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2025 California Energy Code

Multifamily Restructuring

Multifamily Envelope, HVAC
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Revisions as of October 13, 2023	This document contains the following revisions: 1. Included in the visible transmittance section (section 4) of the report is additional justification for forgoing a cost-effectiveness analysis, and details on climate zones included. 2. Information was added to the Skylight Properties section (section 5), including: energy savings results; cost-effectiveness analysis; revised requirements for maximum Solar Heat Gain Coefficient (SHGC); clarification for exceptions; changes needed to the ACM Reference Manual and Chapter 11 of the Nonresidential and Multifamily Compliance Manuals; and additional detail in the market impacts, economic assessments and economic impacts section. 3. In Section 10, Proposed Revisions to Code Language, Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum RSHGC, replaced the values in the row "Skylights 4 habitable stories and greater" (columns 1, 3, 5 and 16) with 'NA'. Changed the name of the last row from "Skylights 4 habitable stories and greater" to "Skylights serving common use areas". Added details to table footnote 2 so it reads "Minimum VT requirements for fenestration other than skylights do not apply to multifamily building 3 habitable stories or less". 4. Embodied carbon results were moved from the body of the report to Appendix D. 5. Fixed a typo in Table 57.

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Executive Summary

This CASE Report presents justifications for restructuring codes in 2022 Title 24, Part 6 governing multifamily buildings by reducing differences in envelope and HVAC requirements between multifamily buildings up to three habitable stories and multifamily buildings of four or more habitable stories.

These proposed code changes simplify code structure and requirements, streamline compliance and enforcement, and continue the 2022 multifamily restructuring effort, under which there was creation of new multifamily-specific chapters. The new chapters:

- Simplified compliance and enforcement by consolidating requirements for multifamily dwelling unit and common use areas.
- Improved equity across multifamily building types, regardless of number of stories.
- Established a platform from which the Energy Commission, Statewide CASE Team, and other stakeholders can investigate energy efficiency solutions unique to multifamily buildings and distinct from single family and nonresidential buildings.

More specifically, the code change proposals in this report would:

- Eliminate eight instances of differentiation in requirements between buildings of three or fewer habitable stories and buildings of four or more habitable stories. These changes reduce code complexity for streamlined compliance. These proposed changes would result in language and requirement simplification:
    - Remove 16 instances of “three or fewer habitable stories” and “four or more habitable stories.”
    - Remove two rows from tables in the multifamily chapters.
- Remove generic references to requirements outside of the multifamily chapters.
- Improve consistency in the structure and outline of the three multifamily chapters for ease of navigation and clarity of requirements.

Depending on climate zone, energy savings result from slab perimeter insulation, quality insulation installation, and central ventilation shaft sealing in new construction, and from skylight properties in alterations. No savings are associated with visible transmittance or verification cleanup.

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the CEC’s efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. 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. This report and the code change proposals 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 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 will 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.

Slab Perimeter Insulation

Proposal Description

Proposed Code Change

This proposed measure would extend the multifamily prescriptive requirement for slab perimeter insulation, currently only required for applicable multifamily buildings with three or fewer habitable stories in Climate Zone 16, to multifamily buildings with any number of habitable stories in Climate Zone 16. This proposed measure would not extend requirements to other climate zones.

Because the proposed measure changes the standard design of multifamily buildings in Climate Zone 16, it requires an update to the compliance software.

This proposed measure would not add or modify field verification or acceptance tests.

This proposed measure would also effectively change the prescriptive requirements for relevant additions of any size, which refer to the new construction requirements and do not have an exception regarding slab edge insulation. The proposed measure does not apply to alterations.

The proposed measure would also clarify one metric used for compliance, from "U-factor" as is currently stated, to "F-factor" as this is the correct term for this metric.

This change would align the code more closely with both the International Energy Conservation Code (IECC) 2021 Commercial thermal envelope requirements and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 2019 requirements for unheated slab-on-grade floors, which require slab edge insulation in high-rise multifamily buildings.

Table 1: Scope of Code Change Proposal – Slab Perimeter Insulation

Proposal Name	Slab Perimeter Insulation
Type of Requirement	Mandatory and Prescriptive
Applicable Climate Zones	Climate Zone 16
Modified Sections of Title 24, Part 6	Section 160.1; Table 170.2-A
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	Yes
Modified Compliance Documents	Certificate of Compliance: • LMCC or NRCC-ENV-01-E Envelope Component Approach Certificate of Installation:

	• 2022-LMCI-ENV-E or 2022-NRCI-ENV-E Envelope Component Approach

Cost-effectiveness

The proposed slab perimeter insulation code changes were found to be cost-effective for the one climate zone where it is proposed to be required. The benefit-to-cost (B/C) ratio over the 30-year period of analysis was 1.23 for Climate Zone 16.[1] See Section 3.4 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Visible Transmittance (VT)

Proposed Code Change

This cleanup measure would change application of VT requirements for fenestration in multifamily buildings to align with the original intent of the requirement. Instead of applying to buildings four or more habitable stories, it would apply to curtain wall/storefront and NAFS performance class AW fenestration in common use areas in multifamily buildings, regardless of number of stories. This change would apply to new construction, additions, and alterations. It does not modify field verification or require updates to the compliance software.

Table 2: Scope of Code Change Proposal – Visible Transmittance (VT)

Proposal Name	Visible Transmittance (VT)
Type of Requirement	Prescriptive
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	170.2(a)3A and Table 170.2-A
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	No
Modified Compliance Document(s)	None

Cost-effectiveness

The VT clean up code change proposal realigns the requirements with the intent of the measure to protect the energy savings from daylighting controls. This proposed measure generally does not increase stringency due to the rarity of curtain wall and NAFS performance class AW windows in multifamily buildings up to three habitable stories. The Statewide CASE Team did not complete cost-effectiveness analysis for this measure.

Skylight Properties

Proposed Code Change

This proposed measure would change the categories that determine the required performance specifications for skylight alterations in multifamily buildings. Instead of requirements of altered

[1] The B/C ratio compares the benefits or cost savings to the costs over the 30-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost-effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

or added skylights based on the number of habitable stories in the multifamily building, under this proposed measure the requirements for maximum U-factor and minimum VT for multifamily buildings with four or more habitable stories would apply instead to all multifamily buildings with any number of stories. This proposed measure would also align the maximum SHGC requirements by removing the requirement for Climate Zones 1, 3, 5, and 16 for multifamily buildings with four or more habitable stories, and for all other Climate Zones would apply the 0.25 maximum SHGC requirement for multifamily buildings with four or more habitable stories to all multifamily buildings.

This proposed measure also would specify that the minimum VT requirement for altered or added skylights in multifamily buildings only applies to skylights that serve common use areas.

This proposed measure also modifies and clarifies exceptions for added and replaced skylights under a certain amount of square feet.

In addition to alterations of skylights, this change applies to small multifamily additions that contain skylights. Section 180.1(a)1.B. states that for additions that are 700 square feet or less, fenestration products shall meet the requirements of Table 180.2-B for Altered Fenestration, which is the table that is changed in this proposed measure. Glass replaced in an existing sash and a frame or sash replaced in an existing frame are considered repairs, not alterations, and are not affected by this proposed measure.

This proposal requires a minor change to the compliance software: update the standard design for additions and alterations using these proposed specifications and exceptions.

Table 3: Scope of Code Change Proposal – Skylight Properties

Proposal Name	Skylight Properties
Type of Requirement	Prescriptive
Applicable Climate Zones	All
Modified Sections of Title 24, Part 6	Section 180.2(b)1.C.; Table 180.2-B
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	Yes
Modified Compliance Documents	Certificate of Compliance: • LMCC-ENV and NRCC-ENV Certificate of Installation: • LMCI-ENV and NRCI-ENV Certificate of Acceptance: • NRCA-ENV

Cost-effectiveness

While the skylight properties code change proposal would not increase the stringency of the existing California Energy Code, the Statewide CASE Team conducted cost-effectiveness analysis for the removal of skylight alteration SHGC requirements in Climate Zones 1, 3, 5, and 16, where it was found to be cost effective. The benefit-to-cost (B/C) ratio over the 30-year period of analysis is greater than one.

Multifamily Quality Installation Inspection (QII)

Proposed Code Change

This measure proposes a Multifamily QII verification procedure that would apply prescriptively to multifamily buildings with four or more habitable stories. Multifamily buildings with three or fewer habitable stories are currently required prescriptively to follow the existing full QII procedure. The proposed Multifamily QII verification procedures are an evolution of the existing full QII procedures, for improved practicability in larger buildings that use staged construction. There is no change proposed to the procedures themselves, only to the percentage of total wall area that is verified by a third party.

This measure would apply to all climate zones except Climate Zone 7. The proposed change applies to additions greater than 700 square feet of conditioned floor area and does not apply to alterations or to buildings using curtainwall assembly.

The measure also proposes full QII compliance option for multifamily buildings with four or more habitable stories and a Multifamily QII option for buildings with three or fewer habitable stories, using the performance compliance approach. The standard design would remain full QII for buildings up to three habitable stories, so Multifamily QII would require additional measures for compliance. The standard design for four or more habitable stories would be Multifamily QII, so full QII would allow trade off credit.

The Multifamily QII verification is designed for fewer visits to the building than full QII. The first and last habitable stories would be 100 percent verified for both the air sealing and insulation installation. Middle floors would require verification of a minimum 15 percent of the remaining total wall surface area. Middle floor inspections can be timed so that air sealing can be inspected on one floor while insulation installation is inspected on another floor. The required verification would be of all available surfaces at the time of inspection. This means that 15 percent of the remaining total wall area would need to be inspected for air sealing at the framing stage, and 15 percent of the remaining total wall area would need insulation inspection at the stage after insulation installation and before drywall installation.

When the multifamily chapter was introduced in the 2022 Title 24, Part 6 code, the 2019 QII requirements were carried over from the residential requirements for multifamily buildings with three or fewer habitable stories. An Energy Commission decision not to add or modify HERS measures at that time prohibited extension of the QII measure to multifamily buildings with four or more habitable stories. This measure seeks to extend the energy savings, cost, and comfort benefits of QII to multifamily buildings with four or more habitable stories, with modifications to requirements for larger buildings to make the measure practical and cost-effective.

The full QII procedures that were developed for single family and small multifamily buildings are not practical or cost-effective to apply to larger multifamily buildings. The full QII procedures require inspection of 100 percent of the building envelope, both for insulation installation and air sealing. Larger buildings with four or more habitable stories are typically built using staged construction, where a portion of the building is completed and walls are sealed before construction of the next phase begins. Inspecting insulation and air sealing for 100 percent of the building with multiple construction phases would require significantly more HERS Rater visits to complete, which can be both costly and logistically difficult. The proposed Multifamily QII verification requires fewer visits and flexibility in visit timing, which is more feasible for this building type, and still offers improved energy savings from improved insulation quality.

The key issues related to compliance and enforcement are summarized below:

- Additional coordination between HERS Raters and contractors to address the number and timing of visits to complete verification. HERS Raters are already required for inspection of ventilation or compartmentalization. This measure will require additional visits by a HERS Rater. HERS Raters are already familiar with the QII procedures and are already required to perform other verifications in multifamily buildings.
- California's HERS registries will need to house verification data related to all multifamily buildings.
- Multifamily project teams will need to ramp up coordination between Title 24 consultants, the developer, installation trades, and HERS Raters. HERS Raters are already familiar with the QII procedures and are already required to perform other verifications in multifamily buildings. Compliance forms would need to be updated to implement this code change proposal.

Additional information on the compliance and enforcement process can be found in Sections 6.1.5.

Table 4: Scope of Code Change Proposal – Multifamily QII

Proposal Name	Multifamily QII
Type of Requirement	Prescriptive, Compliance Option
Applicable Climate Zones	Climate Zones 1-6, 8-16
Modified Section(s) of Title 24, Part 6	170.2(a)6
Modified Title 24, Part 6 Appendices	Residential Appendix 3.5
Would Compliance Software Be Modified	Yes; Section 6.7.4 of ACM
Modified Compliance Document(s)	Certificate of Compliance: • LMCC-ENV-01-E • NRCC-ENV-01-E Certificate of Installation: • NRCI-ENV-01-E-Envelope • LMCI-ENV-21-H QII — Air Infiltration Sealing — Framing Stage • LMCI-ENV-22-H QII — Insulation Installation Certificate of Verification: • NRCV-ENV-01-Envelope • LMCV-ENV-21-H QII — Air Infiltration Sealing — Framing Stage • LMCV-ENV-22-H QII — Insulation Stage

Cost-effectiveness

The proposed Multifamily QII code changes were found to be cost-effective for all climate zones where it is proposed to be required. The B/C ratio over the 30-year period of analysis ranged

between 2.09 and 9.15 depending on climate zone.[2] See Section 6.4 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Central Ventilation Shaft Sealing

Proposed Code Change

This measure would extend mandatory central ventilation duct shaft sealing for multifamily buildings with four or more habitable stories to all multifamily buildings with central ventilation, including buildings with three habitable stories or fewer. The measure would require field verification of central ventilation duct leakage using a fan pressurization test to ensure that leakage does not exceed six percent of the central (e.g., rooftop) fan airflow rate at 50 Pa (0.2 inches of water column [w.c.]) for central ventilation duct serving more than six dwelling units, and it would require fan airflow rate at 25 Pa (0.1 inches w.c.) for central ventilation ducts serving six or fewer dwelling units.

The measure would not modify the established verification test process. Additions would need to follow proposed language for new construction. The measure would not apply to alterations.

Table 5: Scope of Code Change Proposal – Central Ventilation Shaft Sealing

Proposal Name	Central Ventilation Shaft Sealing
Type of Requirement	Mandatory
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	None
Modified Title 24, Part 6 Appendices	Nonresidential Appendix 7.1
Would Compliance Software Be Modified	Yes
Modified Compliance Document(s)	Certificate of Compliance: • LMCC-MCH-01-E Mechanical Certificate of Installation: • LMCI-MCH-27b-H Indoor Air Quality and Mechanical Ventilation Certificate of Verification • LMCV-MCH-27b-H Indoor Air Quality and Mechanical Ventilation

Cost-effectiveness

The proposed central ventilation shaft sealing code changes were found to be cost-effective for all climate zones where it is proposed to be required. The B/C ratio over the 30-year period of analysis ranged between 1 and 7 depending on climate zone.[3] See Section 7.4 for the methodology, assumptions, and results of the cost-effectiveness analysis.

[2] The B/C ratio compares the benefits or cost savings to the costs over the 30-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost-effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

[3] The B/C ratio compares the benefits or cost savings to the costs over the 30-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost-effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

Verification Clean Up

Proposed Code Change

This measure would extend HERS compliance credits to all applicable multifamily buildings, regardless of number of habitable stories, for:

1. **Low Leakage Air-handling Units**: Verify low leakage air handler and ducts installed and system leakage rate meets or exceeds rate specified on certificate of compliance.
2. **Variable Capacity Heat Pump (VCHP) Compliance Option**: Verify system equipment is listed in CEC low-static pressure systems, non-continuous fan operation, refrigerant charge, low leakage ducts in conditioned space, ductless system in conditioned space, airflow to all habitable spaces, wall-mounted thermostats for zones >150 ft^2, ducted airflow, and air filter pressure drop.

The measure would remove verification requirements for buildings with three or fewer habitable stories, so that the compliance options can be claimed without verification for all applicable multifamily buildings, regardless of number of habitable stories, for:

1. **Verified Energy Efficiency Ratio (EER/EER2)**: Verify system equipment is listed in approved directory and necessary information is provided.
2. **Verified Seasonal Energy Efficiency Ratio (SEER/SEER2)**: Verify system equipment is listed in approved directory and necessary information is provided.
3. **Verified Heating Seasonal Performance Factor (HSPF/HSPF2):** Verify system equipment is listed in approved directory and necessary information is provided.
4. **Rated Heat Pump Capacity Verification**: Verify system equipment is listed in approved directory and heating capacities are greater than or equal to values specified on certificate of compliance.

The measure would also remove compliance options that are not applicable or common in multifamily buildings, including:

1. **Evaporatively Cooled Condensers** — Verify low leakage ducts, refrigerant charge, time delay response, listed equipment, and system efficiencies.
2. **Whole House Fan**: Verify airflow rate and watt draw. Calculate efficacy (w/cfm). Confirm airflow rate and efficacy meet or exceed requirements of certificate of compliance.
3. **Central Fan Ventilation Cooling System**: Verify system airflow and fan efficacy meet or exceed requirements of certificate of compliance.
4. **Pre-cooling**: Verify installation and programming of a pre-cooling thermostat.

The measure would not modify the process for conducting the verification tests.

The measure would replace mention of “low-rise residential” and “high-rise residential” in the Residential and Nonresidential Appendices with “single family” and “multifamily” and appropriate mention of multifamily buildings up to three habitable stories and four or more habitable stories. The verification clean up measure would also remove references in Residential Reference Appendices to the multifamily chapter for verification of prescriptive bypass duct requirements, which are not allowed in multifamily buildings.

The proposal would not affect addition or alterations.

The relevant measures would need to be added or removed as HERS compliance options in the compliance software.

Table 6: Scope of Code Change Proposal – Verification Clean Up

Proposal Name	Verification Clean Up
Type of Requirement	Compliance Option
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	None
Modified Title 24, Part 6 Appendices	Residential Appendices 3.1.1 and 3.3
Would Compliance Software Be Modified	Yes; ACM Reference Manual Section 6.8.2
Modified Compliance Document(s)	Certificate of Compliance: • LMCC-MCH-E • NRCC-MCH-E Certificate of Installation: • LMCI-MCH-01-E • LMCI-MCH-(22, 26, 27)- H • NRCI-MCH-01-E • NRCI-MCH-20-F Certificate of Verification • LMCV-MCH- (22,26,27)-H • NRCV-MCH-(04,22)-H Certificate of Acceptance

Cost-effectiveness

A cost analysis is not necessary because the verification clean up measure applies only to compliance options and would not change the mandatory or prescriptive requirements.

