no more than 10 ft above a walking surface comply with this requirement.

Exception: IAQ filters and heat or energy recovery cores for ventilation systems located in an accessible attic and having an FID meeting the requirements of Reference Appendix JA15.

b. IAQ System Component Accessibility. Fans, motors, heat exchangers, and other serviceable components shall meet all applicable requirements of California Mechanical Code Section 304.0 Accessibility for Service.

…

Section 170.2(c)3B

iii. Dwelling Unit Ventilation System Requirements. All balanced and supply ventilation systems serving individual dwelling units shall have a Fault Indicator Display (FID) that meets the requirements of Reference Appendix Section JA15, as confirmed by HERS field verification.

~~iii.~~ iv. Central fan integrated ventilation systems—systems serving individual dwelling units. Central forced air system fans used to provide outside air shall have an air-handling unit fan efficacy less than or equal to the maximum W/cfm specified in a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed through field verification and diagnostic testing in accordance with all applicable procedures specified in Reference Residential Appendix RA3.3. Central Fan Integrated Ventilation Systems shall be certified to the Energy Commission as Intermittent Ventilation Systems as specified in Reference Residential Appendix RA3.7.4.2.

a. 0.45 W/cfm for gas furnace air-handling units; or
b. 0.58 W/cfm for air-handling units that are not gas furnaces:

~~iv.~~ v. Balanced Ventilation Systems with Heat Recovery in Climate Zones 1, 2, 4, 11-14, and ~~11-~~16. ~~When~~A balanced ventilation system~~s~~ with heat or energy recovery shall be ~~are~~ used to meet Section 160.2(2)Aivb1, ~~they~~ and shall meet the applicable requirements of a~~,~~ or b~~, or c~~ below.

a. In Climate Zones 1, 2, 4, 11-14, and ~~11-~~16, balanced ventilation systems serving individual dwelling units shall:
   1. Be an energy recovery ventilator (ERV) or heat recovery ventilator (HRV)
   2. Have a minimum sensible recovery efficiency of 67 percent, rated at 32°F (0°C), and
   3. Have a fan efficacy less than or equal to 0.6 W/~~per~~ cfm
b. In Climate Zones 1, 2, 4, 11-14~~6~~, and 16 balanced ventilation systems serving multiple dwelling units in buildings with four or more habitable stories shall:

4. Be an ERV or HRV,
5. Have a minimum sensible recovery efficiency or effectiveness of 67 percent, rated at 32°F (0° C),
6. Meet the fan power requirements of Section 170.2(c)4A, and
7. Have recovery bypass or control to directly economize with ventilation air based on outdoor air temperature limits specified in Table 170.2-G.

These measures shall be field verified in accordance with NA7.18.4.

~~c.~~ vi. In buildings with three habitable stories or less in Climate Zones ~~4~~ 5-10 and 15, when a heat pump space conditioning system is installed to meet the requirements of Section 170.2(c)3Ai, balanced ventilation systems without an ERV or HRV shall have a fan efficacy less than or equal to 0.4 W/cfm.

…

Section 180.1(a)2. for Additions. [*The following revisions are needed for clarifications and so that the proposed change to the new construction sections affect additions as follows. The proposed changes to FID requirement and balanced and supply ventilation component accessibility are only applicable to additions of more than 1,000 square feet AND which choose to install balanced or supply only ventilation systems. Note that exhaust only systems are permissible in additions for which the FID and component accessibility requirements are not applicable. Dwelling unit air leakage test is not required for additions*]

2. Mechanical ventilation for indoor air quality. Additions to existing buildings shall comply with Section 160.2 subject to the requirements specified in Subsections A and B below. When HERS field verification and diagnostic testing are required by Section 180.1(a)2, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

Exception to Section 180.1(a)2.: A dwelling unit air leakage test is not required for additions.

A. Whole-dwelling unit mechanical ventilation.
   i. Dwelling units that meet the conditions in Subsection a or b below shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.
      a. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by less than or equal to 1000 square feet.

b. Junior Accessory Dwelling Units (JADU) that are additions to an existing building.

ii. Additions to an existing dwelling unit that increase conditioned floor area by more than 1,000 square feet shall have mechanical ventilation airflow in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av, as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the entire dwelling unit comprising the existing dwelling unit conditioned floor area plus the addition conditioned floor area.

Exception to Section 180.1(a)2.A.ii.: Mechanical ventilation systems in additions shall be exhaust, supply, or balanced ventilation systems.

….

Section 180.2(b)5 for Alterations [*The following revisions are needed for clarification and so that the proposed change to the new construction sections affect alterations as follows. The proposed changes to FID requirement and balanced and supply ventilation component accessibility are only applicable for alterations with entirely new or complete replacement of balanced or supply only ventilation systems. Note that exhaust only systems are permissible in new, replacement or altered ventilation system in alterations for which the FID and component accessibility requirements are not applicable. Dwelling unit air leakage test is not required for alterations.*]

5. **Mechanical ventilation and indoor air quality for dwelling units.** Alterations to existing buildings shall comply with subsections A and B below as applicable. When HERS field verification and diagnostic testing is required by Section 180.2(b)5, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   Exception to Section 180.2(b)5.: A dwelling unit air leakage test is not required for alterations.

   A. **Entirely new or complete replacement ventilation systems**. Entirely new or complete replacement ventilation systems shall comply with all applicable requirements in Section 160.2(b)2. An entirely new or complete replacement ventilation system includes a new ventilation fan component and an entirely new duct system. An entirely new or complete replacement duct system is constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air filtration devices and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Exception to Section 180.2(b)5.A.: New or replacement ventilation systems in existing dwelling units shall be an exhaust, supply, or balanced ventilation system.

B. **Altered ventilation systems**. Altered ventilation system components or newly installed ventilation equipment serving the alteration shall comply with Section 160.2(b)2 as applicable subject to the requirements specified in Subsections i and ii below.

i. **Whole-dwelling unit mechanical ventilation**

a. Whole-dwelling unit strategy. The altered ventilation system shall be an exhaust, supply, or balanced ventilation system.

~~a.~~ b. **Whole-dwelling unit airflow**. If the whole-dwelling ventilation fan is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance as applicable.

1. Dwellings that were required by a previous building permit to comply with the whole dwelling unit airflow requirements in Section 160.2(b)2, 120.1(b) or 150.0(o) shall meet or exceed the whole-dwelling unit mechanical ventilation airflow specified in Section 160.2(b)2Aiva or 160.2(b)2Av as confirmed through HERS field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Appendix RA3.7 or NA2.2.

2. Dwellings that were not required by a previous building permit to have a whole-dwelling unit ventilation system to comply with Section 160.2(b)2, 120.1(b) or 150.0(o) shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

~~b.~~ c. **Replacement ventilation fans**. [*No changes except to numbering*]

~~c.~~ d. **Air filters**. [*No changes except to numbering*]

…

Section 180.2(c) Performance approach. [*No changes needed. As shown below, the performance approach refers users to the prescriptive alterations requirements for ventilation.]*

C. Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2, and 3 below.

i. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.

8.3 Reference Appendices

The proposed change would add Joint Appendix JA15, as shown below.

Joint Appendix JA15

Appendix JA15 – Qualification Requirements for IAQ System Fault Indicator Displays

JA15.1 Introduction

Joint Appendix JA15 (JA15) provides the technical specifications for fault indication devices (FIDs) that provide visual and/or audible indications that balanced and supply only ventilation systems maintain their rated airflow and fan efficacy for the life of the equipment.

JA15.2 Fault Indication Categories

Fault indication devices shall respond to the following categories:

(a) Filter check or maintenance, either based on performance or a predetermined schedule.

(b) Low supply airflow.

(c) Low exhaust airflow (balanced systems only)

(d) Sensor failure for sensors that assist in monitoring or controlling for the following operations, where such operations are provided: airflow regulation, frost control, supply air tempering, and economizing.

JA15.3 Fault Indication Means

Fault indication shall use one or more of the following means:

(a) A visual display that is readily accessible to occupants of the dwelling unit.

(b) An electronic application.

(c) An audible alarm accompanied by a visual display.

JA15.4 Instrumentation and Reporting

Instrumentation shall measure and report the following:

(a) Airflow.

(b) Fan power.