Additions and Alterations Clean Up

Proposed Code Change

2022 multifamily restructuring left some gaps and misalignments in the additions, alterations, and repairs chapter. Updating these sections provides an opportunity to clean up the gaps and misalignments and to streamline code language. This clean up measure would simplify language and structure and ensure that dwelling units and common use areas are appropriately addressed. This measure would add clarity and would not change the requirements in the multifamily additions, alterations, and repairs chapter. Changes would include:

- Expanded definitions for “additions” and “alterations”
- Primary organization by dwelling unit and common use area
- Secondary organization by building component
- Specific section references, rather than broad references, back to applicable new construction requirements

- Added language to clarify application of requirements to specific additions or alterations scope and building component or system type

Table 7: Scope of Code Change Proposal – Additions and Alterations Clean Up

Proposal Name	Additions and Alterations Clean Up
Type of Requirement	Reorganization and clean up (no changes to requirements)
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	180.0, 180.1, and 180.2
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	No
Modified Compliance Document(s)	None

Cost-effectiveness

The additions and alterations clean up code change proposal would not modify the stringency of the existing California Energy Code, so the CEC does not need a complete cost-effectiveness analysis to approve the proposed change.

Addressing Energy Equity and Environmental Justice

The Statewide CASE Team reviewed published studies that considered how disproportionately impacted populations (DIPs) would be impacted by the proposed measure. The following measures in this report may benefit DIPs through improved indoor air quality:

- Slab perimeter insulation may prevent mold by reducing condensation issues on the ground floor of buildings, especially in colder parts of Climate Zone 16 (Office of Energy Efficiency and Renewable Energy 2022).
- Improved cavity air sealing through multifamily quality insulation installation may lower exposure to outdoor air pollution, dry rot, and moisture problems.
- Improved duct sealing through central ventilation shaft sealing would reduce air leakage between dwelling units, limiting transfer of smoke and contaminants like carbon monoxide from adjacent units.

Improved insulation and air sealing would also offer other non-energy benefits like sound insulation and thermal comfort for residents. Reduced heat gain and heat loss from a well-insulated and sealed building envelope will maintain adequate temperature conditions for longer, increasing building resilience in extreme weather and power outages. Full details addressing energy equity and environmental justice can be found in Section 2 of this report.

1. Introduction

The proposals included in the Multifamily Restructuring CASE Report focus on continuation of the 2022 multifamily restructuring effort, under which creation of new multifamily-specific chapters:

- Simplified compliance and enforcement by consolidating requirements for multifamily dwelling unit and common use areas;
- Improved equity across multifamily building types, regardless of number of stories; and
- Established a platform from which the Energy Commission, Statewide CASE Team, and other stakeholders can investigate energy efficiency solutions unique to multifamily buildings (and distinct from single family and nonresidential buildings).

More specifically, the code change proposals in this report would:

- Eliminate eight instances of differentiation in requirements between buildings three or fewer habitable stories and buildings four or more habitable stories. These changes reduce code complexity for streamlined compliance. These proposed changes would result in language and requirement simplification including:
    - Removing 16 instances of “three or fewer habitable stories” and “four or more habitable stories”
    - Removing two rows from tables in the multifamily chapters
- Remove generic references to requirements outside of the multifamily chapters.
- Improve consistency in the structure and outline of the three multifamily chapters for ease of navigation and clarity of requirements.

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the CEC’s 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 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’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 will evaluate proposals the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. See https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency for information about the rulemaking schedule and how to participate in the process.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders including

architects and designers, HERS providers, HERS Raters, and Acceptance Test Technicians (ATT). The proposal incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on February 14, 2023, and February 21, 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 disproportionately impacted populations (DIPs), as well as a summary of research and engagement methods.

Sections 3 through 9 include the following subsections for each topic or measure:

Section 3.1– Measure Description of this CASE Report 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 x.2 – Market Analysis includes a review of the current market structure. Section x.2.2 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, as well as whether technical, compliance, or enforceability challenges exist.

Section x.3 – Energy Savings presents the per unit energy, demand reduction, and Long-term Systemwide Cost (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 x.4 – 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 x.5 – 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 and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.

Section 10 – 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 Method (ACM) Reference Manual. Generalized proposed revisions to sections are included for the Compliance Manual and compliance documents.

Section 11 – 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 and the energy savings resulting from reduced water use.

Appendix C**: 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 market actors.

Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.

The California IOUs offer 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

2.1 General Equity Impacts

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, presence of hazardous wastes, as well as 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, and experience the world.[4]

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 energy equity and environmental justice topics, Marissa Lerner (mlerner@energy-solution.com), or the lead for the multifamily restructuring topic, Lucy Albin (lalbin@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 beyond.[5] To

[4] 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 in 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.

[5] The CEC defines energy equity as "the quality of being fair or just in the availability and distribution of energy programs" (CEC 2018). American Council for an Energy-Efficient Economy (ACEEE) defines

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 will 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 will be documented in the 2025 EEEJ Summary Report that is expected to be published on title24stakeholders.com by the end of 2023.

2.1.1 Procedural Equity and Stakeholder Engagement

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 improve representation of DIPs' perspective in future code cycles. 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.
- 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 will come to an end, the Statewide CASE Team's EEEJ efforts will 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 a goal of engagement 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.

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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" (ACEEE n.d.). 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" (State of California n.d.).

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.

Several of the potential negative health impacts from buildings on DIPs are addressed by energy efficiency (Norton 2014., Cluett 2015, Rose 2020). For example, indoor air quality (IAQ) improvements through ventilation or removal of combustion appliances can lessen the incidents 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 intrusion of dampness and contaminants, as well as providing a measure of resilience during extreme conditions. Electrification can reduce the health consequences resulting from NOx, SO_2, and $PM_{2.5}$. Studies have shown that not only do the effects of urban heat islands lead to higher mortality during heat waves, but those in large buildings are disproportionately affected (Smargiassi 2008, Laaidi 2012). These residents tend to be the elderly, people of color, and low-income households (Drehobl 2020, Blankenship 2020, IEA 2014).

As described in Section 2.2, homes in disadvantaged communities (DACs) 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.

2.1.2.2 Energy Efficiency and Energy Burden

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 2014., Rose 2020). See section(s) 3.3, 6.3, and 7.3 for an estimate of energy savings from the current proposals. Moreover, utility cost stability is typically more important to these households compared to average households; for households living paycheck to paycheck, keep that household cyclically impoverished (Drehobl 2020). Energy burdened households are 175 to 200 percent more likely to remain impoverished for longer than households not experiencing energy burden (Drehobl 2020).The impact of a rate increase or weather-related spike is more easily handled the greater the 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 market rate multifamily buildings.

2.1.2.3 First Cost and Cost of New Construction

One potential negative consequence to DIPs of code-based efficiency improvements is the potential for increased housing 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 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 2015). Similarly, developers of market-rate apartments conduct

studies on a case-by-case basis to investigate rent history and other information for comparable multifamily properties, which informs rent levels for specific projects.[6]

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 will be lower to the degree their homes are more energy efficient. However, the utility bill impacts of energy efficiency in subsidized affordable housing are less clear. 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,[7] 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

The measures in this CASE Report apply to all multifamily buildings. Low-income households are more likely to live in multifamily housing. Low-income households range from 38 to 66 percent of all multifamily households for the three major investor-owned utilities and nearly half of all low-income households live in multifamily housing (Elkind and Lamm 2019). Low-income multifamily residents experience higher energy burden (5.0 percent) than the median energy burden in California (3.5 percent) and spend a disproportionate amount of their income on utility bills. According to a study conducted by the American Council for an Energy-Efficient Economy (ACEEE), 5.5 percent of low-income customers in California experienced disconnections for nonpayment as compared with 2.9 percent of non-low-income customers (Ross 2016). Minority households in California, including African American and Latino residents, also experience higher energy burdens (5.4 and 4.1 percent, respectively) than the median according to the ACEEE study.

The measures proposed in this report will result in energy cost savings, which will provide a higher benefit to people in low-income households who spend a higher percentage of their income on energy and rent. Lower utility bills will also decrease the number of customers likely to experience disconnections due to nonpayment.

Measures in this report may benefit DIPs through improved indoor air quality, sound insulation and thermal comfort, as described in Sections 3.6, 6.6, and 7.6.

[6] Examples include Yardi-Matrix (Yardi Matrix 2023), HCA (HCA 2020), and Foley & Puls (Foley & Puls, Inc. 2017), which all conduct market studies.

[7] 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.

3. Slab Perimeter Insulation

3.1 Measure Description

3.1.1 Proposed Code Change

This proposed measure would extend the multifamily prescriptive requirement for slab perimeter insulation, currently only required for applicable multifamily buildings with three or fewer habitable stories, to multifamily buildings with any number of habitable stories.

Slab perimeter insulation is currently prescriptively required in Climate Zone 16. This proposed measure would not extend requirements to other climate zones.

This proposed measure would change the standard design of multifamily buildings in Climate Zone 16—therefore, it requires an update to the compliance software.

This proposed measure would not add or modify field verification or acceptance tests.

This proposed measure would also effectively change the prescriptive requirements for relevant additions of any size, which refer to the new construction requirements and do not have an exception regarding slab edge insulation. The proposed measure does not apply to alterations.

The proposed measure would also clarify one metric used for compliance, from “U-factor” as is currently stated, to “F-factor” as this is the correct term for this metric.

3.1.2 Justification and Background Information

3.1.2.1 Justification

The justification behind this code proposal, as with other proposed measures in this Restructuring CASE Report, is to simplify and streamline an existing code requirement across multifamily buildings that is currently split based on number of habitable stories. For slab perimeter insulation, extending this requirement to all multifamily buildings in Climate Zone 16 would remove this unnecessary split. As described in Section 2.2.2Technical Feasibility and Market Availability, there are no significant technical feasibility issues for slab edge insulation on buildings with four or more stories compared to buildings with fewer stories. This change would align the code more closely with both the International Energy Conservation Code (IECC) 2021 Commercial thermal envelope requirements and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 2019 requirements for unheated slab-on-grade floors, which require slab edge insulation in high-rise multifamily buildings.

3.1.2.2 Background Information

Slab perimeter insulation, also called slab edge insulation, refers to insulation placed alongside the perimeter of a concrete slab. In this usage, *slab* is referring to a slab-on-grade foundation, which is an exterior concrete floor in direct contact with the earth below the building.

Slab perimeter in this section refers to the location of insulation, not a type of floor as with other requirements in the same section of the table in the code.

The slab perimeter insulation requirement applies to buildings with a slab-on-grade foundation that is part of the thermal envelope. The Statewide CASE Team interviewed an energy and

design consultant with multifamily building experience in Climate Zone 16, who expressed that buildings with four or more stories in this part of the state very rarely, if ever, have this kind of foundation, but that almost all buildings with slab-on-grade foundations in Climate Zone 16 are already using slab perimeter insulation, especially to protect the foundation from frost and therefore protect its structural integrity.

Concrete is generally a poor insulator, and so slab edge insulation helps to slow heat flow between the bottom floor of a building and the earth and air around it. This is especially useful in cold climates, where the temperature difference between outside and inside is large during much of the cold season, and significant heat and energy can be lost through a concrete slab foundation. Slab edge insulation also helps prevent moisture and condensation issues from temperature difference; therefore, it helps prevent mold, a contributor to poor indoor air quality (Office of Energy Efficiency and Renewable Energy 2022).

The proposed measure applies only to Climate Zone 16, a map of which is shown in Figure 1. This proposed measure would save energy in the relatively cold Climate Zone 16 by adding insulation to the thermal boundary where heat is lost when outside temperatures and ground temperatures are lower than inside the building envelope. The code specifies that where it is required, “the minimum depth of concrete slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.” This proposed measure does not change this depth requirement.

Figure 1: Climate Zone 16 (Pacific Energy Center 2006)

The current code requirement for slab perimeter insulation has been present in Title 24, Part 6 since at least the 2005 version of the code.

ASHRAE 90.1 and IECC 2021 Commercial requirements for slab edge insulation already apply to high-rise residential buildings with slab-on-grade foundations. Refer to section 2.1.4, Regulatory Context, for more information on this.

3.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[8] See Section 10 of this report for detailed proposed revisions to code language.

3.1.3.1 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 10.2 of this report for marked-up code language.

Section: 160.1(g) — *New*

Specific Purpose: The specific purpose is to require mandatory minimum specifications for slab edge insulation materials regarding water absorption rate, water vapor permeance, damage protection, and ultraviolet protection.

Necessity: These changes are necessary to ensure that materials used for slab perimeter insulation are protected.

Section: TABLE 170.2-A

Specific Purpose: The specific purpose of the change is to apply prescriptive slab perimeter insulation requirements to all multifamily buildings in Climate Zone 16, rather than only to those buildings with three habitable stories or less, and to clarify the correct usage and nomenclature of the "F-factor" compliance metric.

Necessity: These changes are necessary to simplify the energy code and to increase energy efficiency via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

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

The proposed code change would not modify the ACM Reference Manual, as it already includes a Standard Design with slab edge insulation in Climate Zone 16 without a differentiation based on number of stories. If this proposed measure does not become code, this oversight should be corrected in the ACM Reference Manual. This measure would modify the CBECC 2025 compliance software to include slab perimeter insulation in the Standard Design of multifamily buildings with four or more stories in Climate Zone 16.

3.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Section 11.3.3.16 of the Nonresidential and Multifamily Compliance Manual would be changed to remove the words "for buildings up to three habitable stories" in the Slab Edge Prescriptive Requirements.

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

Section 11.3 would add new references to the mandatory requirements for slab edge insulation, 160.1(g), in Table 11-5, and in Section 11.3.3.16.

3.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would change the field regarding slab edge insulation in the Envelope Certificate of Compliance forms for multifamily buildings (LMCC-ENV-01-E and CEC-NRCC-ENV-E) to remove language about this field only applying to low-rise buildings. It would also add a field to the Envelope Component Approach Certificate of Installation form used for multifamily buildings with four or more habitable stories (NRCI-ENV-E) to document installation of slab edge insulation, as is documented in LMCI-ENV-22-H for multifamily buildings with three or fewer habitable stories.

3.1.4 Regulatory Context

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

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

There are no relevant state or local laws or regulations.

3.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

3.1.4.3 Difference From Existing Model Codes and Industry Standards

The current versions of ASHRAE 90.1 (2019) and IECC Commercial (2021) both require perimeter insulation for unheated slab-on-grade foundations of high-rise residential buildings that are part of the thermal envelope in IECC Climate Zones 3 through 8. Applied in California, these IECC Climate Zones cover all but Imperial County. The IECC Commercial and ASHRAE 90.1 standards require between R-10 and R-20 insulation, with a depth requirement between 24” and 48”. California Climate Zone 16 intersects with parts of IECC Climate Zones 3, 4, 5, and 6 (Warm, Mixed, Cool, and Coll).

The IECC Commercial code and ASHRAE 90.1 code both include an F-factor requirement, and the IECC Commercial code specifies that the F-factor calculation method can be used as an alternative.

3.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:**
    - Architect and energy consultant identifies and coordinates slab insulation compliance path options, follows minimum energy code requirements for slab edge insulation, and documents these in plans and schedules.
2. **Permit Application Phase:**
    - Energy consultant completes compliance documents for the permit application, documenting any relevant slab edge insulation.
    - General contractor applies for the building permit with slab edge insulation shown on the LMCC or NRCC-ENV-01-E Envelope Certificate of Compliance document.
    - Plans examiner verifies slab edge insulation information on the construction documents is consistent with requirements on compliance documents.
3. **Construction Phase:**
    - A contractor installs slab edge insulation according to design details, before or after concrete is poured, and completes 2022-LMCI-ENV-22 or 2022-NRCI-ENV-E Envelope Certificate of Installation compliance document.
4. **Inspection Phase:**
    - Building inspector visits the site to verify slab edge insulation.

For compliance verification, this measure would add the steps of an energy consultant filling out fields regarding slab edge insulation in the Envelope Certificate of Compliance form for multifamily buildings with four or more stories in Climate Zone 16, and it would add the step of a plans examiner verifying the information in these fields, the step of a contractor filling out slab edge insulation fields in the Certificate of Installation form, and the inspector performing verification.

3.2 Market Analysis

3.2.1 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.

Throughout the construction process — from design concept to construction — various market actors make decisions regarding the energy efficiency of the thermal envelope of multifamily buildings, including insulation properties of the foundation. The general roles of market actors in compliance verification are:

1. Developers and owners make design decisions regarding the envelope, with support from professional services such as architects, structural engineers, procurement professionals, and construction contractors, both general contractors and specific trades.

2. Energy consultants document energy code requirements and conduct energy modeling for the performance approach.
3. Plans examiners verify compliance.
4. Building inspectors examine the building to verify installation matches plans.

3.2.2 Technical Feasibility and Market Availability

The Statewide Case Team interviewed two architects, one energy consultant, and a designer that works in Climate Zone 16, one constructability expert, and three contractors. None had major concerns about the proposed requirement regarding its technical feasibility or the availability of relevant materials. The energy consultant with relevant experience in the climate zone expressed that slab-on-grade foundations are very uncommon in multifamily buildings with four or more habitable stories in Climate Zone 16. The consultant explained that this is due in part to structural integrity concerns of below freezing winter ground temperatures, which push designers to design habitable space in taller buildings above unconditioned, semi-conditioned, or semi-protected parking garages. Although this proposed measure would not likely affect many buildings in the near term, it would simplify the code requirements and compliance documents while aligning with existing model codes. ASHRAE 90.1 and IECC Commercial codes both apply only to high-rise buildings, and they currently require a slab edge insulation requirement for multifamily buildings in colder parts of California.

The Statewide CASE Team interviewed a Title 24, Part 6 energy code expert who consulted with a structural engineer and confirmed that the most common design choice for buildings with four or more habitable stories with slab perimeter insulation is a monolithic slab with vertical insulation on the outside, but that a concrete stem wall with vertical insulation is also a foundation design option. With a slab-on-grade foundation with concrete stem walls, insulation can be placed either inside the stem wall (between the stem wall and the slab on grade) or outside of the stem wall. Both options are illustrated in the Title 24, Part 6 2022 Multifamily and Nonresidential Compliance Manual, in Figure 11-6. The interviewee confirmed that there are no significant engineering issues with adding slab perimeter insulation to taller buildings as compared to buildings with three or fewer habitable stories, as footings are typically designed based on vertical soil bearing capacity, and very little load is attributed to the side of the footing where perimeter insulation would be placed.

In a survey conducted by the Statewide CASE Team, 47 builders, designers, and contractors involved primarily with multifamily buildings responded regarding their experience with slab edge insulation, with 26 responding that they did have experience. Of these, only four noted any issues with feasibility, noting concerns with cost, potential improper installation, meeting standards appropriately, sequencing of construction, and adjusting glazing to cover the insulation. None of these issues appear to clearly refer to issues specific to buildings with four or more habitable stories.

Some technical considerations are addressed through this proposed measure's mandatory requirements, which are identical to the existing single family residential mandatory requirements for slab edge insulation in Section 150.0(f). These require that material used for slab edge insulation shall meet minimum specifications for water absorption rate, and water vapor permeance and shall be protected from physical damage and ultraviolet light deterioration. Various materials can be used to protect the insulation from physical damage such as weed trimmers and from the sun's UV radiation such as sheet metal flashing, stainless steel, fiber-reinforced cement board with stucco coating and metal flashing, or ethylene

propylene diene monomer rubber sheets (Ezell 2020). Each material has its own benefits and drawbacks.

Another technical consideration is the possibility of termite damage. This can be addressed in several ways, including using a termite inspection gap (required in some jurisdictions) or a protective membrane (Office of Energy Efficiency and Renewable Energy 2022).

Several types of insulation are widely available in the market that are appropriate for ground contact and for slab edge insulation, such as extruded polystyrene (XPS), rigid fiberglass, and rock wool (Office of Energy Efficiency and Renewable Energy 2022). These products are the same that are used for buildings that currently have a prescriptive slab perimeter insulation requirement, and there are no concerns regarding market availability with this proposed measure.

3.2.3 Market Impacts and Economic Assessments

3.2.3.1 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 to remain current with changes to design practices and building codes.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 8). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction roles in the industrial sector.

Table 8: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

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

Source: (State of California n.d.)

The proposed change to slab perimeter insulation would likely affect multifamily builders but 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 and commercial building industry would not be felt by all firms and workers, but they would rather be concentrated in specific industry subsectors. Table 9 shows the residential building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. Slab

edge insulation is often installed by a general contractor, an insulation contractor, or a concrete or foundation contractor, while the other components such as siding are often installed by a siding contractor. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.2.4 Economic Impacts.

Table 9: 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 poured foundation contractors	1,505	16,369	1.1
Residential masonry contractors	1,177	10,071	0.6
Residential siding contractors	242	2,081	0.1
Other residential exterior contractors	628	2,875	0.2
Residential site preparation contractors	1,418	11,526	0.9

Source: (State of California n.d.)

3.2.3.2 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 current with changes to design practices and building codes.

The proposed code change would potentially impact the workflow of builders, building designers, architects, engineers, and energy consultants with projects in Climate Zone 16, as the new prescriptive requirement would change the design requirements of some multifamily buildings in this climate zone.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System [NAICS] 541310). Table 10 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact a moderate proportion of firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for slab edge insulation to affect firms that focus on multifamily construction.

There is not a NAICS[9] 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

[9] 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.

of residential and nonresidential buildings.[10] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 10 provides an upper bound indicating the size of this sector in California.

Table 10: 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 and nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspectional services.

3.2.3.3 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 (DOSH). 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.

3.2.3.4 Impact on Building Owners and Occupants Including Homeowners and Potential First-Time Homeowners

Residential Buildings

According to data from the U.S. Census, American Community Survey (ACS), there were more than 14.5 million housing units in California in 2021 and nearly 13.3 million were occupied (see Table 11). 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 ten or more units. The California Department of Revenue estimated that building permits for 67,300 single family and 54,900 multifamily dwelling units will be issued in 2022, up from 66,000 single family and 53,500 multifamily permits issued in 2021.

[10] 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.

Table 11: California Housing Characteristics in 2021

Housing Measure [a]	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 12 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 2019).

Table 12: 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 13 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 13: 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 11. Table 13 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 12 and Table 13.

Estimating Impacts

Building owners and occupants would benefit from lower energy bills. As discussed in Section 3.2.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

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

Because this measure is expected to impact less than one building per year, and requires components that are widely available, the Statewide CASE Team anticipates the proposed change would have negligible material impact on California component retailers.

3.2.3.6 Impact on Building Inspectors

Table 14 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 proposed measure extends the application of an existing prescriptive requirement that building inspectors in Climate Zone 16 are already accustomed to. 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 14: 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.)

a. 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.

b. 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.

3.2.3.7 Impact on Statewide Employment

As described in Sections 3.2.3.1 through 3.2.3.6, 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 Section 3.2.4, the Statewide CASE Team estimated the proposed change in slab perimeter insulation would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors.

3.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[11], along with economic information from published sources, and professional judgment 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 total number of jobs created due to a code. The assumptions of IMPLAN include constant returns to

[11] 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.

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 macroeconomy.

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 aspect 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 and remodeling 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.[12]

The estimates in this section used estimated incremental first cost as described in Section 3.4.3, and assumed that the measure would affect five percent of mid-rise multifamily buildings in Climate Zone 16, which amounts to approximately one building every nine years. The estimates also assume approximately 30 minutes of additional time needed by building designers and energy consultants per building.

Table 15: Estimated Impact that Adoption of the Proposed Measure would have on the California Residential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income (Dollars)	Total Value Added (Dollars)	Output (Dollars)
Direct Effects (Additional spending by Multifamily Builders)	0.0	$544	$720	$878
Indirect Effect (Additional spending by firms supporting Multifamily Builders)	0.0	$62	$101	$175
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.0	$174	$312	$497
Total Economic Impacts	**0.0**	**$781**	**$1,134**	**$1,550**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[13]

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

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

Table 16: Estimated 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 (Dollars)	Total Value Added (Dollars)	Output (Dollars)
Direct Effects (Additional spending by Building Designers & Energy Consultants)	0.0	$3	$3	$5
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.0	$1	$1	$2
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.0	$1	$2	$3
Total Economic Impacts	**0.0**	**$5**	**$6**	**$10**

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

Table 17: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income (Dollars)	Total Value Added (Dollars)	Output (Dollars)
Direct Effects (Additional spending by Building Inspectors)	0.0	$1	$2	$2
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.0	$0	$0	$0
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.0	$0	$1	$1
Total Economic Impacts	**0.0**	**$2**	**$3**	**$4**

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

3.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation 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 estimates of economic impacts discussed in Section 3.2.4 would lead to modest changes in employment of existing jobs.

3.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.2.4.1, 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 slab perimeter insulation prescriptive requirements, 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.

3.2.4.3 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.[14] 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.

3.2.4.4 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.[15] As Table 18 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 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 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 18: 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	518.47	1882.46	28
2018	636.85	1977.48	32
2019	690.87	1952.43	35
2020	343.62	1908.43	18
2021	506.33	2619.98	19
5-Year Average	**539.227**	**2068.156**	**26**

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

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant increase or decrease in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume will be allocated to net business investment.[16]

[14] 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.

[15] 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.

[16] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 18.

3.2.4.5 Incentives for Innovation in Products, Materials, or Processes

The proposed measure incentivizes innovation in building materials, components, and processes by setting broad prescriptive requirements and sensible mandatory attributes without mandating any specific construction techniques or materials.

3.2.4.6 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.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will 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 cost savings and policy benefits associated with the code change proposals. This multifamily measure would not affect state buildings.

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 IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 3.1.5 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.

3.2.4.7 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. Multifamily dwelling unit renters and owners in Climate Zone 16 are expected to be impacted by the costs of this measure, and of those people, those residing on the bottom floor are expected to benefit the most from energy savings and indoor air quality benefits. Refer to Section 2 for more details addressing energy equity and environmental justice.

3.2.5 Fiscal Impacts

3.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because the measure impacts multifamily buildings only.

3.2.5.2 Costs to Local Agencies or School Districts
There are no costs to local agencies or school districts because the measure impacts multifamily buildings only.

3.2.5.3 Costs or Savings to Any State Agency
There are no costs or savings to any state agencies because the measure impacts multifamily buildings only, and state agencies are not involved in the enforcement of the measure.

3.2.5.4 Other Nondiscretionary Cost or Savings Imposed on Local Agencies
There are no added nondiscretionary costs or savings to local agencies because the measure impacts multifamily buildings only.

3.2.5.5 Costs or Savings in Federal Funding to the State
There are no costs or savings to federal funding to the state because the measure impacts multifamily buildings only and would not require federal funding to implement.

3.3 Energy Savings
The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis, and interviewed two architects, one energy consultant and designer that works in Climate Zone 16, one constructability expert, and three contractors. These interviews informed modifications to the prototype building to represent a building with four or more habitable stories more likely to have a slab-on-grade foundation, as described in Section 3.3.1.1. See Appendix F for a summary of stakeholder engagement.

Energy savings benefits may affect DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

3.3.1 Energy Savings Methodology

3.3.1.1 Key Assumptions for Energy Savings Analysis
The energy savings analysis relied on California Building Energy Code Compliance for Commercial/Nonresidential Buildings Software (CBECC) 2025 software to estimate energy use for a multifamily building with four habitable stories in Climate Zone 16, and it compared the current requirements without slab edge insulation to the proposed requirements. The proposed case was modeled by adding R-7 insulation to the slab foundation at a depth of 16 inches, which would be the minimum amount and depth to meet the code.

Because none of the multifamily prototypes has greater than four stories with a slab-on-grade foundation, the Loaded Corridor prototype was modified by adding one story to create a base case model. The Statewide CASE Team simulated the energy impacts in Climate Zone 16 only.

3.3.1.2 Energy Savings Methodology per Prototypical Building
The Statewide CASE Team measured 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 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 GHG emissions. Finally, the Statewide CASE Team calculated LSC Savings, formerly known as Time Dependent Valuation (TDV) Energy Cost Savings. LSC Savings are calculated using hourly LSC factors for both electricity and natural gas provided by the CEC. These 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 CO_2 emissions.[17]

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. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 19. Because none of the multifamily prototypes has four or more stories with a slab-on-grade foundation, the Loaded Corridor prototype was modified by adding a fourth story to create a base case model that would represent a building affected by this proposed change. The story added was an identical, duplicated version of the original prototype's second story. The prototype was also modified by removing the slab edge insulation for the base case, as this represents the current prescriptive requirement meeting minimum code requirements for buildings with four or more habitable stories.

Table 19: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Loaded Corridor, Modified	4	52,388	4-story, 49-unit apartment building. Average dwelling unit size: 960 ft^2. Dual fuel in CZ16.

The Statewide CASE Team estimated LSC, source energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change using the modified prototypical building and rulesets from the 2025 Research Version of the CBECC software (California Energy Commission n.d.).

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[18] 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 the modified prototypical building with the Standard Design representing compliance with 2022 code and the Proposed Design representing

17 See Hourly Factors for Source Energy, SLCC, and GHG Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

18 CBECC 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.

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.

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 20 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume vertical R-7 insulation around the exterior of the slab foundation, in Climate Zone 16.

Table 20: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Loaded Corridor, Modified	16	ResSlabFlr	EdgeInsulation	0	1

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/y) and therms per year (therms/y). 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/y) and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions. CBECC also calculates annual peak electricity demand measured in kilowatts (kW).

Since the proposed code change only applies to Climate Zone 16, the Statewide CASE Team simulated the energy impact in Climate Zone 16 only. Per unit energy impacts for multifamily buildings are presented in savings per dwelling unit. Annual energy and peak demand impacts for the modified 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.

3.3.1.3 Statewide Energy Savings Methodology

The per unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided (California Energy Commission 2022). The Statewide Construction Forecasts estimate new construction that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. The construction forecast provides construction (new construction) by building type and climate zone, as shown in Appendix A. The construction forecasts for multifamily buildings with four or more habitable stories were used to estimate statewide impacts by multiplying these forecasts by the percentage of each that is expected to have s slab-on-grade foundation. These percentages were estimated through interview responses.

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

3.3.2 Per Unit Energy Impacts Results

The per unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per unit gas savings for the first year are expected to be 310 kBtu/y, with a per unit increase in electricity usage of 3 kWh/y. Demand increases are expected to be 0.07 kW per unit.

As modeled, the proposed measure shows some gas energy savings. It also shows a very small amount of added electricity usage, likely due to increased cooling as less heat is transferred to the outside air and ground. In terms of lifecycle cost savings, the gas energy savings far outweigh the small amount of added electricity.

Energy savings are likely conservative, as one contractor expressed in an interview with the Statewide CASE Team that 24 inches of insulation would often be installed if 16 inches is required, as this is a standard size that would not require cutting the insulation.

Table 21: Per unit Energy Impacts — Slab Perimeter Insulation

Type of Impact from Proposed Code Change: Slab Perimeter Insulation — Loaded Corridor Prototype, Climate Zone 16	Estimated Savings
First-year Electricity Savings (kWh) Per Dwelling Unit	-3
First-Year Peak Demand Reduction (kW) Per Dwelling Unit	-0.07
First-Year Natural Gas Savings (kBtu) Per Dwelling Unit	310
First-Year Source Energy Savings (kBtu) Per Dwelling Unit	277
30-year LSC Savings (2026 PV$) Per Dwelling Unit	366

3.4 Cost and Cost-effectiveness

3.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 3.4.1. LSC hourly factors are a normalized metric to calculate energy cost 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 30-year period of analysis.

The CEC requested LSC savings over the 30-year period of analysis in both 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 3.4 of this report. The CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (Form 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars.

This proposed measure also applies to the prescriptive requirements for relevant additions of any size but does not apply to alterations.

3.4.2 Energy Cost Savings Results

Per unit energy cost savings for newly constructed buildings in terms of LSC savings realized over the 30-year period of analysis are presented 2026 PV$ in Table 22. As explained in Section 3.3.1.2, the prototype building has a gas heating in Climate Zone 16. The results show gas

savings from decreased heating load, as well as a relatively small increase in electricity usage from increased cooling load.

The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Any time code changes impact cost, there is potential to affect DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

Table 22: 2026 PV LSC Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction and Additions — Loaded Corridor Modified Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Energy Savings (2026 PV$)
16	-18	384	366

3.4.3 Incremental First Cost

The Statewide CASE Team solicited cost estimates from several stakeholders involved with multifamily construction, by providing the proposed mandatory requirements and one basic diagram of perimeter insulation on a monolithic slab-grade beam and asking the stakeholders to provide estimated costs for the same or similar design for a building with 522 linear feet of perimeter (the perimeter of the Loaded Corridor Modified prototype building). The Statewide CASE Team consulted with an expert on Title 24, Part 6 energy code requirements, who advised on design elements that would meet proposed mandatory minimum code requirements.

One stakeholder provided a design that met the requested specifications. This stakeholder is a multifamily and commercial contractor mostly working as an insulation subcontractor in the Sacramento area, who consulted with colleagues at the same company who build in colder climates. This stakeholder only provided costs for the following components, and costs were given in dollars per linear foot of perimeter:

- 1.5″ extruded polystyrene (XPS) insulation, R7.5
- Hilti X-IE pins to mechanically fasten insulation
- Applicable labor, including transportation to Climate Zone 16

The stakeholder explained that if any additional exterior protection board or facer, or metal flashing, were required, this would likely be included in the scope of the subcontractor building the exterior system on the building, and these components were therefore not included in this estimate. Because a protective facer exterior to the insulation and an insect shield above the insulation are required by the proposed measure, the following components were therefore added to the estimate of incremental first cost for the measure, by sourcing materials and labor costs from the RS Means database, and adjusting those costs by city-based material and labor adjustment factors of Climate Zone 16's city of Susanville:

- Sheet metal flashing, steel sheets, flexible, galvanized, 20 gauge, including up to 4 bends, 6 in. by 522 ft., including labor.
- Fiber cement siding, panel siding, smooth texture, 5/16" thick, 14 in. by 522 ft., including labor.

The estimates as adjusted for 522 linear feet of perimeter were $8,743 for the contractor's components, and $5,807 for those from RS Means database. The sum of these two values, $14,550, was used as the incremental first cost.

3.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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 SLCC Hourly Factors. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

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

Maintenance costs were expected to be zero over the 30-year period of analysis. While protective siding can be damaged, the Statewide CASE Team has not found evidence that maintenance activities would typically occur in the first 30 years.

3.4.5 Cost-effectiveness

This measure proposes a primary prescriptive requirement. As such, a cost analysis is required to demonstrate that the measure is cost-effective over the 30-year period of analysis.

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 PV costs and cost savings.

Results of the per unit cost-effectiveness analyses are presented in Table 23 for new construction, additions, and alterations, respectively.

The proposed measure saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost-effective.

Table 23: 30-Year Cost-Effectiveness Summary Per Dwelling Unit — New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	B/C Ratio
16	366	297	1.23

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC savings over the period of analysis (California Energy Commission 2016, 51-53). Other savings are discounted at a real (nominal — inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.
b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis if PV of proposed cost is greater than PV of current costs. Costs are discounted at a real (inflation-adjusted) three percent rate. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

3.5 First-Year Statewide Impacts

The Statewide CASE Team interviewed one energy consultant with experience in Climate Zone 16, who expressed that very few if any multifamily buildings with four or more habitable stories are built with a slab-on-grade foundation in the climate zone, and that high-rise buildings would likely never be built with this foundation type. As such, for the purposes of estimating first-year statewide impacts, the Statewide CASE Team estimated that five percent of the mid-rise dwelling units and zero percent of the high-rise dwelling units forecasted to be constructed annually would be in an applicable slab-on-grade building where this measure would apply, which amounts to approximately one mid-rise building every nine years.