JA 15.5 Manufacturer Certification

To qualify, manufactures must certify to the CEC that FID systems meet the requirements of JA15.2 – JA15.6.

A listing of certified products is provided at the following location:

https://www.energy.ca.gov/media/7020

Residential Appendix

RA3.8.3 Enclosure Leakage Measurement Procedures

The enclosure leakage measurement procedure shall conform to the following specifications:

(a) The procedure for preparation of the building or dwelling unit for testing shall conform to the applicable requirements in RESNET 380 Section 4.2.

(b) The procedure for installation of the test apparatus, and preparations for measurement shall conform to the applicable requirements in RESNET 380 Section 4.3.

If compliance requires the results of the test to be reported in cubic feet per minute per ft2 of dwelling unit enclosure surface area at 50 Pa (0.2 inch water) (CFM50/ft2 of enclosure), the dwelling unit enclosure interior surface area in ft2 (compartmentalization boundary area) shall be recorded. Note: the compartmentalization boundary area is the sum of the interior surface areas of the dwelling unit enclosure walls between dwelling units, exterior walls, ceiling, and floor.

(c) The procedure for the conduct of the enclosure leakage test shall conform to the One-Point Airtightness Test specified in RESNET 380 Section 4.4.1 or the Multi-Point Airtightness Test specified in RESNET 380 Section 4.4.2.

RA3.8.4 Determination of Test Results

The results of the test shall be determined as follows:

(a) The leakage airflow in CFM50 if determined by the One-Point Airtightness Test specified in RESNET 380 Section 4.4.1 shall be adjusted using RESNET 380 Section 4.5.1, equation (5a).

(b) If compliance requires the results of the test to be reported in air changes per hour at 50 Pa (0.2 inch water) (ACH50), the leakage results determined by RESNET 380 Section 4.5.1, equation (5a) shall be converted to ACH50 using RESNET 380 Section 4.5.2, equation (7a).

(c) If compliance requires the results of the test to be reported in CFM50/ft2 of enclosed the leakage results determined by RESNET 380 Section 4.5.1, equation (5a) shall be converted to CFM50/ft2 of enclosure using RESNET 380 Section 4.5.2, equation 10.

Nonresidential Appendix

NA1.9.1 Field Verification by the Acceptance Test Technician

Under this alternative procedure, when the Certificate of Compliance indicates that HERS field verification and diagnostic testing is required as a condition for compliance with Title 24, Part 6, a certified ATT may perform the verification to satisfy the condition of compliance, at the discretion of the enforcement agency. Systems verified under this procedure are not eligible for use of the sampling procedures described in NA1.6, with the exception of NA2.3, Field Verification and Diagnostic Testing of Multifamily Dwelling Unit Enclosures, for which ATTs may use sampling.

NA2.3.3 Enclosure Leakage Measurement Procedures

The enclosure leakage measurement procedure shall conform to the following specifications:

1) The procedure for preparation of the building or dwelling unit for testing shall conform to the applicable requirements in RESNET 380 Section 4.2.

2) The procedure for installation of the test apparatus, and preparations for measurement shall conform to the applicable requirements in RESNET 380 Section 4.3.

If compliance requires the results of the test to be reported in cubic feet per minute per ft2 of dwelling unit enclosure surface area at 50 Pa (0.2 inch water) (CFM50/ft2 of enclosure), the dwelling unit enclosure interior surface area in ft2 (compartmentalization boundary area) shall be recorded.

Note: the compartmentalization boundary area is the sum of the interior surface areas of the dwelling unit enclosure walls between dwelling units, exterior walls, ceiling, and floor.

3) The procedure for the conduct of the enclosure leakage test shall conform to the One-Point Airtightness Test specified in RESNET 380 Section 4.4.1 or the Multi-Point Airtightness Test specified in RESNET 380 Section 4.4.2.

NA2.3.4 Determination of Test Results

The results of the test shall be determined as follows:

1) The leakage airflow in CFM50 if determined by the One-Point Airtightness Test specified in RESNET 380 Section 4.4.1 shall be adjusted using RESNET 380 Section 4.5.1, equation (5a).

2) If compliance requires the results of the test to be reported in air changes per hour at 50 Pa (0.2 inch water) (ACH50), the leakage results determined by RESNET 380 Section 4.5.1, equation (5a) shall be converted to ACH50 using RESNET 380 Section 4.5.2, equation (7a).

3) If compliance requires the results of the test to be reported in CFM50/ft2 of enclosure, the leakage results determined by RESNET 380 Section 4.5.1, equation (5a) shall be converted to CFM50/ft2 of enclosure using RESNET 380 Section 4.5.2, equation 10.

8.4 ACM Reference Manual

Single-family ACM Reference Manual

2.4.10 Indoor Air Quality Ventilation

Proposed Design

…

Systems with supply ducts (balanced and supply-only) are simulated with increased fan wattage and reduced SRE and ASRE to account for maintenance and installation factors affecting system efficacy. For these systems, fan wattage is increased by a factor of 1.10 (10 percent increase in wattage) and SRE and ASRE are reduced by a factor of 0.90 (10 percent decrease in recovery efficiencies). For IAQ systems with fault indicator displays (FID) meeting the below specifications provided in Joint Appendix JA15, Qualification Requirements for IAQ System Fault Indicator Displays, these factors don't apply.

IAQ System Fault Indicator Display Requirements

Installation factors affecting system efficacy do not apply if the following specifications are met.

1. Fault indication responding to the following categories:
   a. Filter check or maintenance, either based on performance or a predetermined schedule.
   b. Low supply airflow.
   c. Low exhaust airflow.
   d. Sensor failure for sensors that assist in monitoring or controlling for the following operations, where such operations are provided: airflow regulation, frost control, supply air tempering, and economizing.
2. Fault indication using one or more of the following means:
   a. A visual display that is readily accessible to occupants of the dwelling unit and located on or within one foot of the IAQ system control.
   b. An electronic application.
   c. An audible alarm accompanied by a visual display.
3. Instrumentation and reporting of the following:
   a. Airflow.
   b. Fan power.
4. FID certified to CEC by the manufacturer as meeting the above requirements.

To receive compliance credit relative to the standard design, balanced and supply-only systems must have accessible supply air filters, outside air inlets, and heat/energy recovery cores (if applicable) as specified in Title 24 Part 6 Section 150.0(o)1Civ.Table 22: IAQ System Component Accessibility Criteria. For systems not meeting these requirements, compliance credit would be neutralized. (See IAQ system standard design for details.)

~~Table 22: IAQ System Component Accessibility Criteria~~

~~Dwelling Unit Ventilation System Component~~	~~Location~~	~~Accessible Determination~~
~~Outdoor Air Intake~~	~~All locations~~	~~Intake louvers, grilles, or screens shall be >3/8 inches except where prohibited by local jurisdictions or other code requirements.~~
~~Outdoor Air Intake~~	~~Exterior wall, soffit, or gable end~~	~~A point on the perimeter of the outdoor air intake shall be located within 10 feet of a walking surface or grade or the system shall meet the IAQ System FID requirements in the ACM Reference Manual.~~
~~Outdoor Air Intake~~	~~Roof~~	~~Access shall be provided in accordance with California Mechanical Code Section 304.3.1 requirements for appliances.~~
~~Filters and Heat Exchangers~~	~~Serviceable from conditioned space, unconditioned basements, or mechanical closets. Heat exchangers may also be serviceable from unconditioned attics if the IAQ system meets the RACM Reference Manual.~~	~~The H/ERV or supply ventilation system access panel shall be located within 10 feet of the walking surface.~~

Standard Design

For single-family buildings, the standard design mechanical ventilation system type (balanced, supply, or exhaust) is the same as the proposed. Fan efficacy is 0.35

W/CFM for exhaust or supply systems and 0.70 W/CFM for balanced systems. Airflow rate is equal to the proposed design value or 1.25 times the CFM required by the Energy Code, whichever is smaller.

If the proposed IAQ system uses the central air handler fan, the standard design IAQ fan efficacy is equal to:

- 0.45 W/CFM for gas furnace air-handling units, as well as air-handling units that are not gas furnaces and have a capacity less than 54,000 BTU/h.
- 0.58 W/CFM for air-handling units that are not gas furnaces and have a capacity greater than or equal to 54,000 BTU/h.
- 0.62 W/CFM for small-duct high-velocity forced air systems.