3.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per unit savings, which are presented in Section 3.4.2, 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 Table 24, 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).

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

Table 24 presents the first-year statewide energy and energy cost savings from newly constructed buildings and additions by climate zone.

Because of relatively low forecasted new construction in Climate Zone 16, approximately 118 dwelling units in multifamily buildings with four or more stories, the forecasted statewide impact is minimal. This measure would simplify the code language, while providing a small amount of energy savings for any multifamily buildings with four or more habitable stores and slab-on-grade foundations in Climate Zone 16.

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

Table 24: Statewide Energy and Energy Cost Impacts — New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Dwelling Units)	First-Year[a] Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2026 PV$)
16	5	-17	-0.4	17	1,502	1,989

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

3.5.2 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 CO_2e) (California Energy Commission 2020).

The monetary value of avoided GHG emissions is based on a proxy for permit costs not social costs.[19] The Cost-Effectiveness Analysis presented in Section 3.4.5 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 25 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 0.1 (metric tons CO_2e) would be avoided.

Table 25: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (kWh/y)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO_2e)	Natural Gas Savings[a] (Therms/y)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO_2e)	Total Reduced GHG Emissions[b] (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
Slab Perimeter Insulation	-17	-0	17	0.1	0.1	12

a. First-year savings from all applicable newly constructed buildings, additions, and alterations completed statewide in 2026.
b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and Source Energy hourly factors 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 Energy Commission here: https://www.energy.ca.gov/files/tdv-2022-update-model

[19] 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.

3.5.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

3.5.4 Statewide Material Impacts

The proposed measure would result in statewide material impacts due to increased use of materials. To estimate statewide material impacts, the Statewide CASE Team calculated pounds of material using the design and materials used for the proposed measure's incremental first cost analysis, namely:

- 1.5" extruded polystyrene (XPS) insulation, 16 in. by 522 ft.
- Galvanized sheet metal flashing, 20 gauge, 6 in. by 522 ft.
- Fiber cement siding, 5/16" thick, 14 in. by 522 ft.

The Statewide CASE Team calculated pounds of materials by multiplying the area of material by product pounds per area. See Appendix D for more details.

Table 26: First-Year Statewide Impacts on Material Use

Material	Impact	Per unit Impacts (Pounds per Dwelling Unit)	First-Year [a] Statewide Impacts (Pounds)
Mercury	No change	0	0
Lead	No change	0	0
Copper	No change	0	0
Plastic	No change	0	0
Steel	Increase	8.8	48
Concrete	Increase	29.8	162
Insulation	Increase	8.0	43

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

3.5.5 Other Non-Energy Impacts

Other non-energy impacts from this proposed measure would include:

- Increased thermal comfort in cold months due to reduced heat loss.
- Indirectly improved indoor air quality due to reduction of mold caused by condensation due to temperature difference.

3.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice outside of any impacts mentioned in Section 2, therefore reducing the impacts of disparities in DIPs. The measure may benefit DIPs through improved indoor air quality, as it may prevent mold by reducing condensation issues on the ground floor of buildings. The Statewide CASE Team does not recommend further research or action at this time. See Section 2 for further information.

4. Visible Transmittance (VT)

4.1 Measure Description

4.1.1 Proposed Code Change

This clean up measure would change the application of VT requirements for fenestration in multifamily buildings to align with the original intent of the requirement. Instead of applying to buildings four or more habitable stories, it would apply to fenestration in common use areas in multifamily buildings, regardless of number of stories. This change would apply to new construction, additions, and alterations for the curtain wall/storefront and NAFS performance class AW window types. It does not modify field verification or require updates to the compliance software.

4.1.2 Justification and Background Information

4.1.2.1 Justification

VT has an energy impact when lighting energy is reduced by automated daylighting controls. In multifamily buildings automated daylighting controls are required in common use areas of buildings of all heights. There is no requirement for automated daylighting controls in dwelling units.

4.1.2.2 Background Information

The VT requirements were introduced in 2013 Title 24, Part 6 to protect the lighting energy savings from automated daylighting controls in nonresidential buildings. Because multifamily buildings with four or more habitable stories were covered by the nonresidential requirements, this requirement applied by default, but it did not result in energy savings because there is no requirement for automated daylighting controls, except in the common use areas of the building. Common use areas in multifamily buildings up to three habitable stories did not need to meet this requirement.

When the 2022 multifamily chapters were created, the VT requirement for buildings with four or more habitable stories was carried over into the multifamily chapters, but it was not applied to common use areas in buildings three or fewer habitable stories. This measure is meant to return the application of VT requirements to space types that have an automated daylighting controls requirement, where the VT has an energy impact.

This proposed measure would change the VT requirements for curtain wall/storefront and NAFS performance class AW window types only. These fenestration types are exceedingly rare in multifamily buildings with three or fewer habitable stories, which overwhelmingly include windows in the “all other fenestration” category. Therefore, extending these VT requirements to apply to multifamily buildings with three or fewer stories is likely to only have a negligible impact, and generally does not increase stringency of the requirements.

4.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[20] See Section 10 of this report for detailed proposed revisions to code language.

4.1.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 6 as well as the reference appendices to Part 6 are described below. See Section 10.2 of this report for marked-up code language.

Section: 170.2(a)3A and Table 170.2-A

Specific Purpose: The specific purpose is to clarify that VT requirements apply to common use areas in all multifamily buildings, where requirements for automated daylighting controls reduce lighting loads.

Necessity: These changes are necessary to protect the intent of the requirements.

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

The proposed code change would not modify the ACM Reference Manual.

4.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Section 11.3.4 of the Nonresidential and Multifamily Compliance Manual would need to be revised to describe the VT requirement for common use areas.

4.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would not modify the compliance documents.

4.1.4 Regulatory Context

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

There are no relevant state or local laws or regulations.

4.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

4.1.4.3 Difference From Existing Model Codes and Industry Standards

ASHRAE 90.1 and 2024 IECC both have requirements for VT in multifamily buildings with four or more stories and in common use areas. Neither has VT requirements for buildings with three or fewer stories.

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

4.1.5 Compliance and Enforcement

This section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:** The design team, including the developer and architect, makes decisions on window types and selections. Designers will provide window areas and performance specifications. Designers will provide a VT specification for fenestration in common use areas. Designers may or may not specify VT for dwelling unit fenestration.
2. **Permit Application Phase:** The general contractor ensures fenestration schedules and National Fenestration Rating Council (NFRC) labels or other certificates such as NFRC's Component Modeling Approach Software Tool are submitted as part of certificate of compliance documents (LMCC or NRCC).
3. **Construction Phase:** The window contractor installs the products as designed. Installations are done in coordination with other trades on site, primarily the framing contractor. The general contractor is responsible for populating the Certificate of Installation (LMCI-ENV-E or NRCI-ENV-E) that documents the characteristics and performance specifications of the installed windows. For site-built fenestration, the general contractor must also sign the Certificate of Acceptance (NRCA-ENV).
4. **Inspection Phase:** The general contractor usually compiles the forms for submission prior to the field inspection.

There are no changes in compliance or enforcement processes, and no additional coordination needs between trades anticipated from this measure.

4.2 Market Analysis

4.2.1 Current Market Structure

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.

The general roles of market actors in compliance verification are:

- Developers and owners make design decisions regarding fenestration, with support from professional services such as architects, structural engineers, procurement professionals, and construction contractors (both general contractors and specific trades).
- Energy consultants document energy code requirements and conduct energy modeling for the performance approach.
- Building inspectors verify that fenestration labels meet or exceed the specifications listed in the compliance documentation.

Fenestration products fall into two primary categories when installed in framed wall construction, often referred to as punched windows: manufactured and site-built. Field fabricated is a third category and is significantly less common. Curtain wall fenestration follows a different market structure described later in this section. For manufactured fenestration in framed walls, developers and their contractors may order fenestration products directly from distributors and

have them delivered to the construction site as a unit. These products come in a wide variety of sizes and dimensions, and their energy performance characteristics are certified and displayed on their NFRC labels.

In contrast, window contractors assemble site-built fenestration within framed construction openings at the building site according to size and aesthetic specifications provided by the design team. Site-built fenestration is assembled with specific factory cut or formed framing and glazing units and typically fulfills a custom aesthetic or provides for larger fenestration that cannot be easily shipped when fully assembled. Field fabricated windows are those whose frame is built on-site and has no previous manufacturing component and is not a subset of site-built fenestration. Field fabricated windows are comparatively uncommon. Site-built fenestration commonly uses the CMA approach for determining NFRC ratings.

Manufactured, site-built, and field-fabricated fenestration are placed into an opening within the building envelope, based on specifications from the design team. The curtain wall fenestration market is similar to that for site-built. The building's design team specifies curtain wall fenestration size, aesthetics, and thermal properties, and they order customized products that meet the specification. The specified fenestration can either be assembled off site in a factory within panelized wall sections or delivered in components and assembled on site.

For all fenestration, architects work with developers and/or building owners early in the design process to decide fenestration size and construction type — punched window or curtain wall. These early design decisions set the direction of the code compliance options or path. Once that path is chosen, it is common for the project team to adjust product selection choices in response to cost and product availability. Often, energy consultants inform product selection to ensure energy code compliance.

4.2.2 Technical Feasibility and Market Availability

Technical feasibility and market availability are demonstrated through successful application of this requirement to nonresidential buildings and common use areas of multifamily buildings of all heights prior to the 2022 Title 24, Part 6 update.

4.2.3 Market Impacts and Economic Assessments

Adoption of this code change proposal would not result in measurable market impacts.

4.2.4 Economic Impacts

Adoption of this code change proposal would not result in measurable economic impacts.

4.2.5 Fiscal Impacts

Adoption of this code change proposal would not result in measurable fiscal impacts to local agencies, school districts, or state agencies.

4.3 Energy Savings

This proposed measure will assist in realizing the savings from the daylighting controls requirements already in the code, and generally does not increase stringency due to the rarity of curtain wall and NAFS performance class AW windows in multifamily buildings up to three habitable stories. The Statewide CASE Team did not conduct energy analysis.

4.4 Cost and Cost-effectiveness

This proposed measure generally does not increase stringency due to the rarity of curtain wall and NAFS performance class AW windows in multifamily buildings up to three habitable stories. The Statewide CASE Team did not complete cost-effectiveness analysis for this measure.

4.5 First-Year Statewide Impacts

The code change proposal would not modify the stringency of the existing California Energy Code, so there are no savings associated with this proposed change.

4.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice. This measure does not have notable energy or environmental impacts. The Statewide CASE Team does not recommend further research or action at this time.

5. Skylight Properties

5.1 Measure Description

5.1.1 Proposed Code Change

This proposed measure would change the categories that determine the required performance specifications for skylight alterations in multifamily buildings. Instead of requirements for altered or added skylights differing based on the number of habitable stories in the multifamily building, under this proposed measure, the requirements for maximum U-factor and minimum VT for multifamily buildings with four or more habitable stories would apply to all multifamily buildings with any number of stories. This proposed measure would also align the maximum SHGC requirements by removing the requirement for Climate Zones 1, 3, 5, and 16 for multifamily buildings with four or more habitable stories, and for all other Climate Zones would apply the 0.25 maximum SHGC requirement for multifamily buildings with four or more habitable stories to all multifamily buildings.

This proposed measure also would specify that the minimum VT requirement for altered or added skylights in multifamily buildings only applies to skylights that serve common use areas.

This proposed measure also modifies and clarifies exceptions for added and replaced skylights. The proposal would remove an exception for added skylights under 16 square feet total per dwelling unit. The proposal would also extend the exception for skylights under 50 square feet total per building to skylight replacements, which currently only applies to added skylights. Additionally, the proposal would extend an area-weighted compliance option for U-factor and SHGC, currently only an option for replaced fenestration, to added fenestration.

In addition to alterations of skylights, this change applies to small multifamily additions that contain skylights. Section 180.1(a)1.B states that for additions that are 700 square feet or less, fenestration products shall meet the requirements of Table 180.2-B for Altered Fenestration, which is the table that is changed in this proposed measure. Glass replaced in an existing sash, and a frame or sash replaced in an existing frame, are considered repairs, not alterations, and are not affected by this proposed measure.

This proposal requires a minor change to the compliance software: update the standard design for additions and alterations using these proposed specifications and exceptions.

5.1.2 Justification and Background Information

5.1.2.1 Justification

The justification behind this code proposal, as with other proposed measures in this Restructuring CASE Report, is to simplify and streamline an existing code requirement across multifamily buildings that is currently split based on number of habitable stories.

This proposed measure also addresses an oversight regarding technical feasibility and market availability, as skylights that meet the current prescriptive requirements for skylight replacements in multifamily buildings with three or fewer habitable stories are not generally commercially available. Only certain tubular daylighting devices can reasonably meet the current U-factor requirements for buildings with three or fewer habitable stories, and these are

not interchangeable with larger skylights. The proposed measure would create a feasible prescriptive compliance pathway for replacement of skylights in these buildings where there currently is not a feasible way to comply.

This proposed measure also would align specify that the minimum VT requirement for altered or added skylights only applies to skylights that serve common use areas, in order to align with multifamily daylighting controls requirements that apply to common use areas.

This proposed measure also modifies and clarifies exceptions for added and replaced skylights under a certain amount of square feet, which aims to simplify the requirements by keeping exceptions at the building level instead of the dwelling unit level, to improve and simplify compliance.

5.1.2.2 Background Information

Before the restructuring of the multifamily code in 2022 that created the multifamily chapter, requirements for skylight alterations in multifamily buildings and skylight additions in multifamily buildings were found in either the 2019 residential code for buildings with three or fewer habitable stories or the 2019 nonresidential code for buildings with four or more habitable stories. In this 2019 version of Title 24, Part 6, the only replaced or added skylights in an alteration that required a 0.30 U-factor or lower were multifamily skylights in buildings with three or fewer stories where more than 16 ft^2 of skylights were added per dwelling unit, and where more than 50 ft^2 of total skylights were added to the building. All other cases of added or replaced skylights in multifamily buildings required only between a 0.46 and 0.88 maximum U-factor, and a 0.25 SHGC at the most stringent.

Under these 2019 Title 24, Part 6 requirements, this 0.30 U-factor, 0.23 SHGC requirement for large amounts of added skylights applied because the alterations requirements referenced the previous low-rise multifamily building prescriptive requirements for fenestration in new construction. These thermal property specifications were general to all fenestration and were not specific to skylights.

The published requirements for multifamily buildings with three or fewer stories in Climate Zones 6-15 show SHGC maximum values that are less stringent than the single family code requirements from which they were derived, and the Statewide CASE Team believes that this is due to a clerical error, and that the correct 2022 requirement is a maximum 0.23. Therefore, the proposed change in SHGC does not increase stringency when compared to the appropriate baseline.

As explained in Section 4.2.2 Technical Feasibility and Market Availability, a review of skylight product options found no certified skylight product lines with lower than a 0.35 U-factor, including both double- and triple-pane options (United States Environmental Protection Agency 2021).

Skylights in multifamily buildings are rare. In a review of 90 existing multifamily buildings by Evergreen Economics, only three had skylights over a residential floor. In a review of the last 10 years of multifamily new construction projects designed by an architect specializing in multifamily and interviewed by the Statewide CASE Team, only one building had skylights over a residential floor. Of these four total buildings, two of them had four or more habitable stories. Similarly, in a 2023 survey carried out by the Statewide CASE Team, out of 100 builders, contractors, and design professionals who responded that they primarily work in multifamily residential construction, only 18 responded that they have included or installed skylights in any

of their multifamily projects in the last five years. Of these, nine respondents answered that their selection of type and properties of skylights vary with building height, but only one respondent described how they might vary and only mentioned aesthetics. Although skylights are rare in multifamily buildings, this proposed measure would create a feasible compliance option for replacing skylights in all multifamily buildings that have them, remedying an unintentional market exclusion.

U-factor and SHGC ratings of skylights and other fenestration generally describe the heat gain and loss of windows and skylights. Relative solar heat gain coefficient (RSHGC) allows for an external shading correction from an overhang. Skylights are regulated for SHGC rather than RSHGC because skylights do not have overhangs, and this measure also corrects a nomenclature oversight regarding this terminology.

VT ratings of skylights and other fenestration generally describes how much visible light comes through.

5.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[21] See Section 10 of this report for detailed proposed revisions to code language.

5.1.3.1 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 10.2 of this report for marked-up code language.

Section: 180.2(b)1.C.

Specific Purpose: The specific purpose of the change is to modify and simplify the exceptions to fenestration alterations requirements.

Necessity: These changes are necessary to simplify the energy code, to keep exceptions for a small amount of skylight area to the building level instead of the dwelling unit level, and to add an exception for small skylight replacements.

Section: Table 180.2-B

Specific Purpose: The specific purpose of the change to this table is to align the requirements for added or replaced skylights for all multifamily buildings regardless of number of stories.

Necessity: These changes are necessary to simplify the energy code and to correct an oversight that prescriptively required skylights to a specification that is not generally commercially available.

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

5.1.3.2 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 10.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Section: 6.12.4, Table 45

Specific Purpose: The specific purpose is to update the standard design default SHGC value for altered skylights in CZ 1, 3, 5, and 16.

Necessity: These changes are necessary to simplify the energy code and to align requirements across multifamily buildings regardless of number of stories.

5.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Chapter 11 of the Nonresidential and Multifamily Compliance Manual would need to be revised. The Fenestration Alterations section would need to be updated to reflect the revised exemptions and requirements.

5.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the certificate of compliance forms (LMCC-ENV and NRCC-ENV), certificate of installation forms (LMCI-ENV and NRCI-ENV), and certificate of acceptance form (NRCA-ENV) to align fields with the proposed values, categories, and exceptions.

5.1.4 Regulatory Context

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

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

There are no relevant state or local laws or regulations.

5.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

5.1.4.3 Difference From Existing Model Codes and Industry Standards

IECC and ASHRAE additions and alterations requirements generally refer to new construction requirements regarding fenestration. IECC Commercial and ASHRAE 90.1 share the same U-factor and SHGC requirements for skylights of newly constructed high-rise residential buildings, but these standards differ from Title 24, Part 6 requirements. In the IECC climate zones found in California, the U-factor requirements fall between 0.50 and 0.65 and are all less stringent than those in Title 24, Part 6. These SHGC requirements in California fall between 0.3 and 0.4, which is in some cases more stringent and in other cases less stringent than Title 24, Part 6.

IECC Commercial and IECC Residential standards both cover multifamily buildings, with Commercial covering multifamily buildings with four or more habitable stories and Residential

covering multifamily buildings with three or fewer habitable stories. These standards differ slightly in skylight U-factor and SHGC requirements. IECC Residential is also less stringent on U-factor than Title 24, Part 6, with the lowest in the relevant climate zones being 0.55.

5.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:**
   - The contractor specifies skylight product when providing cost estimate to the building owner.
   - The energy consultant identifies relevant compliance path options.
   - Designers provide skylight areas and performance specifications that meet energy code requirements.
2. **Permit Application Phase:**
   - The energy consultant completes certificates of compliance, either LMCC-ENV for three or fewer stories or NRCC-ENV for four or more stories, for the permit application.
   - The contractor applies for the permit.
3. **Construction Phase:**
   - The general contractor assures fenestration schedules, installs products as designed, and is responsible for populating the LMCI-ENV or NRCI-ENV Certificate of Installation that documents the characteristics and performance specifications of the installed skylights.
   - The contractor completes compliance document Certificate of Acceptance NRCA-ENV and submits it to the enforcement agency or field inspector.
4. **Inspection Phase:**
   - Building inspector verifies that documented thermal properties of installed skylights match those submitted in compliance documentation.

Under this measure, contractors and energy consultants would need to specify whether added or replaced skylights meet the exceptions and specifications proposed by this measure, as opposed to the exceptions and specifications as currently required, in the compliance documents. Plan checkers and building inspectors would need to check for compliance with the proposed exceptions and specifications. There are no other changes in compliance or enforcement processes and no additional coordination needs between trades anticipated from this measure.

5.2 Market Analysis

5.2.1 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. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, architects, and manufacturing representatives. 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.

Skylight products, as with other fenestration products, fall into two primary categories when installed in framed construction: manufactured and site-built. Field fabricated fenestration, where the frame is built on-site and has no previous manufacturing component, is a third category but is significantly less common. For manufactured skylights in framed roof openings, developers and their contractors may order skylight products directly from distributors and have them delivered to the construction site as a unit. These products come in a wide variety of sizes and dimensions, and their energy performance characteristics are certified and displayed on their NFRC labels.

In contrast, window contractors assemble site-built skylights within framed construction openings at the building site according to size and aesthetic specifications provided by the design team. Site-built skylights are assembled with specific factory-cut or formed framing and glazing units. Site-built fenestration is typically chosen to fulfill a custom aesthetic or to provide for larger fenestration that cannot be easily shipped when fully assembled.

Manufactured, site-built, and field fabricated fenestration are placed into an opening within the building envelope, based on specifications from the design team.

5.2.2 Technical Feasibility and Market Availability

Although skylights are rare in multifamily buildings as explained in Section 5.1.2.2 Background Information, the proposed measure would allow for technically feasible replacement options in all buildings that have skylights.

The U.S. Environmental Protection Agency evaluated the distribution of performance of certified commercially available skylights and did not find any product lines with lower than a 0.35 U-factor, as shown in Figure 2 (United States Environmental Protection Agency 2021).

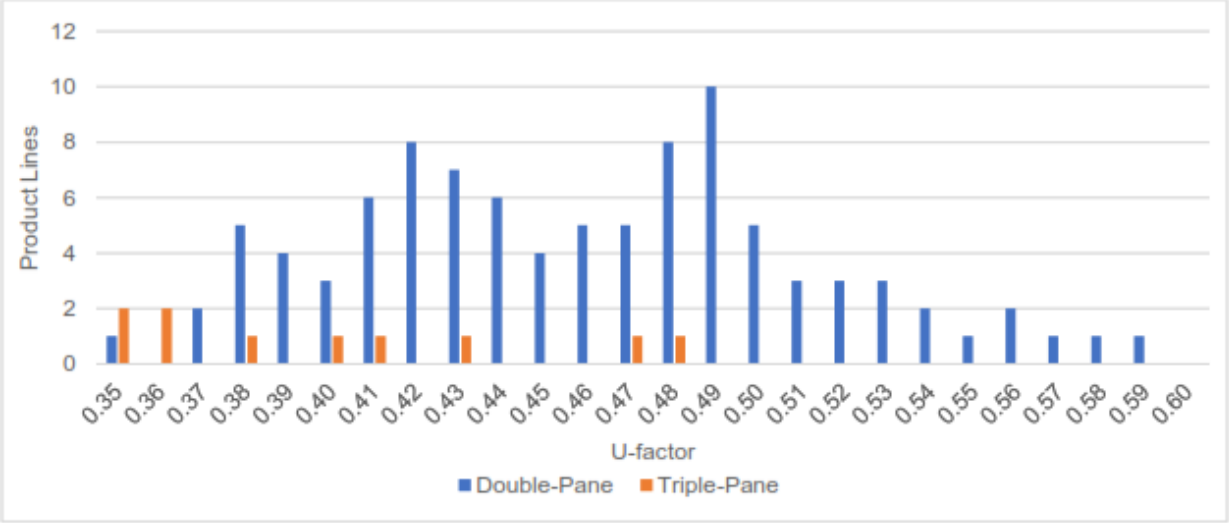

Figure 2: Performance distribution of certified skylights by number of panes (United States Environmental Protection Agency 2021)

This data is supported by feedback that the Statewide CASE Team received in interviews with a window manufacturer representative, which was that the current 0.30 U-factor requirement for alterations seems exceedingly stringent for skylights, and that even the proposed new ENERGY STAR® Most Efficient skylight criteria is only 0.40-0.43 U-factor.

The Statewide CASE Team carried out research into the performance ratings of certified skylights from two major skylight manufacturers, Velux and Solatube (VELUX Group 2023) (Solatube International 2020). Velux does not have any product lines listed that meet the 0.30 U-factor and 0.23 SHGC requirements; Solatube has two tubular daylighting device products listed that meet these requirements. Both companies have several products available that meet the 0.46 U-factor and 0.25 SHGC requirements.

The current Title 24, Part 6 requirements do not include an exception for replaced skylights with equal square footage, as was included in the 2019 Title 24, Part 6 code language. Therefore, under the current requirements, replaced skylights in multifamily buildings with three or fewer stories cannot reasonably meet the current prescriptive requirements.

5.2.3 Market Impacts and Economic Assessments

Adoption of this code change proposal would not result in measurable market impacts, as the Statewide CASE Team did not find any examples of multifamily buildings with more than 50 square feet of total skylights in its research, as described in Section 5.1.2.

5.2.4 Economic Impacts

Adoption of this code change proposal would not result in measurable economic impacts, as the Statewide CASE Team did not find any examples of multifamily buildings with more than 50 square feet of total skylights in its research, as described in Section 5.1.2.

5.2.5 Fiscal Impacts

Adoption of this code change proposal would not result in measurable fiscal impacts to local agencies, school districts, or state agencies.

5.3 Energy Savings

The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. This included discussions with a multifamily focused architect and a fenestration manufacturer representative. These discussions yielded anecdotal evidence that while skylights over multifamily buildings are rare, they are likely more common over corridors than over dwelling units, which informed the decision to design a building energy model with skylights over the top floor corridor. See Appendix F for a summary of stakeholder engagement.

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

5.3.1 Energy Savings Methodology

5.3.1.1 Key Assumptions for Energy Savings Analysis

The energy savings analysis relied on California Building Energy Code Compliance for Commercial/Nonresidential Buildings Software (CBECC) 2025 software to estimate energy use for a modified vintage 10-story high-rise mixed use multifamily building with 56 square feet of skylights in Climate Zones 1, 3, 5, and 16, and it compared the baseline requirements of 0.25 SHGC to a less stringent 0.35 SHGC to represent the proposed removal of the SHGC requirement in these climate zones for buildings with four or more habitable stories.

The change in U-factor requirement for multifamily buildings with three or fewer habitable stories was not modeled for energy impacts, as the current requirement is technically infeasible with products that are currently generally commercially available, and this change is being proposed in order to create a feasible compliance option.

5.3.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team measured per unit energy savings expected from the proposed code changes in several ways in order 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 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 CEC are strongly correlated with GHG emissions.[22] Finally, the Statewide CASE Team calculated LSC Savings, formerly known as Time Dependent Valuation (TDV) energy cost 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.[23]

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. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 27.

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[23] See Hourly Factors for Source Energy, Long-term Systemwide Cost, and Greenhouse Gas Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

The Statewide CASE Team used a modified high-rise mixed use prototype, which had several aspects modified to approximately reflect a baseline vintage 2000 building. The modified prototype has single zone air-conditioning with furnace heating, and the domestic hot water had a central gas storage system. The prototype building has 56 square feet of skylights serving the top floor corridor.

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

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
High-Rise Mixed-Use (HRMU), Modified	10	125,400	10-story (9-story residential, 1-story commercial), 117-unit building. Avg dwelling unit size: 850 ft^2. Central gas storage DHW. 56 ft^2 of skylights serving top floor corridor.

The Statewide CASE Team estimated LSC, Source Energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change using the modified prototypical building and rulesets from the 2025 Research Version of the California Building Energy Code Compliance (CBECC) software (California Energy Commission n.d.).

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[24] 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.

The Standard Design is minimally compliant with the 2022 Title 24 requirements, and represents a building with over 50 square feet of newly altered or added skylights with 0.25 SHGC. Note that the skylights are modeled in both the standard design and the proposed design with the proposed U-factor of 0.46 in order to model a technically feasible and commercially available skylight.

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, the proposed conditions assume a 0.35 SHGC skylight in order to model the removal of the maximum SHGC requirement for these climate zones.

[24] CBECC-Res creates a third model, the Reference Design, that represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 International Energy Conservation Code (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 Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
HRMU, Modified	1, 3, 5, 16	Skylight	SHGC	0.25	0.35

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/yr) and therms per year (therms/yr). 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/yr), and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions. CBECC also calculates annual peak electricity demand measured in kilowatts (kW).

The energy impacts of the proposed code change do 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.

5.3.1.3 Statewide Energy Savings Methodology

The per-unit energy impacts were not extrapolated to statewide impacts. Adoption of this code change proposal would not result in measurable statewide impacts, as the Statewide CASE Team did not find any examples of multifamily buildings with more than 50 square feet of total skylights in its research, as described in Section 5.1.2.

5.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit resulting from the proposed removal of skylight alteration SHGC requirements in four Climate Zones are presented in Table 29. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per-unit natural gas savings for the first year are expected to range from - and 5.30 to 8.03 kBtu/yr depending upon climate zone. Per-unit electricity use is expected to increase between 0.03 and 0.56 kWh/yr, except in Climate zone 16, where savings are expected at an estimated 0.04 kHh per dwelling unit. Demand increases are expected to range between 0.00 kW and 0.15 kW depending on climate zone.

Note that these per-unit figures are averaged across all dwelling units in the high-rise mixed use prototype building, not only those on the floor served by skylights.

Table 29: Energy Impacts Per Dwelling Unit – Skylight Alterations

Climate Zone	First-year Electricity	First-Year Peak Demand	First-Year Natural Gas	First-Year Source Energy	First-Year Lifecycle Cost

	Savings (kWh)	Reduction (kW)	Savings (kBtu)	Savings (kBtu)	Savings (2026 PV$)
1	(0.03)	(0.01)	5.30	4.72	6.32
3	(0.08)	(0.01)	6.41	5.68	7.29
5	0.04	0.00	8.03	7.40	10.07
16	(0.56)	(0.15)	6.84	5.79	5.25

5.4 Cost and Cost-effectiveness

The code change proposal would overall not increase costs for applicable alterations. When compared to the appropriate baseline requirements, as explained in Section 5.1.2.2, no SHGC U-factor or requirements would increase in stringency from this proposed measure. While a VT requirement would be added for skylights that serve common use areas in buildings with three or fewer stories, increased VT is generally found in skylights with less expensive glazing, and therefore is generally associated with lower costs.

While the measure does not increase stringency, the Statewide CASE Team conducted cost-effectiveness analysis for the removal of SHGC requirements in Climate Zones 1, 3, 5, and 16.

5.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 3.3.1. 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 30-year period of analysis.

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 and 2026 PV$ are presented in Section 3.4 of this report. 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 for the removal of SHGC requirements in Climate Zones 1, 3, 5, and 16.

5.4.2 Energy Cost Savings Results

Per-unit energy cost savings for alterations in terms of LSC savings realized over the 30-year period of analysis are presented 2026 present value dollars (2026 PV$) in Table 30.

The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 30: 2026 PV LSC Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Alterations – High-Rise Mixed-Use, Modified

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	(0.11)	6.43	6.32
3	(0.54)	7.82	7.29

5	0.32	9.75	10.07
16	(3.11)	8.36	5.25

5.4.3 Incremental First Cost

The code change proposal would not increase costs for applicable alterations. When compared to the appropriate baseline requirements, as explained in Section 5.1.2.2, no SHGC U-factor or requirements would increase in stringency from this proposed measure. While a VT requirement would be added for skylights that serve common use areas in buildings with three or fewer stories, increased VT is generally found in skylights with less expensive glazing, and therefore is generally associated with lower costs.

5.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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 Statewide CASE Team does not anticipate maintenance and replacement for this measure over the 30-year period of analysis.

5.4.5 Cost Effectiveness

While the measure does not increase stringency, the Statewide CASE Team conducted cost-effectiveness analysis for the removal of SHGC requirements in Climate Zones 1, 3, 5, and 16.

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 PV costs and cost savings.

Results of the per-unit cost-effectiveness analysis are presented in Table 31 for alterations.

The proposed measure's change to SHGC in these Climate Zones saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost effective in every climate zone.

Table 31: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings[a] (2026 PV$)	Costs Total Incremental PV Costs[b] (2026 PV$)	Benefit-to-Cost Ratio
1	6.32	$0	> 1
3	7.29	$0	> 1
5	10.07	$0	> 1

16	5.25	$0	> 1

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (California Energy Commission 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of the CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis if PV of proposed costs is greater than PV of current costs. Costs are discounted at a real (inflation-adjusted) three percent rate. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

5.5 First-Year Statewide Impacts

Adoption of this code change proposal would not result in measurable statewide impacts, as the Statewide CASE Team did not find any examples of multifamily buildings with more than 50 square feet of total skylights in its research, as described in Section 5.1.2. Based on this research, the statewide impacts of this proposed measure to energy savings, greenhouse gas emissions, and non-energy impacts would be negligible. The proposed measure would not have per-unit or statewide impacts to water use or material consumption.

5.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice. This measure is a clean up measure and does not have notable energy or environmental impacts. The Statewide CASE Team does not recommend further research or action at this time.

6. Multifamily Quality Installation Inspection

6.1 Measure Description

6.1.1 Proposed Code Change

This measure proposes a Multifamily QII verification procedure that would apply prescriptively to multifamily buildings with four or more habitable stories. Multifamily buildings with three or fewer habitable stories are currently required prescriptively to follow the existing full QII procedure. The proposed Multifamily QII verification procedures are an evolution of the existing full QII procedures, for improved practicability in larger buildings that use staged construction. There is no change proposed to the procedures themselves, only to the percentage of total wall area that is verified by a third party.

While the multifamily restructuring topic generally aims to remove the divide between buildings of three or fewer habitable stories and four or more habitable stories, the Statewide CASE Team determined that four stories is an appropriate threshold for buildings using staged construction.

This measure would apply to all climate zones except Climate Zone 7. The proposed change applies to additions greater than 700 square feet of conditioned floor area and does not apply to alterations or to buildings using curtainwall assembly types.

The measure also proposes full QII compliance option for multifamily buildings with four or more habitable stories and a Multifamily QII option for buildings with three or fewer habitable stories, using the performance compliance approach. Updates to the compliance software would be required to introduce 30 percent insulation derating in multifamily buildings with four or more habitable stories when QII is not verified, consistent with multifamily buildings up to three habitable stories. For all multifamily buildings, full QII would result in no insulation derating, and Multifamily QII would result in 15 percent derating. The standard design would remain full QII for buildings up to three habitable stories, so Multifamily QII would require additional measures for compliance. The standard design for four or more habitable stories would be Multifamily QII, so full QII would allow trade off credit.

The Multifamily QII verification is designed for fewer visits to the building than full QII. The first and last habitable stories would be 100 percent verified for both the air sealing and insulation installation. Middle floors would require verification of a minimum 15 percent of the remaining total wall surface area. Middle floor inspections can be timed so that air sealing can be inspected on one floor while insulation installation is inspected on another floor. The required verification would be of all available surfaces at the time of inspection. This means that 15 percent of the remaining total wall area would need to be inspected for air sealing at the framing stage, and 15 percent of the remaining total wall area would need insulation inspection at the stage after insulation installation and before drywall installation.

6.1.2 Justification and Background Information

6.1.2.1 Justification

When the multifamily chapter was introduced in the 2022 Title 24, Part 6 code, the 2019 QII requirements were carried over from the residential requirements for multifamily buildings with three or fewer habitable stories. An Energy Commission decision not to add or modify HERS

measures at that time prohibited extension of the QII measure to multifamily buildings with four or more habitable stories. This measure seeks to extend the energy savings, cost, and comfort benefits of QII to multifamily buildings with four or more habitable stories, with modifications to requirements for larger buildings to make the measure practical and cost-effective.