The standard design is assumed to meet the accessibility criteria in Title 24 Part 6 Section 150.0(o)1Civ Table 22: IAQ System Component Accessibility Criteria and incorporates an FID meeting the requirements in this section Joint Appendix JA15, Qualification Requirements for IAQ System Fault Indicator Displays.

If the proposed design is balanced or supply-only and doesn't meet the Section 150.0(0)1Cvi accessible requirements listed in Table 22: IAQ System Component Accessibility Criteria, the standard design W/CFM equals the proposed or the default value whichever is lower. Furthermore if the proposed system has heat recovery the standard would have heat recovery with SRE and ASRE equal to the proposed system. Otherwise, the standard design does not have heat recovery.

Nonresidential and Multifamily ACM Reference Manual

The Statewide CASE Team proposes the following changes to the Multifamily section of the ACM.

Section 6.6 Air Leakage and Infiltration

Air leakage is a building level characteristic. The compliance software distributes the leakage over the envelope surfaces in accordance with the building configuration and constructs a pressure flow network to simulate the airflows between the conditioned zones, unconditioned zones, and outside.

6.6.1 Building Air Leakage and Infiltration

The airflow through a blower door at 50 pascals (Pa) of pressure measured in cubic feet per minute is called CFM50. CFM50 multiplied by 60 minutes, divided by the volume of conditioned space, is the air changes per hour at 50 Pa, called ACH50. This method is used for multifamily buildings with three or fewer habitable stories.

Proposed Design

The proposed design for dwelling units in ACH50 defaults to 7 for multifamily buildings shall be 2.3 ACH50. The proposed design for common use areas in all multifamily buildings shall be 7 ACH50.

Standard Design

The standard design for dwelling units in multifamily buildings shall have be 2.37 ACH50, reflecting the exterior leakage associated with the mandatory required maximum infiltration of 0.30 CFM50/ft^2. The standard design for common use areas in all multifamily buildings shall be 7 ACH50.

Verification and Reporting

Due to the lack of an applicable measurement standard, the ACH50 for multifamily buildings is fixed at 7 and cannot be lowered. HERS verification is not required because the proposed design cannot be lowered beyond the standard design defined ACH50 of 7. For dwelling units in multifamily buildings, diagnostic testing to confirm the details and target values modeled in the proposed design is required and must be reported in the HERS-required verification listing on the compliance form.

Section 6.8.6 Indoor Air Quality (IAQ) Ventilation

For newly constructed buildings and additions greater than 1,000 ft2, the Energy Code requires that all dwelling units meet the requirements of ASHRAE Standard 62.2 with California amendments specified in §160.2(b)2 and 160.2(c)3. Providing acceptable IAQ through mechanical ventilation is one of the requirements of Standard 62.2.

To receive compliance credit relative to the standard design, balanced and supply-only systems must have accessible supply air filters, outside air inlets, and heat/energy recovery cores (if applicable) as specified in section -409042400.346.694811. For systems not meeting these requirements, compliance credit would be neutralized (see IAQ system standard design for details).

IAQ System Type

Proposed Design

For dwelling units in multifamily buildings, tThe user identifies the type of IAQ system in the proposed design (exhaust, supply only, or balanced) and whether the supply and/or exhaust are central or individual. System type must be consistent for all dwelling units in a building.

Standard Design

For dwelling units, the standard design mechanical ventilation system type is the same as the proposed design except in Climate Zones 1, 2, 4, 11 through 14, and 16, where the software defaults to balanced with HRV to reflect the prescriptive requirement.

System type is determined by whether the supply/exhaust is central (system serving multiple zones) vs. individual (system serving one zone) and the configuration of the system; balanced (supply and exhaust with equal airflow)~~,~~ or supply only, ~~or exhaust only~~. The standard design system type, either individual or central, is the same as the proposed design for each type of supply and exhaust stream. For example, if the proposed design has central supply and individual exhaust, the standard design would have central supply and individual exhaust.

For multifamily common use areas, ventilation is provided by the standard heating and cooling system described in Table 21: Standard Design Common Area HVAC System.

IAQ System Fan Efficacy

Proposed Design

All individual systems serving multifamily dwelling units must meet IAQ system fan efficacies based on the following conditions:

Systems with supply ducts (balanced and supply-only) are simulated with increased fan wattage to account for maintenance and installation factors affecting system efficacy. For these systems, fan wattage is increased by a factor of 1.10 (10 percent increase in wattage). For IAQ systems with fault indicator displays (FID) meeting the specifications in Joint Appendix JA15~~ Section -409042400.346.699504~~, these factors do not apply.

Systems with heat or energy recovery serving a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm in accordance with Section 160.2(b)2.A.iv.b.1.

Standard Design

Table 38: Individual IAQ System Standard Design Fan Efficacy

Climate Zone	~~Exhaust or~~ Supply Only	Balanced (no heat recovery)	Balanced with Heat recovery
1-2, 4~~and~~11-~~15~~ 14, and 16	0.35 W/cfm	N/A	0.6 W/cfm
5~~4~~-10, and 15 (4+ stories)	0.35 W/cfm	0.7 W/cfm	N/A
5~~4~~-10, and 15 (<4 stories)	0.35 W/cfm	0.4 W/cfm	N/A
3	0.35 W/cfm	0.7 W/cfm	N/A

Individual IAQ standard design fan efficacy equals the value in Table 38 based on the proposed system design and climate zone.

Table 39: Central IAQ System Standard Design Fan Efficacy Limits

Type	≤5,000 cfm	>5,000 and ≤10,000 cfm	>10,000 cfm
Supply-Only	0.441 W/cfm	0.476 W/cfm	0.450 W/cfm
~~Exhaust-Only~~	~~0.302 W/cfm~~	~~0.286 W/cfm~~	~~0.281 W/cfm~~
Central Supply + Individual Exhaust	0.791 W/cfm	0.826 W/cfm	0.800 W/cfm
Individual Supply + Central Exhaust	0.652 W/cfm	0.636 W/cfm	0.631 W/cfm
Central Supply + Central Exhaust	0.743 W/cfm	0.762 W/cfm	0.731 W/cfm
Central Supply + Central Exhaust + Heat Recovery	1.098 W/cfm	1.069 W/cfm	1.005 W/cfm

Central IAQ standard design fan efficacy equals proposed or the limit from Table 39 whichever is lower.

~~Additionally, for multifamily dwelling units, if the proposed system type is balanced, supply-only, or HRV/ERV, and the system maintenance components (supply air filters, outside air inlets, and heat/energy recovery cores) are not accessible, then the standard design fan efficacy equals proposed or the value from Table 34 Individual IAQ System Standard Design Fan Efficacy, whichever is lower. For non-accessible proposed systems with heat recovery the standard design is equal to the Proposed or 0.6 W/cfm whichever is lower.~~

Heat/Energy Recovery

Heat/Energy recovery can be specified using recovery effectiveness or adjusted sensible recovery efficiency (ASRE) and sensible recovery efficiency (SRE). For larger AHRI rated equipment, inputs are covered in Section 5.7.7 Heat Recovery.

Proposed Design

Systems serving individual dwelling units with supply ducts (balanced and supply-only) are simulated with reduced recovery efficiency (SRE and ASRE or recovery effectiveness) to account for maintenance and installation factors affecting system efficacy. For these systems, recovery efficiency is reduced by a factor of 0.90 (10 percent decrease in recovery efficiency). For IAQ systems with an FID meeting the specifications in Joint Appendix JA15 ~~Section -409042400.346.702361 IAQ System Fault Indicator Display~~, these factors don't apply.

Standard Design

If the proposed design is a balanced central system, both central supply and central exhaust systems serving multiple dwelling units, in Climate Zones 1, 2, 4, ~~or~~ 11-14, or 16, in a building with four or more habitable stories, the standard design is a heat recovery ventilation system with a sensible recovery effectiveness of 67 percent in both heating and cooling modes and includes recovery bypass to directly economize with ventilation air based on the outdoor air temperature limits specified in Table 170.2-G.

If the proposed design is a balanced system serving individual dwelling units in Climate Zones 1, 2, 4, ~~or~~ 11-14, or 16, the standard design is a heat recovery ventilation system with a sensible recovery effectiveness of 67 percent in both heating and cooling modes.