The full QII procedures that were developed for single family and small multifamily buildings are not practical or cost-effective to apply to larger multifamily buildings. The full QII procedures require inspection of 100 percent of the building envelope, both for insulation installation and air sealing. Larger buildings with four or more habitable stories are typically built using staged construction, where a portion of the building is completed and walls are sealed before construction of the next phase begins. Inspecting insulation and air sealing for 100 percent of the building with multiple construction phases would require significantly more HERS Rater visits to complete, which can be both costly and logistically difficult. The proposed Multifamily QII verification requires fewer visits and flexibility in visit timing, which is more feasible for this building type, and still offers improved energy savings from improved insulation quality.

6.1.2.2 Background Information

The Statewide CASE Team developed and proposed this measure in the 2022 Multifamily Restructuring CASE Report, but it was tabled due to a CEC decision not to add or modify HERS measures in the 2022 cycle update.

Title 24, Part 6 has included QII HERS verification as a compliance option or prescriptive requirement since the 2008 code update. Based on data from the HERS registry provided by CalCERTS, 45 percent of registered low-rise multifamily projects built under the 2013 and 2016 Title 24, Part 6 code requirements took the QII performance credit. QII became a prescriptive requirement under the 2019 requirements, and stakeholder interviews indicate that very few multifamily buildings are trading off this requirement with the performance approach. The adoption of QII among multifamily buildings appears to be increasing.

QII became a prescriptive requirement under the 2019 Title 24, Part 6 code cycle for single family and low-rise multifamily buildings. The 2019 residential QII CASE Study (Dakin and German 2017) found QII to be cost-effective in all climate zones except Climate Zone 7. These results were based on lifecycle cost analyses derived from a one in four sampling rate and using an eight-unit low-rise garden style multifamily prototype.

6.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[25] See Section 10 of this report for detailed proposed revisions to code language.

6.1.3.1 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 10.2 of this report for marked-up code language.

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

Section: Section 170.2(a)6

Specific Purpose: The specific purpose is to define the QII requirements for multifamily buildings depending on the number of habitable stories.

Necessity: These changes are necessary to increase energy efficiency via cost-effective building design standards, as directed by the California Public Resources Code Sections 25213 and 25402.

Section: RA3.5

Specific Purpose: The specific purpose is to describe the process for verifying the Multifamily QII measure, as compared to the full QII requirements.

Necessity: These changes are necessary to define feasible and cost-effective Multifamily QII procedures for multifamily buildings with phased insulation installation.

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

See Section 10.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Section: 6.7.4

Specific Purpose: The specific purpose is to add Multifamily QII as an option in the compliance software for all multifamily buildings and update the standard design.

Necessity: These changes are necessary to define performance credits and penalties for the Multifamily QII measure.

6.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Section 11.3.3.20 of the Nonresidential and Multifamily Compliance Manual would need to be revised.

The proposed change would add an explanation of the QII requirements for multifamily buildings. The proposed change would provide descriptions on the scope and special cases for Multifamily QII protocols. These descriptions include compliance software cavity insulation R-value derating rules under full and Multifamily QII scenarios.

6.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised forms are presented in Section 10.5.

- Certificates of compliance would need to be updated to reflect full vs. Multifamily QII options based on number of habitable stories.
    - NRCC-ENV-01-E
    - LMCC-ENV-01-E
- Certificates of installation would need to be updated to reflect full and Multifamily QII requirement and respective protocols.

    - NRCI-ENV-01-E-Envelope and new NRCI forms
    - LMCI-ENV-21-H QII — Air Infiltration Sealing — Framing Stage
    - LMCI-ENV-22-H QII — Insulation Installation
- Verification documents would need to be updated to reflect full and Multifamily QII requirement and respective protocols.
    - NRCV-ENV-01 — Envelope and new NRCV forms
    - LMCV-ENV-21-H QII — Air Infiltration Sealing — Framing Stage
    - LMCV-ENV-22-H QII — Insulation Stage

6.1.4 Regulatory Context

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

The current multifamily prescriptive requirements for QII are shown in Table 32.

Table 32: 2022 Prescriptive QII Requirements for Multifamily Buildings

Measure	Multifamily Buildings 4+ habitable stories	Multifamily Buildings 3 habitable stories or fewer
Full QII	No requirements or performance option	Prescriptive requirement using a verification protocol designed for single family residences; all CZ except for CZ 7

2022 Title 24, Part 11 CALGreen includes QII along with energy design ratings as Tier 1 and Tier 2 prerequisites for the performance approach for newly constructed buildings.

6.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no separate, relevant state, or federal laws for the proposed QII measure.

6.1.4.3 Difference From Existing Model Codes and Industry Standards

A number of market initiatives and industry standards have similar intent and scope. The Residential Energy Services Network's (RESNET) Multifamily Rating (RESNET 2020) process includes an insulation grading procedure similar in scope and method to California's QII. The procedure rates one of the three grades: Grade I, with minor defects; Grade II, with moderate defects, and Grade III, with substantial defects. Of these, Grade I is aligned most closely with QII Standards. RESNET currently allows for dwelling unit sampling protocols covering one of seven similar units. For multifamily buildings, RESNET is in the process of changing sampling protocols to instead fulfill a 20 percent of surface area requirement.

The ENERGY STAR Multifamily New Construction Certification (Energy Star 2020) includes the Thermal Bypass Checklist, which is designed as a verification procedure similar in scope and method to California's QII. The Thermal Bypass Checklist is a program requirement for all buildings of all heights and sizes. The Thermal Bypass Checklist allows for dwelling unit sampling protocols as set forth by RESNET; therefore, Thermal Bypass Checklist requirements may be subject to change with RESNET's proposed changes. The Thermal Bypass Checklist allows for considerable subjective discretion by the verifier for dealing with areas difficult to inspect, (such as behind bathtubs) and collaborative in-person mitigation for field-encountered installation quality failures.

The New York State Energy Research and Development Authority implements the Multifamily Performance Program (NYSERDA 2020). The Multifamily Performance Program includes an implemented verification process similar to California's QII in scope and intent. The Multifamily Performance Program's insulation verification process uses a multifamily method, where the verifier visits the site on a day roughly aligning at 30 percent construction completion and inspects all available thermal envelope surfaces in whatever state of construction they are at that time. The Multifamily Performance Program's inspection, administered by the program implementer directly, allows for considerable subjective discretion by the inspector, in-person field mitigation of quality lapses, and no minimal inspected area requirements.

2018 IECC states (ICC 2020),

> *The components of the building thermal envelope shall be installed in accordance with the manufacturer's instruction and criteria indicated in Table R402.4.1.1 […] Where required by the code official, an approved third party shall inspect all components and verify compliance.*

Though the IECC Residential code does not give this installation and verification requirement a separate name, and comparably contains less details, it shares the same principle as California's QII requirement.

6.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:** During the design phase, the energy consultant identifies relevant requirements or compliance path options. Inspection access and timing coordination should be considered when determining design. The design team, including developer and architect, coordinates with the developer to specify wall construction type. The design team coordinates energy code requirements with authorities having jurisdiction for rigid continuous insulation and specifies products and construction assemblies that meet energy code. The architect identifies air barriers on plans to show QII is effective. The architect and energy consultant coordinate on compliance requirements to include frame type, dimensions, cavity, and continuous insulation types, R values, and overall assembly U-factor. The energy consultant populates the LMCC (three or fewer stories) or NRCC-ENV-01-E Envelope Component Approach (four or more stories) compliance documents.
2. **Permit Application Phase:** During the permit phase, the design team submits the building permit application, including framing schedules, insulation components and product specifications. New installation compliance documents would be needed for multifamily buildings four habitable stories or greater. The general contractor submits compliance documents LMCC for three or fewer stories or NRCC-ENV-01-E Envelope Component Approach for four or more stories.
3. **Construction Phase:** During the construction phase, the framing, insulation, and drywall installers coordinate with the general contractor, insulation installer, and other

trades on communication, expectations, and timing for wall and ceiling access. The general contractor and HERS Rater coordinate field verification visits such that wall area is visually accessible at the right construction stages at rough-in and again after installation but before drywalls. Planning and oversight during construction include timing of site access, cost of failure mitigation, and just-in-time training of trades. The general contractor ensures insulation installer completes and signs the Certificates of Installation LMCI-ENV-21-H QII and LMCI-ENV-22-H-QII for three or fewer stories at verification visits, or the new NRCI documents for four or more stories.

4. **Inspection Phase:** During the inspection phase, third-party inspections coordinate with construction schedule for timing of inspections; physical and visual access to air-sealing and insulation layers; and just-in-time training of trades. The general contractor ensures insulation installer completes and signs the Certificates of Installation LMCI-ENV-21-H QII — Air Infiltration Sealing — Framing Stage and LMCI-ENV-22-H QII — Insulation Installation for three or fewer stories, at verification visits, or the new NRCI documents for four or more stories. The HERS Rater coordinates with the general contractor for inspection and verification if failure occurs, and notes deficiencies and corrections as applicable. A second inspection would be scheduled to verify corrections. The building inspector coordinates energy code and fire code requirements for rigid continuous insulation. The HERS Rater populates, signs, and submits the Certificates of Verification LMCV-ENV-21-H QII — Air Infiltration Sealing — Framing Stage and LMCV-ENV-22-H QII — Insulation Stage for three or fewer habitable stories and submits to the registry for compliance. New inspection compliance forms would be needed for multifamily buildings of four or more habitable stories.

The only difference between existing QII and proposed Multifamily QII procedures occurs in the inspection phase above, where a smaller portion of the wall area is verified in Multifamily QII. Coordination between the trades is needed to facilitate successful field verifications. The construction industry has familiarity and understanding of the scope, coverage, and process in current code where QII is a performance credit. Since existing requirements are for multifamily buildings with three or fewer habitable stories only, contractors working solely on multifamily buildings with four or more habitable stories may not possess the experience and knowledge base unless they participated in LEED for Homes, Green Point Rated, or similar voluntary programs.

The number and timing of visits to complete Multifamily QII verification would need additional coordination between HERS Raters and contractors. Verification for the first and last habitable story and the 15 percent minimum remaining wall surface area inspected may be difficult to enforce, as multiple visits are required and there is less flexibility with timing for the required floors. The proposed failure mitigation option may itself be too difficult to fulfill. Maintaining third-party independence and randomization of verification timing to avoid biased space selection may be difficult, while ensuring the visits are timed during the correct phase of construction. California's HERS registries would need to house verification data related to multifamily buildings with four or more habitable stories. New installation forms, inspection forms, and registry requirements would be necessary to apply the Multifamily QII requirements. Multifamily project teams will need to increase coordination between Title 24, Part 6 consultants, the developer, installation trades, and HERS Raters.

6.2 Market Analysis

6.2.1 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 14, 2023.

The energy consultant often decides in consultation with the rest of the design team whether to include QII to improve the compliance margin using the performance approach, or as required if using the prescriptive approach, common in most climate zones. QII verification, typically managed by the construction manager, takes place during construction and requires coordination between the installation trades and verifier. QII consists of two distinct stages of verification:

- Air-seal stage after framing when framed cavities are exposed.
- Insulation installation stage when insulation has been installed but before drywall or other internal finishes, such as shower stalls or cabinetry, cover visual access to the insulation.

The air sealing inspection is to confirm that the framed cavities would have minimal likelihood of air movement through the insulation, which would render insulation less effective. The insulation installation inspection is to confirm that insulation was installed per the manufacturer's instructions, without compressions, gaps, or voids, filling the cavity's volume in its entirety.

The 2022 Energy Code multifamily QII protocol calls for direct inspection of 100 percent of the thermal envelope at each of these stages. Due to these verification protocols, HERS Raters visit each building site at minimum two times, one for each stage. However, for projects that have trouble coordinating the timing of inspection access relative to the trade's installation schedules and for large projects where the entire envelope could not be inspected within the span of one visit, it is possible and common for HERS Raters to visit multiple times, for each stage of inspection, to capture the entirety of the envelope. This is particularly likely for larger buildings and buildings with a more complicated envelope.

A failed QII verification, especially one that fails due to lack of visual access to conduct the protocol, rather than observed insulation installation defects, can be prohibitive to mitigate, as it would require the removal of internal finishes or installed insulation to grant mitigation and verification access. Additionally, by the time the project knows that it has failed QII, there are very few performance compliance options available to replace the energy impact of that failed QII using the performance approach. For this reason, a project that is using QII as a code compliance measure must plan and coordinate between the energy consultant, the insulation trades, the site foreman, and the HERS Rater.

The current QII protocol is based on residential wall assembly types and is not conducive to application to curtainwall assemblies. In some cases, curtainwall assemblies are shipped to the

site fully sealed, preventing the capacity for either the air-sealing or insulation quality inspection altogether. The Statewide CASE Team determined that developing appropriate and applicable QII protocols for the diverse types of curtainwall assemblies would be prohibitive and therefore proposes that curtain wall assembly types be exempted from the QII requirement, regardless of the building's total conditioned floor area. Buildings that use curtainwall assemblies on only a portion of their envelope would still be required to have QII conducted on all other wall sections.

6.2.2 Technical Feasibility and Market Availability

The proposed code change leverages existing requirements for multifamily buildings with three or fewer habitable stories and applies them to all multifamily buildings. Overall technical feasibility is not a barrier for the proposed QII code requirement. The materials, methods, and construction norms are all within current technical limits.

Because the proposed QII code change would improve the quality of insulation installation before sealing the walls, the energy savings are expected to last for the entirety of building lifetime, 30 years, with minimal degradation over time. The proposed code change improves the thermal performance and overall quality of envelope construction and results in enhanced occupant comfort. There are no anticipated changes in maintenance routines associated with QII.

The Statewide CASE Team used subject matter experts (SMEs) and stakeholder feedback as the principle means of soliciting, then vetting, code requirement options. The Statewide CASE Team solicited general proposal feedback, study approach, and relevant technical and market data sources via phone interviews and email correspondence with six SMEs. The SMEs represent views and experience from market actors including manufacturers, insulation installers, designers, energy consultants, HERS Raters, and voluntary efficiency program implementers.

6.2.2.1 Technical Feasibility

The Statewide CASE Team proposes to extend QII verification to multifamily buildings with four or more habitable stories, which had in previous codes applied to multifamily buildings with three or fewer habitable stories, either prescriptively or for performance credit. There are two critical challenges in applying QII to all multifamily buildings:

- Verification for larger buildings becomes logistically challenging and cost prohibitive due to staged construction and timing of access for verification activities.
- Performance compliance mechanisms, such as derate factors and verification protocols, only exist for multifamily buildings with three or fewer habitable stories and were derived from single family home norms that do not necessarily work well in multifamily settings.

SMEs described challenges in inspecting larger multifamily buildings. For such buildings, wall-assembly air-sealing, insulation installation, and installation of interior finishes such as drywall are not scheduled uniformly across the building envelope, but they are instead staged over time, with some steps occurring in parts of the building concurrent to other steps occurring elsewhere. Often, staging is floor-by-floor. Installation of certain interior finishes, such as shower stalls, kitchen cabinets, and stairwell framing often occurs separately and earlier than the rest of a wall's interior finish. Experts varied in their sense of what triggers staged construction in a multifamily building, but four or more habitable stories is generally accepted as a reasonable threshold.

The current QII verification protocol relies on two inspection points, each intended to visually verify 100 percent of the building's insulated thermal envelope in a single visit: walls, attic and roof, and floors over unconditioned space. One inspection point is for air sealing of the envelope with all cavities uninsulated and exposed, the second is with cavity insulation installed but without interior finishes covering it. For some assembly types, a third visit is required to verify aspects of full air sealing that occur late in construction, or when loose fill insulation is used for ceiling insulation that is installed after drywall. The protocol calls for inspection of other insulating surfaces, such as continuous insulation layers, either external or internal to framed cavities. For staged construction, it is impossible to conduct these inspections in one visit each. Verifiers of larger buildings informed the Statewide CASE Team that managing logistics and scheduling, even of multiple visits, can be prohibitively complicated, which results in missed opportunities to inspect certain envelope sections at the required inspection points and therefore failed compliance with QII's requirements.

The Statewide CASE Team considered multiple metrics and specific criteria to serve as the upper threshold for buildings with staged construction for which the extended QII requirement would apply. The metrics include number of stories, conditioned floor area, dwelling unit floor area, number of dwelling units, thermal envelope surface area, as well as multi-criteria combinations. The Statewide CASE Team's decision to use number of stories was driven by it being an uncomplicated standard data point for all multifamily buildings and for being the most determinant of the options available on whether thermal envelope assemblies would be completed in multiple stages. This was determined based on a combination of SME interviews and stakeholder surveys results. Experts and stakeholder considerations included the likelihood of construction staging practices and an assessment impact on verification time and consequently number of visits and costs likely for full-QII at varying building sizes.

6.2.2.2 Market Availability and Current Practices

The CEC oversees the HERS providers who train and certify HERS Raters. CalCERTS and California Home Energy Efficiency Rating Services (CHEERS) are the two HERS providers. CalCERTS reported 606 active Raters providing 5,620 home ratings in 2018. ATT personnel currently perform compliance verification for lighting and mechanical systems in multifamily buildings with four or more habitable stories, but not for envelope related measures such as QII. This measure, if performed by an ATT, would present a new type of ATT verification services for multifamily new construction buildings. This report presumes that HERS Raters would be leveraged for this verification process rather than ATT professionals. CalCERTS data show that 45 percent of low-rise multifamily buildings built under 2013 and 2016 Title 24, Part 6 codes took advantage of the QII performance credit for buildings. As of 2019, PG&E's above-code multifamily incentive program, California Multifamily New Homes data showed 29 of 94 unique buildings — just over 30 percent of participating buildings — reported electing to go through QII HERS verification on their compliance documents. Since QII only recently became a prescriptive requirement for low-rise multifamily buildings under the 2019 code cycle, industry experts expect that use of QII HERS verification, even in buildings that use the performance approach for compliance, would increase sharply.