~~For systems serving individual dwelling units, if the system does not meet the requirements in Section 6.8.6.11 IAQ System Component Accessibility, the standard design effectiveness matches the proposed or 67% whichever is higher.~~

…

Economizer Enabled during Heat Recovery

All systems with airside heat recovery must identify if the economizer is enabled during heat recovery.

Proposed Design

Indication of whether the economizer is enabled when heat recovery is active is based on the proposed design.

Standard Design

The economizer is disabled if using a balanced system serving multiple dwelling units in Climate Zones 1, 2, 4, ~~or~~ 11-14, or 16. Not applicable for Climate Zones 3, 5-10, and 15.

For existing buildings, the economizer is disabled if using a balanced system serving multiple dwelling units in Climate Zones 1, 2, 4, ~~or~~ 11-14, or 16. Not applicable for Climate Zones 3, 5-10, and 15.

...

IAQ System Fault Indicator Display

All individual IAQ systems with a supply fan must specify if the system includes an FID that meets the ~~following~~ requirements in Joint Appendix JA15, Qualification Requirements for IAQ System Fault Indicator Displays.

~~IAQ System Fault Indicator Display Requirements~~

~~1. Fault indication responding to the following categories:~~

~~a. Filter check or maintenance, either based on performance or a predetermined schedule.~~

b. Low supply airflow.

c. Low exhaust airflow.

d. Sensor failure for sensors that assist in monitoring or controlling for the following operations, where such operations are provided: airflow regulation, frost control, supply air tempering, and economizing.

2. Fault indication using one or more of the following means:

a. A visual display that is readily accessible to occupants of the dwelling unit and located on or within one foot of the IAQ system control.

b. An electronic application.

c. An audible alarm accompanied by a visual display.

3. Instrumentation and reporting of the following:

a. Airflow.

b. Fan power.

4. FID certified to CEC by the manufacturer as meeting the above requirements.

Proposed Design

Selection is based on the proposed design.

Standard Design

The standard design assumes an FID system meeting the above requirements of Joint Appendix JA15.

IAQ System Component Accessibility

All individual IAQ systems with a supply fan must specify if the system meets the following accessibility requirements.

Table 40. Multifamily IAQ System Component Accessibility Criteria

Dwelling Unit Ventilation System Component	**Location**	**Accessible Determination**
Outdoor Air Intake	All locations	Intake louvers, grilles, or screens shall be >3/8 inches except where prohibited by local jurisdictions or other code requirements.

~~Dwelling Unit Ventilation System Component~~	~~Location~~	~~Accessible Determination~~
~~Outdoor Air Intake~~	~~Exterior wall, soffit, or gable end~~	~~A point on the perimeter of the outdoor air intake shall be located within 10 feet of a walking surface or grade or the system shall meet the IAQ System FID requirements in the ACM Reference Manual.~~
~~Outdoor Air Intake~~	~~Roof~~	~~Access shall be provided in accordance with California Mechanical Code Section 304.3.1 requirements for appliances.~~
~~Filters and Heat Exchangers~~	~~Serviceable from conditioned space, unconditioned basements, or mechanical closets. Heat exchangers may also be serviceable from unconditioned attics if the IAQ system meets the RACM Reference Manual.~~	~~The H/ERV or supply ventilation system access panel shall be located within 10 feet of the walking surface.~~

~~Proposed Design~~

~~Selection is based on proposed design.~~

~~Standard Design~~

~~The standard assumes an IAQ system meeting the above requirements.~~

8.5 Compliance Forms

The following compliance documents would need to be revised, as summarized below:

For multifamily buildings with three or fewer habitable stories, the compliance documents that would be updated include:

- Certificates of Compliance:
  - LMCC-MCH-01-E Mechanical Systems
- Certificates of Installation:
  - LMCI-MCH-27b-H Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method

- LMCI-MCH-24a Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter
- LMCI-MCH-24b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Automatic Meter

- Certificates of Verification:
  - LMCV-MCH-27b Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method
  - LMCV-MCH-24a Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter
  - LMCV-MCH-24b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Automatic Meter

For multifamily buildings with four or more habitable stories, the compliance documents that would be updated include:

- Certificates of Compliance:
  - NRCC-MCH-01-E Mechanical Systems
- Certificates of Installation:
  - 2022-NRCI-MCH-E Mechanical Systems
- Certificates of Verification:
  - 2022-NRCV-MCH-24a Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Single Point Test—Manual Meter
  - and 2022-NRCV-MCH-24b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Single Point Test—Automatic Meter
  - NRCA-MCH-20a-H MF Dwelling Ventilation
  - NRCA-MCH-20c-H MF IAQ Ventilation System
  - NRCA-MCH-20d-H MF Dwelling Ventilation—HRV-ERV
  - NRCA-MCH-23-A HRV-ERV Verification

For these compliance documents:

- For ventilation strategy, the compliance documents would need to be changed so that exhaust only ventilation is no longer an option. The compliance documents would also need to be changed to ask about the presence of an FID and accessibility of supply and balanced ventilation systems.
- For compartmentalization, the compliance documents would need to be changed so it no longer asks if HERS verification of compartmentalization is required.

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Appendix A: Statewide Savings Methodology

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per unit savings estimates by statewide construction forecasts that the CEC provided (California Energy Commission 2022). The CEC provided the construction estimates on March 27, 2023, at the Staff Workshop on Triennial California Energy Code Measure Proposal Template.

The Statewide CASE Team followed guidance provided in the CEC's New Measure Proposal Template, developed by the CEC, to calculate statewide energy savings using the CEC's construction forecasts, including a request to assume a statewide weighting as follows: Low-Rise Garden (four percent), Loaded Corridor (33 percent), Mid-Rise Mixed-Use (58 percent) and High-Rise Mixed Use (five percent). See Section 5.2 of the CEC's New Measure Proposal Template.

The Statewide CASE Team did not make any changes to the CEC's construction estimates.

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per unit savings estimates by the CEC's statewide construction forecasts. The Statewide CASE Team made assumptions about the percentage of buildings in each climate zone that would be impacted by the proposed code change: 100 percent of new construction dwelling units would be affected. Because the proposed measure would not impact alterations, the Statewide CASE Team assumed that 0 percent of existing dwelling units would be affected.

Table 53 presents the number of new construction dwelling units that the Statewide CASE Team assumed would be impacted by the proposed code change during the first year the 2025 code is in effect.

Table 53: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone

Building Climate Zone	Total Dwelling Units Completed in 2026 (New Construction) [A]	Percent of New Dwelling Units Impacted by Proposal [B]	New Dwelling Units Impacted by Proposal in 2026 C = A x B	Total Existing Dwelling Units in 2026 [D]	Percent of Existing Dwelling Units Impacted by Proposal [E]	Dwelling Units Impacted by Proposal in 2026 F = D x E
1	144	100%	144	17,558	0%	0
2	1,391	100%	1,391	105,894	0%	0
3	7,699	100%	7,699	553,186	0%	0
4	3,417	100%	3,417	288,786	0%	0
5	285	100%	285	45,671	0%	0
6	2,243	100%	2,243	322,513	0%	0
7	5,156	100%	5,156	307,272	0%	0
8	8,600	100%	8,600	515,137	0%	0
9	10,302	100%	10,302	1,117,605	0%	0
10	4,306	100%	4,306	329,302	0%	0
11	1,173	100%	1,173	85,339	0%	0
12	5,537	100%	5,537	471,876	0%	0
13	1,009	100%	1,009	157,075	0%	0
14	1,446	100%	1,446	83,480	0%	0
15	373	100%	373	41,152	0%	0
16	187	100%	187	28,066	0%	0
TOTAL	**53,268**		**53,268**	**4,469,912**		**0**

Source: (California Energy Commission 2022)

Appendix B: Embedded Electricity in Water Methodology

There are no on-site water savings associated with the proposed code change.

Appendix C: California Building Energy Code Compliance (CBECC) Software Specification

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for multifamily buildings and CBECC-Res for single family buildings along with the supporting documentation that CEC staff and the technical support contractors would need to approve and implement the software revisions. Most of the changes impact multifamily buildings and thus require modifications to the CBECC software. Some updates are also needed to CBECC-Res to accommodate the accessibility and FID proposed code change.

Technical Basis for Software Change

The proposed code changes would need to be incorporated into the software to accommodate updates to the Standard Design to match new prescriptive requirements and incorporate new defaults to reflect the proposed mandatory requirements.