The proposed code change would increase the number of buildings that require QII verification. This in turn would increase the demand for trained and available HERS Raters and the demand on the HERS registry to compile compliance documentation. Staff at CalCERTS stated that they are confident in their ability to update and expand the registry itself to capture QII

documentation from this larger quantity of buildings. Likewise, they are confident in the availability of enough Raters to serve the expanded market base.

6.2.3 Market Impacts and Economic Assessments

6.2.3.1 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 to remain current with changes to design practices and building codes.

Approximately 93,000 business establishments and 943,000 employees comprise California's construction industry (see Table 33). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in the industrial sector: utilities, infrastructure, and other heavy construction roles.

Table 33: California Residential Building Construction Industry — Establishments, Employment, and Payroll in 2022 (Estimated)

Residential Building Sector	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 QII would likely affect multifamily builders but 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 and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 34 shows the building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 6.2.4 Economic Impacts.

Table 34: 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 roofing contractors	2,600	18,918	1.1

Residential Building Subsector	Establishments	Employment	Annual Payroll (Billions $)
Residential siding contractors	242	2,081	0.1
Other residential exterior contractors	628	2,875	0.2
Residential drywall contractors	1,901	32,631	2.0
Residential flooring contractors	2,142	9,326	0.5
Other residential finishing contractors	699	4,277	0.2
Residential site preparation contractors	1,418	11,526	0.9
All other residential trade contractors	2,554	21,509	1.4

Source: (State of California n.d.)

6.2.3.2 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 current with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (NAICS 541310). Table 35 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for Multifamily QII to affect firms that focus on multifamily construction.

There is not a NAICS[26] 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 composed of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[27] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 35 provides an upper bound indication of the size of this sector in California.

[26] 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.

[27] 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 and enforcement of building codes and regulations.

Table 35: 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 and nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

6.2.3.3 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 DOSH. 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.

6.2.3.4 Impact on Building Owners and Occupants, Including Homeowners and Potential First-Time Homeowners

Residential Buildings

According to data from the U.S. Census, ACS, there were more than 14.5 million housing units in California in 2021 and nearly 13.3 million were occupied (see Table 36). 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 will be issued in 2022, up from 66,000 single family and 53,500 multifamily permits issued in 2021.

Table 36: California Housing Characteristics in 2021a

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

Housing Measure	Estimate
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 37 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 or 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 2019).

Table 37: 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.), (Federal Reserve Economic Data (FRED) n.d.)

Table 38 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 38: 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

Household Income	Total	Owner Occupied	Renter Occupied
$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.), (Federal Reserve Economic Data (FRED) 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 36 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 37and Table 38.

Estimating Impacts

Building owners and occupants would benefit from lower energy bills. As discussed in Section 6.2.4.1 when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

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

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers.

6.2.3.6 Impact on Building Inspectors

Table 39 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 39: 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.)

a. 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.
b. 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.

6.2.3.7 Impact on Statewide Employment

As described in Sections 6.2.3.1 through 6.2.3.7, 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 Section 6.2.4, the Statewide CASE Team estimated the proposed change in Multifamily QII would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors.

6.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[28], 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 total number of jobs created due to a code. 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.

[28] 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.

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 aspect 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 in the multifamily building and remodeling 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.[29] 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.

Table 40: Estimated 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 Multifamily Builders)	2.7	$216,395	$286,256	$349,099
Indirect Effect (Additional spending by firms supporting Residential Builders)	0.3	$24,692	$40,217	$69,355
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	1.0	$69,284	$124,043	$197,429
Total Economic Impacts	**4.1**	**$310,371**	**$450,515**	**$615,883**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[30]

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

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

Table 41: Estimated 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)	0.4	$48,553	$48,067	$75,974
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.2	$14,457	$20,092	$32,344
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.3	$18,118	$32,446	$51,642
Total Economic Impacts	**0.9**	**$81,128**	**$100,604**	**$159,960**

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

Table 42: Estimated 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)	1.4	$163,300	$193,653	$253,327
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.2	$15,124	$23,555	$41,025
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.8	$51,363	$92,007	$146,445
Total Economic Impacts	**2.4**	**$229,786**	**$309,215**	**$422,798**

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

6.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation 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 estimates of economic impacts discussed in Section 6.2.4 would lead to modest changes in employment of existing jobs.

6.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 6.2.4.1, 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 building insulation installation and inspection, 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.

6.2.4.3 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.[31] 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.

6.2.4.4 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).[32] As Table 42 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 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 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 43: 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 does not anticipate that the economic impacts associated with the proposed measure would lead to significant increase or decrease in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed

[31] 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.

[32] 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.

measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume will be allocated to net business investment.[33]

6.2.4.5 Incentives for Innovation in Products, Materials, or Processes

The proposed measure does not incentivize innovation in products, materials, or processes.

6.2.4.6 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.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will 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. Multifamily measures would not impact state buildings, other than state owned multifamily housing.

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 IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 6.1.4 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.

6.2.4.7 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. Renters are more likely to reside in multifamily buildings and are therefore expected to experience a greater impact from the proposed code change than persons generally. Refer to Section 2 for more details addressing energy equity and environmental justice.

6.2.5 Fiscal Impacts

6.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because the measure impacts multifamily buildings only.

[33] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 18.

6.2.5.2 Costs to Local Agencies or School Districts
There are no costs to local agencies or school districts because the measure impacts multifamily buildings only.

6.2.5.3 Costs or Savings to Any State Agency
There are no costs or savings to any state agencies because the measure impacts multifamily buildings only, and state agencies are not involved in the enforcement of the measure.

6.2.5.4 Other Nondiscretionary Cost or Savings Imposed on Local Agencies
There are no added nondiscretionary costs or savings to local agencies because the measure impacts multifamily buildings only.

6.2.5.5 Costs or Savings in Federal Funding to the State
There are no costs or savings to federal funding to the state because the measure impacts multifamily buildings only and would not require federal funding to implement.

6.3 Energy Savings
The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. The Statewide CASE Team interviewed three HERS Raters and ATTs, three designers, and two compliance consultants to inform the direction of this measure. The Statewide CASE Team also received feedback and responses to poll questions during the first utility-sponsored stakeholder meetings. See Appendix F for a summary of stakeholder engagement.

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

6.3.1 Energy Savings Methodology

6.3.1.1 Key Assumptions for Energy Savings Analysis
The prototypes are modeled with a derate factor applied to each type of cavity insulation, including both the walls and attics. The prototypes do not contain floors above unconditioned space. The other two derate mechanisms in the code only apply when attic zones are present. All prototypes in this analysis use cathedral ceilings with no attic. Comparisons across these derate factors represent the baseline and proposed conditions for various scenarios. The derate factors and their scenario applications within the savings analysis are the following:

1) **30 percent derate**: This is the baseline standard mid-rise mixed use and high-rise mixed use prototypes, representing unverified insulation quality for buildings of four or more habitable stories.
2) **15 percent derate**: This is the proposed standard design for the mid-rise mixed use and high-rise mixed-use scenarios representing a building with Multifamily QII verification.

6.3.1.2 Energy Savings Methodology per Prototypical Building
The Statewide CASE Team measured 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 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 GHG emissions. Finally, the Statewide CASE Team calculated LSC savings, formerly known TDV Energy Cost 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 CO_2 emissions.[34]

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 .

Table 44: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Mid-Rise Mixed-Use (MRMU)	5	113,100	5-story (4-story residential, 1-story commercial), 88-unit building. Avg dwelling unit size: 870 ft^2. Individual ducted split heat pump.
High-Rise Mixed-Use (MRMU)	10	125,400	10-story (9-story residential, 1-story commercial), 117-unit building. Avg dwelling unit size: 850 ft^2. Four-pipe fan coil.

The Statewide CASE Team estimated LSC, source energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change using prototypical buildings and rulesets from the 2025 Research Version of the CBECC software (California Energy Commission n.d.).

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[35] 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 Residential and Nonresidential ACM Reference Manuals. 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.

[34] See Hourly Factors for Source Energy, SLCC, and GHG Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

[35] 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.

There are no existing requirements in Title 24, Part 6 that cover the QII requirement for multifamily buildings with four or more habitable stories. The Statewide CASE Team modified the Standard Design so that it calculated energy impacts of the wood framed building with cavity insulation derated by 30 percent.

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 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume 50 percent credit back with a cavity insulation derated by 15 percent. This is done for all climate zones except Climate Zone 7 where QII is not required.

Table 45: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value (Multifamily QII)	Proposed Design Parameter Value (Full QII)
MRMU, HRMU	1, 2, 4, 8-16	Residential ceiling	Cavity insulation R-value	27	32	38
MRMU, HRMU	3, 5, 6	Residential ceiling	Cavity insulation R-value	21	26	30
MRMU, HRMU	6	Residential exterior wall	Cavity insulation R-value	15	19	22
MRMU, HRMU	1-5, 8-16	Residential exterior wall	Cavity insulation R-value	15	18	21

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/y) and therms per year (therms/y). It then applies the 2025 LSC hourly factors to calculate LSC in 2026 PV$, Source Energy hourly factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/y), 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 energy cost impacts.

Per unit energy impacts for multifamily buildings are presented in savings per dwelling 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.

6.3.1.3 Statewide Energy Savings Methodology

The per unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided (California Energy Commission 2022). 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. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction/additions and existing building stock) by building type and climate zone, as shown in Appendix A.

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

6.3.2 Per unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 45 through Table 49. The savings presented are from new construction. The per unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per unit savings for the first year are expected to range from 2 to 20 kWh/y and 0 to 0.84 therms/y depending upon climate zone. Demand reductions/increases are expected to range between 0 kW and 4 W depending on climate zone.

Energy savings vary greatly by climate zone. These savings variations are because quality insulation provides more energy savings in climate zones with greater heating and cooling needs. This measure saves both heating energy and cooling energy. In climate zones 1 and 16 a dual fuel (electric with gas backup) heat pump is the base case dwelling unit HVAC equipment. In climate zones 2 through 15, an all-electric heat pump provides heating and cooling of the dwelling units.

Table 46: First-Year Electricity Savings (kWh) Per Dwelling Unit by Climate Zone (CZ) and Prototype — Multifamily QII

Climate Zone	Mid-Rise Mixed Use	High-Rise Mixed Use
1	4.42	4.02
2	11.3	6.39
3	9.16	5.36
4	20.25	10.75
5	8.47	5.45
6	5.9	2.76
7	-	-
8	12	5.67
9	6	3.86
10	7.91	4.56
11	11.7	8.49
12	16.02	9.03
13	11.86	7.8
14	14.25	9.4
15	14.88	8.77
16	12.81	6.67

Table 47: First-Year Peak Demand Reduction (W) Per Dwelling Unit by Climate Zone (CZ) and Prototype — Multifamily QII

Climate Zone	Mid-Rise Mixed Use	High-Rise Mixed Use
1	1.33	1.11
2	2.24	1.69
3	3.33	1.8
4	3.89	2.21
5	3	1.71
6	0.68	0.56
7	-	-
8	0.83	0.58
9	1.46	0.99
10	1.89	1.16
11	2.82	1.99
12	2.78	2.02
13	2.21	1.69
14	3.7	2.51
15	0.73	0.61
16	2.25	1.37

Table 40: First-Year Natural Gas Savings (kBtu) Per Dwelling Unit — Multifamily QII

Climate Zone	Mid-Rise Mixed Use	High-Rise Mixed Use
1	15.00	9.57
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	84.20	54.44

Table 49: First-Year Source Energy Savings (kBtu) Per Dwelling Unit by Climate Zone (CZ) and Prototype — Multifamily QII

Climate Zone	Mid-Rise Mixed Use	High-Rise Mixed Use
1	28.03	21.01
2	26.62	17.68
3	30.08	17.04
4	45.31	24.97
5	27.52	16.51
6	12.42	7.61
7	-	-
8	18.3	9.43
9	17.41	10.83
10	19.07	11.36
11	30.34	21.54
12	32.51	20.79
13	24.19	17.2559
14	37.25	24.86564
15	16.38	9.431795
16	104.06	63.98615

Table 50: 30-Year LSC Savings (2026 PV$ Per Dwelling Unit by Climate Zone (CZ) and Prototype — Multifamily QII

Climate Zone	Mid-Rise Mixed Use	High-Rise Mixed Use
1	55.42	44.48
2	81.41	49.62
3	78.72	45.23
4	149.76	79.74
5	68.74	42.87
6	44.03	21.33
7	-	-
8	79.98	37.08
9	46.72	29.58
10	58.62	33.87
11	90.88	64.41
12	118.79	67.63
13	88.83	58.41
14	107.52	70.74
15	98.18	55.95
16	197.63	116.93

6.4 Cost and Cost-effectiveness

6.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 6.3.1. LSC hourly factors are a normalized metric to calculate energy cost 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.

The CEC requested LSC savings over the 30-year period of analysis in both 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 6.4 of this report. The CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (Form 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars.

The Statewide CASE Team anticipates a negligible number of instances of additions or alterations larger than four habitable stories. Additions of 700 square feet or more to buildings with four or more habitable are also rare. The Statewide CASE Team estimates that zero percent of additions and alternations would be impacted by the proposed Multifamily QII measure.

6.4.2 Energy Cost Savings Results

Per unit energy cost savings for newly constructed buildings in terms of LSC savings realized over the 30-year period of analysis are presented in 2026 present value dollars (2026 PV$) in **Error! Reference source not found.** through Table 52.

The LCCHF methodology allows peak electricity savings to be valued more than electricity savings during nonpeak periods.

Any time code changes impact cost, there is potential to affect DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

Table 51: 2026 PV LSC Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction and Additions — Mid-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	$36.48	$18.94	$55.42
2	$81.41	$0.00	$81.41
3	$78.72	$0.00	$78.72
4	$149.76	$0.00	$149.76
5	$68.74	$0.00	$68.74
6	$44.03	$0.00	$44.03
7	-	-	-
8	$78.98	$0.00	$78.98
9	$46.72	$0.00	$46.72
10	$58.62	$0.00	$58.62
11	$90.88	$0.00	$90.88
12	$118.79	$0.00	$118.79
13	$88.83	$0.00	$88.83
14	$107.52	$0.00	$107.52
15	$98.18	$0.00	$98.18
16	$92.29	$105.34	$197.63

Table 52: 2026 PV LSC Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction and Additions — High-Rise Mixed Use Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	$32.37	$12.11	$44.48
2	$49.62	$0.00	$49.62
3	$45.23	$0.00	$45.23
4	$79.74	$0.00	$79.74
5	$42.87	$0.00	$42.87
6	$21.44	$0.00	$21.44
7	-	-	-
8	$37.08	$0.00	$37.08
9	$29.58	$0.00	$29.58
10	$33.87	$0.00	$33.87
11	$64.41	$0.00	$64.41
12	$67.63	$0.00	$67.63
13	$58.41	$0.00	$58.41
14	$70.74	$0.00	$70.74
15	$55.95	$0.00	$55.95
16	$48.87	$68.06	$116.93

Table 53: Average 2026 PV LSC Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction and Additions — Weighted Average of All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	$36.15	$18.40	$54.56
2	$78.89	$0.00	$78.89
3	$76.06	$0.00	$76.06
4	$144.20	$0.00	$144.20
5	$66.68	$0.00	$66.68
6	$42.24	$0.00	$42.24
7	-	-	-
8	$75.65	$0.00	$75.65
9	$45.36	$0.00	$45.36
10	$56.66	$0.00	$56.66
11	$88.78	$0.00	$88.78
12	$114.73	$0.00	$114.73
13	$86.42	$0.00	$86.42
14	$104.60	$0.00	$104.60
15	$94.83	$0.00	$94.83
16	$88.84	$102.39	$191.23

6.4.3 Incremental First Cost

The incremental first cost of QII measure is equal to the verification cost of HERS rating. There are no additional material costs or installation costs. The Statewide CASE Team derived verification costs by estimating the time it would take to conduct the new verification protocol, priced at HERS Rater labor rates with appropriate markups for profit and overhead. The Statewide CASE Team accounted for the additional costs for vehicular travel to and from the work site for each visit using the reimbursement rates of $0.63 per mile traveled.

For each data point in the cost estimation—labor rates, verification time, travel distance, and surface area coverage—the Statewide CASE Team chose conservative values. The estimates and their methodology were informed by interviews and email correspondence with multiple HERS Raters, energy consultants, HERS Providers, and by the 2019 CASE Report on QII (Dakin and German 2017). The Statewide CASE Team received cost method input from a total of six SMEs. The cost estimate uses the following assumptions:

- A HERS Rater's field time would be billed at $90 per hour.
- The HERS Rater would verify the first and last habitable story and 20 percent of the remaining wall area, higher than the proposed 15 percent of minimum required area to reflect the proposed requirement to verify all visually accessible areas, even if that goes beyond the minimum.
    - Taking into account the area and geometry of the prototypes, this equates to 52 percent of the wall area inspected for the mid-rise prototype with a total of seven HERS Rater visits and 36 percent of the wall area inspected for the high-rise prototype with a total of six HERS Rater visits.
- The air sealing verification would take 20 minutes for a 500 ft^2 of wall area (the approximate average wall area of a typical multifamily dwelling unit).
- The insulation installation verification would take 30 minutes for a 500 ft^2 of wall area.
    - These time estimations encompass the average time to conduct wall inspections, attic and roof inspections, floor-over-unconditioned space inspections, documentation of findings, transition between spaces, and communication of verification-revealed failures with installing trades to allow for mitigation.
- An average 100-mile round trip travel distance per site visit.
- A maximum site visit time of five hours.
    - Given the assumptions for labor time for each phase of inspection and wall area inspected, as listed above, and rounding up for a conservative approach, this is assumed to be 8 visits for the mid-rise prototype and 7 visits for the high-rise prototype.

When applied to the prototype buildings, the costing method results in a per dwelling unit incremental cost of $43.18 for mid-rise ($37.49 for labor and $5.68 for travel), and $27.37 for high-rise ($23.63 for labor and $3.74 for travel). The Statewide CASE Team then applied the climate zone labor rate adjustment based on RS Means data across CASE topics.

6.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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.