Description of Software Change

Background Information for Software Change

See Section 5.1.1.1 of this report for a discussion of how compartmentalization's impact on ACH50 was estimated.

Existing CBECC Building Energy Modeling Capabilities

CBECC currently has the capability necessary to model all of the IAQ system types, characteristics and air infiltration rates referenced in this code change proposal. No new modeling capabilities are necessary.

Summary of Proposed Revisions to CBECC and CBECC-Res

The proposed code changes summarized in Section 3.1 revise the mandatory and prescriptive requirements for building air leakage as well as IAQ systems. The required software changes to CBECC for multifamily buildings are summarized below.

- Reduce the dwelling unit air leakage rate from 7 ACH50 to 2.3 ACH50 for both the Standard and Proposed Designs. Default values for common areas would remain unchanged. Air infiltration would continue to not be an input that is available for the software user to edit.

- Remove exhaust-only options for IAQ systems within the Proposed Design for newly constructed dwelling units.
- For newly constructed dwelling units in Climate Zones 1, 2, 4, 11 through 14, and 16, change IAQ system type within the Standard Design to be a balanced system with heat or energy recovery regardless of the Proposed Design system type. Fan efficacy and sensible heat recovery shall be modeled per the ACM.
- For newly constructed dwelling units in Climate Zone 15, set the IAQ system type within the Standard Design to be the same type as the Proposed Design with fan efficacy modeled per the ACM. For balanced systems there is no heat recovery.
    - The Standard Design for Climate Zones 3, and 5-10 is modeled the same as in Climate Zone 15, but this does not represent a change from the 2022 Standards.

The required software changes apply to both CBECC and CBECC-Res.

- Remove the checkbox related to supply or balanced IAQ fan component accessibility since this would become a mandatory requirement.
    - Remove the logic in the ruleset that sets the Standard Design equal to the Proposed Design if the IAQ fan component accessibility requirements are not met.

User Inputs to CBECC

There are no new recommended user inputs to CBECC.

The following user inputs are recommended to be removed or changed in CBECC.

- To accommodate the proposed code change that does not allow exhaust ventilation within dwelling units.
    - In the IAQ tab of the Dwelling Unit interface remove the “Minimum Exhaust IAQ Fan” and “Central Exhaust” options.
    - In the Residential IAQ Fan Data interface remove the “Exhaust” option for IAQ Fan Type.
- Remove the user input for dwelling unit air leakage except in research mode. Since 2.3 ACH50 is a mandatory requirement and there is no credit for achieving lower infiltration rates this input should not appear for users.
- In the IAQ tab of the Dwelling Unit interface:
    - Remove the checkbox "All supply air filters, outside air inlets, and H/ERV recovery cores are accessible per RACM Reference Manual.
    - Change the checkbox “IAQ system has fault indicator display (FID) in compliance with RACM Reference Manual” to read “IAQ system has fault indicator display (FID) in compliance with Standards Section 170.2(c)3biii”.

The following user inputs are recommended to be removed or changed in CBECC-Res.

- Remove the checkbox "All supply air filters, outside air inlets, and H/ERV recovery cores are accessible per RACM Reference Manual.
- Change the checkbox “IAQ system has fault indicator display (FID) in compliance with RACM Reference Manual” to read “IAQ system has fault indicator display (FID) in compliance with Standards Section 150.1(c)”.

Simulation Engine Inputs

There is no recommended change to how CBECC translates user inputs into California Simulation Engine (CSE) inputs.

Simulation Engine Output Variables

There is no need to verify this software change with CSE output variables.

Compliance Report

The recommended changes to the multifamily LMCC-PRF-01-E compliance report are intended to accommodate the proposed code change related to the IAQ system FID prescriptive requirements. No changes are necessary for the other code change proposals.

- Add a new column in the ventilation section for Individual Fans (see Table 54) to indicate whether an FID is present.

Table 54: Example of LMCC-PRF-01-E Report

H10. MULTIFAMILY DWELLING UNIT TYPE CENTRAL / INDIVIDUAL VENTILATION												
01	02	03	04	05	06	07	08	09	10	11	12	13
Dwelling Unit Type Name	IAQ Option	Central Fan (If applicable)					Individual Fan (if applicable)					
		IAQ Fan Type Type	Supply Airflow CFM	Supply Fan Efficacy W/CFM	Exhaust CFM	Exhaust Fan Efficacy W/CFM	IAQ Fan Type	Count	Airflow CFM	Fan Efficacy W/CFM	Recovery Efficiency SRE	Recovery Efficiency ASRE
OneBedroomZ1	Individual IAQ Fan	N/A	N/A	N/A	N/A	N/A	Balanced	1	37.5	0.6	67	72
TwoBedroomZ1	Individual IAQ Fan	N/A	N/A	N/A	N/A	N/A	Balanced	1	54.9	0.6	67	72
OneBedroomZ2	Individual IAQ Fan	N/A	N/A	N/A	N/A	N/A	Balanced	1	37.5	0.6	67	72
TwoBedroomZ2	Individual IAQ Fan	N/A	N/A	N/A	N/A	N/A	Balanced	1	54.9	0.6	67	72

The presence of an FID is already reported in the single family CF1R-PRF-01-E compliance report so there are no recommended changes to that report.

Compliance Verification

Verification of code compliance would be similar to the current process today. The one difference is that authorities having jurisdiction would need to verify the mandatory IAQ system component accessibility and prescriptive FID proposed requirements.

Testing and Confirming CBECC Building Energy Modeling

Table 55 describes the recommended testing to confirm software updates have been properly incorporated. Tests should be completed with the base case prototypes that are set up to match the Standard Design properties.

Table 55: Proposed CBECC & CBECC-Res Testing

Software	Climate Zone	Prototype	Objects Modified	Parameter Name	Design Parameter Value	Expected Test Outcome
CBECC	Any 1 CZ	2-story & 5-story	Infiltration Rate	ACH50	Not a user input	Verify in CSE file that 2.3 ACH50 is applied to all dwelling units and 7 ACH50 to common area spaces
CBECC	Any 1 CZ	Any 1 prototype	IAQ System	IAQ System & Fan Type	Exhaust-only	Confirm this isn’t available to select
CBECC	1, 2, 4, 11 -14, and 16	2-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced with HRV, 0.6 W/cfm, 67% sensible recovery	0% compliance margin
CBECC	12	2-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced with HRV, 0.6 W/cfm, 67% sensible recovery, FID unchecked	Negative compliance impact (Standard Design should not change from case above, 10% penalty in Proposed Design on W/cfm & effectiveness)
CBECC	12	2-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced with HRV, 0.4 W/cfm, 70% sensible recovery	Positive compliance impact, verify that credit is applied with accessibility checkbox removed
CBECC	1, 2, 4, 11 -14, and 16	2-story	IAQ System (Individual)	IAQ System Type & Specs	Supply only, 0.35 W/cfm	Negative compliance impact (Standard Design should still be balanced with HRV)
CBECC	1, 2, 4, 11 -14, and 16	5-story with central DOAS	IAQ System (Central)	IAQ System Type & Specs	Balanced with HRV, 67% sensible recovery, fan power per ACM	0% compliance margin

Software	Climate Zone	Prototype	Objects Modified	Parameter Name	Design Parameter Value	Expected Test Outcome
CBECC	1, 2, 4, 11 -14, and 16	5-story with central DOAS	IAQ System (Central)	IAQ System Type & Specs	Supply only, 0.35 W/cfm	Negative compliance impact (Standard Design should still be balanced with HRV)
CBECC	15	2-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced, 0.4 W/cfm	0% compliance margin
CBECC	15	2-story	IAQ System (Individual)	IAQ System Type & Specs	Supply, 0.35 W/cfm	0% compliance margin
CBECC	15	2-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced with HRV, 0.4 W/cfm, 67% sensible recovery	Positive compliance impact (Standard Design should be balanced w/o heat recovery)
CBECC	15	5-story	IAQ System (Individual)	IAQ System Type & Specs	Balanced, 0.7 W/cfm	0% compliance margin
CBECC	15	5-story	IAQ System (Central)	IAQ System Type & Specs	Balanced with HRV, 67% sensible recovery, fan power per ACM	Positive compliance impact (Standard Design should be balanced w/o heat recovery)
CBECC-Res	12	2100	IAQ System	IAQ System Type & Specs	Balanced with HRV, 0.6 W/cfm, 67% sensible recovery, FID checked	Positive compliance margin
CBECC-Res	12	2100	IAQ System	IAQ System Type & Specs	Balanced with HRV, 0.6 W/cfm, 67% sensible recovery, FID unchecked	Positive compliance impact, but lower than the above case

Description of Changes to ACM Reference Manual

See Section 8.4 for further details.

Appendix D: Environmental Analysis

This section discusses the potential environmental impacts of the proposed measure.

The Statewide CASE Team has determined that incorporating both balanced or supply-only ventilation and compartmentalization would benefit the environment through energy and GHG savings, which are discussed in the Statewide Energy and LSC Savings in Section 7.1 and the Statewide GHG Emissions Reductions in Section 7.2.

It should not have a significant negative environmental impact. The current requirement is for balanced ventilation or compartmentalization. Based on market-research, the Statewide CASE Team believes that the majority of low-rise multifamily units are meeting the current requirement through compartmentalization, and that most mid-rise and high-rise projects are meeting the current requirement through balanced ventilation.

Consequently, there would be an increase in ERV, HRV, and supply fan materials, particularly for low-rise dwelling units, as they switch from exhaust-only to supply-only or balanced with ERV or HRV ventilation, which would increase the building materials by 11 lb or 56 lb, respectively. These materials are primarily composed of steel and plastic, and they are not typically composed of heavy metals or toxic materials. The Statewide CASE Team assumed there would be 5 lb of steel and 1 lb of plastic increase for the prescriptive requirement for the FID.

For dwelling units that add compartmentalization due to the proposed code change, the main impact would be the greater application of nontoxic building sealing materials, such as polyurethane foam, acrylic polymer, and fiberglass, used in compartmentalization. The Statewide CASE Team assumed a total of 7 lb of sealing materials per dwelling unit to seal the exterior and interior walls. This greater material use would lead to an increase in embodied carbon (and embodied energy), which results from GHG emissions arising from the extraction, manufacturing, and transportation of these materials. The Statewide Material Impacts Section 7.4 includes more information on the ventilation and compartmentalization materials and the embodied GHG emissions. In general, this analysis estimated that statewide GHG emissions would increase due to materials by 521 $MTCO_2e$ as a one-time increase, but GHG emissions would be reduced through reduced energy use: 185 $MTCO_2e$ per year, as shown in Section 7.2. The materials impact occurs only at construction, and a portion would need to be replaced around year 15. Consequently, over its lifetime, the measure would save far more GHG emissions due to energy savings than the increase from the materials.

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (i.e., CEQA) for the 2025 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed standards. A “significant effect on the environment” is “a substantial adverse change in the physical conditions which exist in the area affected by the proposed project.” (Cal. Code Regs., tit. 14, § 15002(g).)

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal including, but not limited to, an evaluation of factors contained in the California Code of Regulations, Title 14, Section 15064 and determined that the proposal would not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

The proposal would directly benefit the environment through energy savings due to reduced air leakage and energy demand. The reduction in energy use would result in lower GHG emissions and other pollutants. The energy and GHG emissions impacts are detailed in the Statewide Energy and LSC Savings Section 7.1 and the Statewide GHG Emissions Reductions Section 7.2.

Direct Adverse Environmental Impacts

The increased use of materials would adversely impact the environment and result in greater embodied carbon, which constitutes a considerable portion of a building’s GHG emissions. The embodied GHG emissions from the materials used for the proposal are found in the Statewide Material Impacts in Section 7.4.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team has determined that the proposal would result in the following indirect environmental benefit, which is mild: heating and cooling needs would be reduced. As the air tightness of each dwelling unit is improved, there would be reduced energy loss, resulting in less heating and cooling need as well as the associated GHG emissions being released into the air. As a result, outdoor air pollution, such as PM2.5, associated with generating electricity and combustion gases from electricity generation or onsite combustion would be reduced (California Air Resources Board 2011) (California Air Resources Board 2011), especially in cities with poor air quality.

Indirect Adverse Environmental Impacts

The primary adverse impact would be the relatively small increase in ventilation and air sealing materials, which has already been discussed.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of “specific economic, environmental, legal, social, and technological factors.” (Cal. Code Regs., tit. 14, § 15021.) The Statewide CASE Team did not determine that this measure would result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and believes that no alternative achieves the purpose of the proposal with less environmental effect. There are no other measures that achieve the same objectives, and there are IAQ benefits, such as reductions in pollutant transfer from neighbors and a dedicated source of outdoor air, and energy savings benefits from the proposed measure.

Water Use and Water Quality Impacts Methodology

There are no significant impacts to water quality or water use.

Embodied Carbon in Materials

Accounting for embodied carbon emissions is important for understanding the full picture of a proposed code changes environmental impacts. The embodied carbon in materials analysis accounts specifically for emissions produced during the cradle-to-grave phase: emissions produced from material extraction, manufacturing, and transportation. Understanding these emissions ensures the proposed measure considers these early stages of materials production and manufacturing instead of emissions reductions from energy efficiency alone.

The Statewide CASE Team calculated emissions impacts associated with embodied carbon from the change in materials as a result of the proposed measure. The calculation builds on the materials impacts outlined in the Statewide Materials Impacts, see Section 7.4 for more details on the materials impact analysis.

After calculating the materials impacts, the Statewide CASE Team applied average embodied carbon emissions for each material. The embodied carbon emissions are based on industry-wide environmental product declarations (EPDs).[35, 36] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[37] The Statewide CASE Team chose the industry-wide average for GWP values in the EPDs because the materials accounted for in the statewide calculation would have a range of embodied carbon; i.e. some materials like concrete have a wide range of embodied carbon depending on the manufacturer's processes, source of the materials, etc. The Statewide CASE Team assumes that most building projects would not specify low embodied carbon products. Therefore, an average is appropriate for a statewide estimate.

First-year statewide impacts per material (in pounds) were multiplied by the GWP impacts for each material. This provides the total statewide embodied carbon impact for each material. If a material's use is increased, then there is an increase in embodied carbon impacts or additional emissions. If a material's use is decreased, then there is a decrease in embodied carbon impacts or an emissions reduction.

[35] Are documents that disclose a variety of environmental impacts, including embodied carbon emissions. These documents are based on lifecycle assessments of specific products and materials. Industry-wide EPDs disclose environmental impacts for one product for all or most manufacturers in a specified area and are often developed through the coordination of multiple manufacturers and associations. A manufacturer EPD only examines one product from one manufacturer. Therefore, an industry-wide EPD discloses all the environmental impacts from the entire industry for a specific product or material, but a manufacturer EPD only factors one manufacturer.

[36] An industry wide EPD was not used for mercury, lead, copper, plastics, or refrigerants. Global warming potential values of mercury, lead, and copper are based on data provided in a Lifecycle Assessment (LCA) conducted by Yale University in 2014. The GWP value for plastic is based on a LCA conducted by Franklin Associates, which captures roughly 59 percent of the U.S. total production of PVC and HDPE production. The GWP values for refrigerants are based on data provided by the Intergovernmental Panel on Climate Change Fourth Assessment Report.

[37] GWP values for concrete and wood were in units of kg CO_2 equivalent by volume of the material rather than by weight. An average density of each material was used to convert volume to weight.

Appendix E: Discussion of Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, which is described in Section 3.5, could impact various market actors. Table 56 and Table 57 identify the market actors who would play a role in complying with the proposed changes, the tasks for which they are responsible, how the proposed code changes could impact their existing workflow, and ways negative impacts could be mitigated. Appendix F summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

Table 56 and Table 57 identify the market actors who would play a role in complying with the proposed change for balanced or supply-only ventilation, and for compartmentalization, respectively. These tables also show the tasks for which each market actor would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing workflow, and ways negative impacts could be mitigated.

While the ventilation system type and compartmentalization verification describes actions taken by a HERS rater, an Acceptance Test Technician (ATT) may instead provide HERS rater verifications in high-rise multifamily buildings. The 2022-Title 24 Part 6 Nonresidential Appendix Section 1.9 allows ATTs to provide HERS rater verifications and diagnostic tests in high-rise multifamily buildings but prohibits ATTs from using sampling. The Statewide CASE Team proposes that ATTs be allowed to use sampling when conducting the verification of compartmentalization, since the verification would be cost-prohibitive if all units were measured, and field measurements show relatively small variation unit-to-unit in buildings targeting compartmentalization.

CEC compliance documents are used to show compliance with 2022 California Energy Code. Registration of residential compliance documentation include:

- Certificate of Compliance LMCC/NRCC-MCH-01-E Mechanical Systems would be completed by the project proponent and submitted to the enforcement agency during the plan review phase.
- Certificate of Installation LMCI-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter or for ventilation strategy LMCV-MCH-27b Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method for three or fewer stories or 2022-NRCI-MCH-E Mechanical Systems for four or more stories would be completed by the

installer or contractor during the construction phase and submitted to the enforcement agency during the project inspection phase.

- Certificate of Verification LMCV-MCH-24a/b Building Air Leakage Diagnostic Test Worksheet—Building Enclosures and Dwelling Unit Enclosures—Manual Meter or for ventilation strategy LMCV-MCH-27b Indoor Air Quality and Mechanical Ventilation—Total Vent Rate Method for three or fewer stories or 2022-NRCV-MCH-24a/b Building Air Leakage Diagnostic Test—Building Enclosures and Dwelling Unit Enclosures—Air Leakage Worksheet—Automatic Meter for four or more stories would be completed by a third-party agent certified by an CEC approved field verification and diagnostic testing provider and submitted to the enforcement agency during the final inspection phase.

Please note, these form names have recently changed. The new numbering and naming format is to be determined.

Table 56: Roles of Market Actors in the Proposed Compliance Process for Balanced or Supply-only Ventilation

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect	• Coordinate with mechanical designer to determine equipment to be installed and duct routing. • Submit plans and specifications, including LMCC/NRCC-MCH-01-Eforms, design drawings, and specifications to the enforcement agency.	• Since exhaust-only systems would no longer be allowed, the architect, working with the mechanical designer, may have to locate an additional wall penetration for the outdoor air intake that meets code requirements for minimum separation from exhaust outlets. • The architect, working with the mechanical designer, would have to locate the ventilation equipment for unobstructed access for servicing supply air filters.	No significant impact	N/A
Mechanical Designer	• Identify strategy for providing whole dwelling-unit ventilation. • Specify equipment, including fan airflow rates and control methods. • Locate duct routing and duct exterior terminations in coordination with architect. • Submit plans and specifications, including LMCC/NRCC-MCH-01-E forms, design drawings, and specifications to the enforcement agency.	• No longer able to design an exhaust-only system. • The mechanical designer, working with the architect, would have to locate the ventilation equipment for unobstructed access for servicing supply air filters. • The mechanical designer would have to specify a ventilation system with an FID from the certified list of FIDs. • The mechanical designer would indicate presence of FID and access in compliance forms. • The mechanical designer, working with the architect, may have to locate an additional wall penetration from the outdoor air intake that meets code requirements for minimum separation from exhaust outlets. • Minor impact on the existing building design phase process	• Minor impact • Would need to more carefully review ventilation product documentation to ensure all requirements are met	N/A

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Energy Consultant	• Conduct energy analysis and prepare Title 24 compliance documentation. • Analyze heat recovery and other options to help inform design. • Complete LMCC/NRCC-MCH-01-E	No significant impact.	No significant impact.	N/A
Plans Examiner	• Verify that LMCC/NRCC-MCH-01-E is consistent with building plans and meets compliance criteria for local jurisdiction. • Verify ventilation strategy and that provides ventilation at the required rate.	• Confirm the presence of an FID and that the FID is on the certified list. • Confirm unobstructed access of the equipment. • Minor impact on the building permit application phase process. Must check that using balanced or supply-only ventilation.	Verify that the dwelling units have continuous balanced ventilation or supply only ventilation.	Record equipment information on documents for easy comparison to plans.
General Contractor	• Work with subcontractors to ensure design documents are carried out in construction. • Complete form LMCI/NRCI-24a/b or 27b	Minor impact on the existing building construction phase process. Can no longer install exhaust-only systems.	• N/A	• N/A
Mechanical Contractor	• Install ventilation system. • Conduct commissioning and start up to ensure equipment has continuous ventilation and runs as designed. • Complete form LMCI/NRCI-24a/b or 27b.	• Minor impact on the existing building construction phase process. Can no longer install exhaust-only systems. • Install FID. • Ensure unobstructed access for servicing supply air filters in ventilation equipment.	• N/A	• N/A
HERS Rater or ATT	Verify ventilation system type and ventilation airflow.	• Minor impact on the existing building construction phase process. Verify the system is either balanced or supply-only. • Verify the presence of an FID and that the FID is on the certified list.	No significant impact.	• N/A
Inspector	• Verify ventilation system type as permitted is installed. • Review HERS Rater test results in HERS registry and ensure HERS documentation is complete.	• Minor impact on existing building inspection phase process. Verify the system is either balanced or supply-only. • Verify unobstructed access of the equipment	• N/A	• N/A

Table 57: Roles of Market Actors in the Proposed Compliance Process for Compartmentalization

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect	• Specify in the plans and specifications what, where, and how the contractors need to seal dwelling units for waterproofing and quality insulation inspection. • Submit plans, specs, and LMCC/NRCC-MCH-01-E forms to enforcement agency.	• Moderate impact on the existing building design phase process. • No significant impact when compartmentalization is done in the existing process, the main change is that more projects would be meeting the compartmentalization process. • May dovetail with waterproofing and acoustical sealing.	No significant impact	The CEC or the Statewide CASE Team could provide example specifications for compartmentalization, including examples for wood framed and metal framed construction.
Energy Consultant	• Work with architect to identify strategies to tighten dwelling unit envelope. • Show permissible air leakage on drawings. • Prepare Title 24 compliance documentation.	N/A	No significant impact	N/A
Plans Examiner	• If design specifies compartmentalization, ensure the design documents identify the target compartmentalization level. • Verify that LMCC/NRCC-MCH-01-E is consistent with building plans and meets compliance criteria for local jurisdiction	For projects that are not already meeting compartmentalization target, ensure the design documents identify the target compartmentalization level and specify air sealing.	No significant impact	• Record equipment information on documents for easy comparison to plans. • The CEC or the Statewide CASE Team could provide training or examples, so that plans examiners become familiar with changes to compartmentalization requirements.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
General Contractor	• Work with subcontractors to ensure design documents are carried out in construction, including executing air sealing specified at each construction phase. • Coordinate with HERS Rater to verify compartmentalization when specified. • Complete forms LMCI/NRCI-24a/b or 27b. • If a unit fails air leakage diagnostic testing, take corrective action to improve the sealing. Repeat this process until the unit passes.	• Moderate impact on the existing building construction phase process. • Due to tighter compartmentalization requirement, the general contractor and subcontractors, including but not limited to mechanical, insulation, sheetrock, and drywall contractors, would coordinate to follow all air sealing design specifications.	Minor impact	• While not required by code, best practice is that before completing the air sealing process, the contractor does a mockup to test the compartmentalization at one dwelling unit to ensure that it meets the requirement, which allows the contractor to adjust the air sealing process as needed before completing the remaining dwelling units. • Provide training on how to specify and conduct dwelling unit air sealing. • Provide guidance to subcontractors on how to meet air sealing specifications during construction.
HERS Rater or ATT	• Field verify the compartmentalization, when specified, according to RA3.8 • If a unit fails, retest the unit after corrective action is taken to verify corrective action was successful. Repeat this process until the unit passes. • Conduct resampling and test another dwelling unit in the group to determine whether the first failure in the group is unique, or if the rest of the dwelling units in the group are likely to have a similar failing. • Complete forms LMCV/NRCV-MCH-24a/b or 27b. • Identify air barrier. • Conduct surface area and infiltration calculations.	Minor impact on existing building inspection phase process, except that more buildings would now require blower door testing.	• Conduct blower door tests on sample of units. • Minor impact.	N/A

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Inspector	Review HERS Rater test results in HERS registry and ensure HERS Documentation is complete.	Minor impact on existing building inspection phase process.	No significant impact.	No significant impact.

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to solicit insights and ideas for the proposed code changes so that the proposals presented to the CEC in this Final CASE Report are generally supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption including cost effectiveness, market barriers, technical barriers, compliance and enforcement challenges, or potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of stakeholder meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asks for feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results for analyses
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted a stakeholder meeting for MF IAQ: Balanced Ventilation and Compartmentalization via webinar as described in Table 58. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the Bibliography for this report.

Table 58: Utility-Sponsored Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Multifamily IAQ and Multifamily Restructuring Utility-Sponsored Stakeholder Meeting.	February 21, 2023	https://title24stakeholders.com/event/multifamily-restructuring-envelope-hvac-2-compartmentalization-and-balanced-ventilation-utility-sponsored-stakeholder-meeting/
Second Round of Multifamily HVAC and Envelope Utility-Sponsored Stakeholder Meeting.	May 17, 2023	https://title24stakeholders.com/event/multifamily-hvac-and-envelope-utility-sponsored-stakeholder-meeting/

The first round of utility-sponsored stakeholder meetings occurred from January to February 2023, and they were important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued by the Statewide CASE Team. The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred on May 17, 2023, and provided an opportunity for stakeholders to comment on the IAQ component accessibility and FID requirements.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com One email was sent to the entire Title 24 Stakeholders listserv, totaling over 3,000 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page and cross-promoted on the CEC LinkedIn page two weeks before each meeting to reach out to individuals and larger organizations and channels outside of the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted into the listserv. Exported webinar meeting data captured attendance numbers and individual comments, and it recorded outcomes of live attendee polls to evaluate stakeholder participation and support. The first IAQ stakeholder meeting on February 21, 2023, had 68 stakeholders attend the meeting, not including CASE Team members and organizations. Out of the 68 stakeholders that attended, 65 of them were from unique stakeholder organizations.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 59, which includes a summary of individual stakeholders that were either interviewed or engaged via email. These stakeholders provided technical interviews, including a description of their multifamily building practices, and feedback on the proposed measure. Some supported the proposed measure, some supported parts of the proposed measure, and some did not support the proposed measure. The Statewide CASE Team also subcontracted with two market actors that work directly with multifamily projects, including David Baker Architects and Morton Green Building, for insights into typical design and construction.

Table 59: Stakeholder Outreach

Stakeholder Type	Number of Individuals Contacted	Number of Individuals Engaged	Number of Organizations Engaged
Architect	4	3	2
Contractor/ Builder	9	6	5
Compliance Consultant	1	1	1
Designer	5	3	2
Developer	17	3	3
Efficiency Advocates	1	1	1
Energy and Environmental Consultants	3	2	2
HERS Rater or Acceptance Test Technician	3	2	2
Industry/Trade Associations	1	1	1
Manufacturer	4	4	4
National Laboratories and University Researchers	2	2	2
Regulatory Agency	1	0	0
Total	51	28	25

Table 60: Stakeholders Engaged

Organization/Individual Name	Market Role	Do they serve majority Affordable Housing Properties?
David Baker Architects / Billy Forest	Architect	Primarily Affordable
David Baker Architects / Katie Ackerly	Architect	Primarily Affordable
Mogavero Architects / Erin Reschke	Architect	Primarily Affordable
Brown Construction / Steve Mahieu	Contractor/ Builder	Primarily Market Rate
Build Group / Mike Borg	Contractor/ Builder	Primarily Affordable

Organization/Individual Name	Market Role	Do they serve majority Affordable Housing Properties?
Build Group / Bryan Hromatko	Contractor/ Builder	Primarily Affordable
National Core / Tim Kohut	Contractor/ Builder	Primarily Affordable
Nibbi / Kit Chang	Contractor/ Builder	Primarily Affordable
Roberts Obayashi / Scott Smith	Contractor/ Builder	Primarily Affordable
The Holt Weston Consultancy / Theresa Weston	Compliance Consultant	Primarily Market Rate
Capital Engineering / David Yasinskiy	Designer	Primarily Affordable
Capital Engineering / Mike Stanton	Designer	Primarily Affordable
Taylor Engineering / David Heinzerling	Designer	Primarily Affordable
Community Corporation of Santa Monica / Mario Washington	Developer	Primarily Affordable
Eden Housing / Kate Blessing-Kawamura	Developer	Primarily Affordable
Tenderloin Neighborhood Development Corporation / Alberto Benejam	Developer	Primarily Affordable
AEA / Nick Young	Efficiency Advocate	Primarily Affordable
Energy 350 / Meg Waltner	Energy and Environmental Consultant	N/A
Guttmann & Blaevoet Consulting Engineers / Khoeun Meisinger	Energy and Environmental Consultant	Primarily Affordable
Bright Green Strategies / Steve Davis	HERS Rater or Acceptance Test Technician	Primarily Market Rate
VCA Green / Glen Folland	HERS Rater or Acceptance Test Technician	Primarily Market Rate
Stator / Mike Moore	Industry/Trade Association	N/A
System Air/Marc Poirier	Manufacturers	N/A
Venmar/Loic Ares	Manufacturers	N/A
Delta Electronics/Jeff Klonowski	Manufacturers	N/A
Ebtron/Darryl DeAngelis	Manufacturers	N/A
UC Davis / Curtis Harrington	National Laboratories and University Researchers	N/A
Lawrence Berkeley National Laboratory (LBNL) / Iain Walker	National Laboratories and University Researchers	N/A

Engagement with DIPs

The Statewide CASE Team conducted outreach to 39 organizations that serve DIPs, with which the Statewide CASE Team conducted 20 interviews.

Table 61: Stakeholders Engaged that Serve DIPs

Stakeholder Type	Number of Organizations Interviewed	Organizations that Serve DIPs	Average % of Affordable Projects (of those that serve DIPs)
Architects	3	3	57%
Developers	3	3	100%
General Contractors	4	4	56%
Mechanical Engineers	2	2	30%
Raters	3	3	52%
Researchers	5	2	73%
Total	20	17	-

The Statewide CASE Team recommends collecting direct feedback from DIPs—through surveys or focus groups, as mentioned in Section 2: Addressing Energy Equity and Environmental Justice.

Appendix G: LSC Savings in Nominal Dollars

The CEC requested LSC Savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$.

The LSC Savings in nominal dollars are presented in Table 62 through Table 65 for the four prototype buildings.

Table 62: Nominal Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction – LowRiseGarden Prototype

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
CZ01	2536	0	2536
CZ02	1780	0	1780
CZ03	-750	0	-750
CZ04	-745	0	-745
CZ05	-852	0	-852
CZ06	90	0	90
CZ07	358	0	358
CZ08	696	0	696
CZ09	328	0	328
CZ10	213	0	213
CZ11	2256	0	2256
CZ12	2044	0	2044
CZ13	2069	0	2069
CZ14	2094	0	2094
CZ15	1139	0	1139
CZ16	86	4327	4413

Table 63: Nominal Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction – LoadedCorridor Prototype

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
CZ01	1335	0	1335
CZ02	1088	0	1088
CZ03	-471	0	-471
CZ04	-717	0	-717
CZ05	-281	0	-281
CZ06	195	0	195
CZ07	388	0	388
CZ08	581	0	581
CZ09	117	0	117
CZ10	159	0	159
CZ11	1275	0	1275
CZ12	1043	0	1043
CZ13	987	0	987
CZ14	1324	0	1324
CZ15	735	0	735
CZ16	-3	2646	2643

Table 64: Nominal Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction – MidRiseMixedUse Prototype

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
CZ01	731	203	934
CZ02	796	0	796
CZ03	576	0	576
CZ04	1136	0	1136
CZ05	662	0	662
CZ06	187	0	187
CZ07	179	0	179
CZ08	498	0	498
CZ09	500	0	500
CZ10	664	0	664
CZ11	1354	0	1354
CZ12	941	0	941
CZ13	1115	0	1115
CZ14	1402	0	1402
CZ15	1268	0	1268
CZ16	869	1158	2027

Table 65: Nominal Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction – HighRiseMixedUse Prototype

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
CZ01	798	271	1069
CZ02	995	0	995
CZ03	424	0	424
CZ04	617	0	617
CZ05	475	0	475
CZ06	113	0	113
CZ07	84	0	84
CZ08	314	0	314
CZ09	353	0	353
CZ10	468	0	468
CZ11	1342	0	1342
CZ12	1027	0	1027
CZ13	1088	0	1088
CZ14	1476	0	1476
CZ15	825	0	825
CZ16	919	1461	2380