QII verifications involve components of a building envelope and have expected useful life of 30 years. There is no maintenance cost relative to existing conditions if installed and performed properly at the time of construction. Energy performance related to insulations would persist for the 30-year lifetime of the building.

6.4.5 Cost-effectiveness

This measure proposes a prescriptive requirement for multifamily buildings with four or more habitable stories. As such, a cost analysis is required to demonstrate that the measure is cost-effective over the 30-year period of analysis.

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 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 PV costs and cost savings.

Results of the per unit cost-effectiveness analyses are presented in Table 41 for new construction/additions.

The proposed code change is cost-effective in every climate zone in which it is proposed.

Table 41: 30-Year Cost-Effectiveness Summary Per Dwelling Unit — New Construction/Additions

Climate Zone	Benefits LSC Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	B/C Ratio
1	$54.56	$41.19	1.32
2	$78.89	$54.29	1.45
3	$76.06	$48.11	1.58
4	$144.20	$53.57	2.69
5	$66.68	$52.11	1.28
6	$42.24	$40.83	1.03
7	-	-	-
8	$75.65	$40.83	1.85
9	$45.36	$40.83	1.11
10	$56.66	$40.83	1.39
11	$88.78	$41.56	2.14
12	$114.73	$41.92	2.74
13	$86.42	$41.56	2.08
14	$104.60	$40.83	2.56
15	$94.83	$40.83	2.32
16	$191.23	$42.28	4.52

Climate Zone	Benefits LSC Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	B/C Ratio
Total	$77.33	$43.52	1.78

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC savings over the period of analysis (California Energy Commission 2016, 51-53). Other savings are discounted at a real (nominal — inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis if PV of proposed costs is greater than PV of current costs. Costs are discounted at a real inflation-adjusted three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

6.5 First-Year Statewide Impacts

6.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per unit savings, which are presented in Section 6.3.2, 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: Statewide Savings Methodology, as are the Statewide CASE Team's assumptions about the percentage of new construction organized by climate zone and building type that would be impacted by the proposal.

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

presents the first-year statewide energy and energy cost savings from newly constructed buildings and additions by climate zone. Table 42 presents first-year statewide savings from new construction, additions, and alterations.

The proposed code change would impact all new construction Mid-Rise Mixed Use and High-Rise Mixed Use prototypes, except those in Climate Zone 7.

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

Table 42: Statewide Energy and Energy Cost Impacts — New Construction and Additions — by Climate Zone

Climate Zone	Statewide New Construction & Additions 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 Valued LSC Savings (Million 2026 PV$)
1	91	0.00	0.00	0.00	0.00	$0.00
2	876	0.01	0.00	-	0.02	$0.07
3	4,850	0.04	0.02	-	0.14	$0.37
4	2,153	0.04	0.01	-	0.09	$0.31
5	180	0.00	0.00	-	0.00	$0.01
6	1,413	0.01	0.00	-	0.02	$0.06
7	-	-	-	-	-	-
8	5,418	0.06	0.00	-	0.10	$0.41
9	6,490	0.04	0.01	-	0.11	$0.29
10	2,713	0.02	0.00	-	0.05	$0.15
11	739	0.01	0.00	-	0.02	$0.07
12	3,488	0.05	0.01	-	0.11	$0.40
13	636	0.01	0.00	-	0.02	$0.05
14	911	0.01	0.00	-	0.03	$0.10
15	235	0.00	0.00	-	0.00	$0.02
16	118	0.00	0.00	0.00	0.01	$0.02
Total	**30,311**	**0.31**	**0.06**	**0.00**	**0.73**	**$2.34**

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

Table 43: Statewide Energy and Energy Cost Impacts — New Construction, Additions, and Alterations

Construction Type	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 kBtu)	30-Year Present Valued LSC Savings (Million 2026 PV$)
New Construction & Additions	0.3	0.1	0.0	0.7	2
Alterations	-	-	-	-	-
Total	0.3	0.1	0.0	0.7	2

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

6.5.2 Statewide Greenhouse Gas (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 CO_2e). (California Energy Commission 2020)

The monetary value of avoided GHG emissions is based on a proxy for permit costs, not social costs.[14] The Cost-Effectiveness Analysis presented in Section 6.4 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 44 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 39 metric tons CO_2e would be avoided.

Table 44: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/y)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO_2e)	Natural Gas Savings[a] (Million Therms/y)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO_2e)	Total Reduced GHG Emissions[b] (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
Multifamily QII	0.31	38	0.0001	0.65	39	4,792
TOTAL	0.31	38	0.0001	0.65	39	4,792

a. First-year savings from all applicable newly constructed buildings, additions, and alterations completed statewide in 2026.

b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the SLCC hourly factors and Source Energy hourly factors by the CEC: 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

6.5.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.5.4 Statewide Material Impacts

There are no material impacts as a result of the proposed code change.

6.5.5 Other Non-Energy Impacts

The proposed code change will improve the quality of the building's insulation, which will improve resident comfort.

6.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice outside of any impacts mentioned in Section 2, therefore reducing the impacts of disparities in DIPs. The measure may benefit DIPs through improved indoor air quality, as improved cavity air sealing through multifamily quality insulation installation may lower exposure to outdoor air pollution, dry rot, and moisture problems. The Statewide CASE Team does not recommend further research or action at this time. See Section 2 for further information.

7. Central Ventilation Shaft Sealing

7.1 Measure Description

7.1.1 Proposed Code Change

This measure would extend mandatory central ventilation duct shaft sealing for multifamily buildings with four or more habitable stories to all multifamily buildings with central ventilation, including buildings with three habitable stories or fewer. The measure would require field verification of central ventilation duct leakage using a fan pressurization test to ensure that leakage does not exceed six percent of the central (e.g., rooftop) fan airflow rate at 50 Pa (0.2 inches of water column [w.c.]) for central ventilation duct serving more than six dwelling units, and it would require fan airflow rate at 25 Pa (0.1 inches w.c.) for central ventilation ducts serving six or fewer dwelling units.

The measure would not modify the established verification test process in Reference Nonresidential Appendix NA7.18.3. Additions would need to follow proposed language for new construction. The measure would not apply to alterations.

7.1.2 Justification and Background Information

7.1.2.1 Justification

The justification behind this code proposal, as with other proposed measures in this report, is to simplify and streamline an existing code requirement across multifamily buildings that is currently split based on number of habitable stories. For this measure, removing the stipulation that it only applies to buildings with a certain number of stories would extend the existing central ventilation shaft sealing requirement to all multifamily buildings. The measure would result in energy savings from reduced ventilation fan power and reduced heating and cooling energy from less air leakage from conditioned space. Indoor air quality benefits for multifamily residents include reduced bathroom and cooking pollution from central exhaust fans and evenly distributed air from central supply ventilation shafts.

7.1.2.2 Background Information

The central ventilation shaft sealing measure was proposed and adopted as a measure in the 2022 Multifamily IAQ CASE Report for buildings with four or greater habitable stories only. Buildings up to three habitable stories were not included at that time due to a CEC decision not to add stringency for low-rise residential buildings in the 2022 cycle.

7.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[36] See Section 10 of this report for detailed proposed revisions to code language.

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

7.1.3.1 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 10.2 of this report for marked-up code language.

Section: NA7.1

Specific Purpose: The specific purpose is to modify the scope of the central ventilation shaft requirements to apply to all multifamily applications, rather than only to multifamily buildings of four or more habitable stories.

Necessity: These changes are necessary to streamline multifamily building requirements and increase energy efficiency via cost-effective building design standards, as directed by the California Public Resources Code Sections 25213 and 25402.

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

The proposed code change would not modify the ACM Reference Manual.

7.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Section 11.4.3 of the Nonresidential and Multifamily Compliance Manual would need to be revised to include application of the central ventilation shaft sealing requirement to all multifamily buildings with central ventilation shafts, including those with three habitable stories or fewer.

7.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised forms are presented in Section 10.5.

- **LMCC-MCH-01-E:** Would need to be updated to reflect central shaft sealing requirements.
- **LMCI-MCH-27b-H Indoor Air Quality and Mechanical Ventilation:** Would need to be updated to reflect central shaft sealing requirements.
- **LMCV-MCH-27b-H Indoor Air Quality and Mechanical Ventilation:** Would need to be updated to reflect central shaft sealing requirements.

7.1.4 Regulatory Context

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

The duct sealing requirements for ducts carrying conditioned air was first added in the 2005 version of Title 24, Part 6 for nonresidential buildings, and it was expanded to central ventilation system ducts in multifamily buildings with four or more habitable stories in the 2022 version of Title 24, Part 6. It specifies a maximum leakage rate of six percent of the nominal air handler airflow rate based on field verification and diagnostic testing, in accordance with Reference Nonresidential Appendix NA7.18.3. The Central Ventilation System Duct Leakage Acceptance test described in NA7.18.3 states duct leakage testing is done at 25 Pa (0.1 inch water) for ducts serving two to six dwelling units, which is the same test pressure as for a residential duct

leakage test. For systems serving more than six dwelling units, the test pressure is 50 Pa (0.2 inches water).

While the California Mechanical Code has complementary requirements for duct sealing, it does not include duct leakage testing for ventilation ducts in multifamily buildings.

7.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

7.1.4.3 Difference From Existing Model Codes and Industry Standards

Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) is the industry practitioner leader for duct construction and testing. The SMACNA HVAC Air Duct Leakage Test Manual 2nd edition states in Section 2.5.1 Leakage Tests, "It is not required that duct systems constructed to 3 in. wg[37] class or lower be tested." Because central ventilation ducts in multifamily buildings typically have a static pressure of 1 inch w.c. or less, this type of ductwork would not require testing under this manual. However, SMACNA representatives reported to the Statewide CASE Team that they support leakage testing for low pressure classes of ductwork at a meeting held during the 2022 code cycle on October 16, 2019.

The test for this measure is based on ASTM 1554 Method D — Total duct leakage test.

7.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:** During the design phase, the architect, building owner, and contractor develop and implement the central shaft sealing plan. The architect identifies the location of central ventilation shafts; specifies duct sealing materials and sealing strategies; minimum site conditions; and outlines oversight responsibilities.
2. **Permit Application Phase:** During the permit phase, the general contractor submits design documents showing the location of central ventilation shafts and sealing materials with the permit application. The energy consultant completes and submits compliance documents LMCC-MCH-01-E Mechanical Systems for three or fewer stories or NRCC-MCH-01-E Mechanical Systems for four or more stories.
3. **Construction Phase:** During the construction phase, sheet metal workers apply duct sealant to the seams and joints of the ducts during assembly; taking care to cover the seams with sealant of a thickness and width as prescribed by the sealant manufacturer; and ensuring that manufacturer's recommendations for application conditions such as minimum temperature and moisture are met. The general contractor seals each central ventilation shaft following installation and verification procedures and documents on compliance documents.

[37] Note that "in. wg" is inches water gauge, which is the same as inches w.c.

4. **Inspection Phase:** During the inspection phase, the building inspector confirms leakage results are submitted and meet compliance requirements. The ATT conducts leakage test, verifies leakage does not exceed permissible value, performs required compliance testing, and verifies performance meets code requirements. The ATT documents results per the requirements of the compliance Certificates of Acceptance LMCA-MCH-27b-H Indoor Air Quality and Mechanical Ventilation for three or fewer stories or NRCA-MCH-27 for four or more stories.

The compliance and verification processes are already in place for multifamily buildings with four or greater habitable stories. The proposed processes would be the same for multifamily buildings with three or fewer habitable stories. The market actors involved in implementation are the project team of building owners, architects, and builders who would develop and implement central shaft sealing plan, the ATT who would conduct a shaft sealing test and record results, and the code official who would review the shaft sealing test result.

7.2 Market Analysis

7.2.1 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.

Title 24, Part 6 requires ventilation for dwelling units, but does not specify how it must be provided. For multifamily projects, mechanical engineers, general contractors, and developers identify an overall ventilation strategy. These ventilation strategies could include central ventilation ductwork that serves multiple dwelling units, each with its own unitary equipment or unitized ventilation systems for each unit. The ventilation strategy decision may vary by airstream: supply air, bathroom exhaust, kitchen exhaust, etc. Airflows in these central ventilation ducts may be continuous or intermittent. While multifamily buildings use central ventilation ducts, this design is not common in low-rise buildings.

The market is equipped to meet this requirement, since duct sealing is required for some commercial and multifamily duct systems under 2019 Title 24, Part 6, and for industry standard practice such as recommendations from SMACNA.

Mechanical engineers specify details for central ventilation ducts, including the number of central ventilation ducts, location and sizing of ductwork, central fan model and capacity, and balancing method. Testing and balancing contractors conduct balancing to ensure each dwelling receives the required amount of ventilation.

To meet the proposed code change, mechanical engineers will also specify how and where ducts will be sealed. General contractors will be responsible for ensuring that subcontractors seal ducts according to the specifications. An ATT will conduct the leakage test to measure leakage.

7.2.2 Technical Feasibility and Market Availability

Based on Title 24, Part 6 requirements for sealing ducts carrying conditioned air and SMACNA requirements for sealing higher pressure ducts, the industry often seals ductwork. However, industry standard practice is to not seal ventilation ducts, because they are low pressure and carry unconditioned air, or ventilation air with moderate conditioning from an ERV, HRV, or from a Dedicated Outdoor Air Supply (DOAS) with moderate tempering.

The proposed measure is the same as the existing requirement in 2022 Title 24, Part 6, Section 160.2(b)2C, which requires a leakage test for central ventilation ducts serving multiple units for multifamily buildings with four or more habitable stories. In the 2022 Multifamily IAQ CASE Report, the Statewide CASE Team reported discussing the feasibility of conducting the leakage test in shafts serving larger areas with staff from Association for Energy Affordability (AEA). AEA has conducted central ventilation shaft leakage testing on many ducts in multifamily buildings that serve larger areas, including shafts serving up to 14 stories. In almost all cases, AEA staff reported they are able to conduct leakage measurements with a standard duct blaster test; occasionally, they use a blower door fan to achieve the required pressure.

To increase the chance of passing the proposed requirement, the project team could conduct qualitative inspections using visual observations or smoke pencil tests to identify leakage paths and improve sealing.

One major reason why the Statewide CASE Team proposed this measure for new construction and additions is because once construction is complete, most of the duct system will be behind drywall, so visual inspection of the seams will be impractical, and sealing becomes more difficult. Visual inspection will be possible where exposed in mechanical rooms and other unfinished spaces. If supply or exhaust registers are removed for cleaning or replacement, the seam between the register boot and drywall assembly can be checked for cracks or separation and resealed as needed.

7.2.3 Market Impacts and Economic Assessments

7.2.3.1 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 to remain current with changes to design practices and building codes.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 45). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work the industrial sector: utilities, infrastructure, and other heavy construction.

Table 45: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establishments	Employment	Annual Payroll

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

Source: (State of California n.d.)

The proposed change to central ventilation shaft sealing would likely affect multifamily builders but 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 and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 46 shows the building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 7.2.4 Economic Impacts.

Table 46: 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 structural steel contractors	275	3,207	0.2
Residential plumbing and HVAC contractors	9,852	75,404	5.1
Residential site preparation contractors	1,418	11,526	0.9
All other residential trade contractors	2,554	21,509	1.4

Source: (State of California n.d.)

7.2.3.2 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 current with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (NAICS 541310). **Error! Reference source not found.** shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms in the Architectural Services sector. The Statewide CASE Team anticipates the impacts for central ventilation shaft sealing to affect firms that focus on multifamily construction.

There is not a North American Industry Classification System (NAICS)[38] 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.[39] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in **Error! R eference source not found.** provides an upper bound indication of the size of this sector in California.

Table 47: 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 residential and nonresidential building inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

7.2.3.3 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 DOSH. 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.

7.2.3.4 Impact on Building Owners and Occupants Including Homeowners and Potential First-Time Homeowners

Residential Buildings

According to data from the U.S. Census, ACS, there were more than 14.5 million housing units in California in 2021 and nearly 13.3 million were occupied (see Table 48). Most housing units

[38] 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.

[39] 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.

(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 will be issued in 2022, up from 66,000 single family and 53,500 multifamily permits issued in 2021.

Table 48: 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 49 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 Building Code (Kenney 2019).

Table 49: 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.), (Federal Reserve Economic Data (FRED) n.d.)

Table 50 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 50 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.), (Federal Reserve Economic Data (FRED) 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 48 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 49 and Table 50.

Estimating Impacts

Building owners and occupants would benefit from lower energy bills. As discussed in Section 3.2.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the

economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

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

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers.

7.2.3.6 Impact on Building Inspectors

Table 51 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 51: 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.)

a. 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.
b. 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.

7.2.3.7 Impact on Statewide Employment

As described in Sections 7.2.4.1 through 7.2.4.7, 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 Section 7.2.4, the Statewide CASE Team estimated the proposed change in central ventilation shaft sealing would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, and energy consultants, and building inspectors.

7.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[40], along with economic information from published sources, and professional judgment 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 total number of jobs created due to a code. 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 aspect 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 multifamily building and remodeling 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.[41] 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.

[40] 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.

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

Table 52: Estimated Impact that Adoption of the Proposed Measure would have on the California Residential Construction Sector Multifamily New Construction

Type of Economic Impact	Employment	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Multifamily Builders)	0.7	$52,301	$69,185	$84,374
Indirect Effect (Additional spending by firms supporting Residential Builders)	0.1	$5,968	$9,720	$16,763
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.2	$16,745	$29,980	$47,717
Total Economic Impacts	**1.0**	**$75,014**	**$108,885**	**$148,853**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[42]

Table 53: Estimated 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)	0.0	$2,607	$2,581	$4,080
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.0	$776	$1,079	$1,737
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.0	$973	$1,742	$2,773
Total Economic Impacts	**0.0**	**$4,356**	**$5,402**	**$8,590**

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

Table 54: Estimated 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)	0.1	$12,627	$14,974	$18,197
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.0	$1,169	$1,821	$3,172
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.1	$3,972	$7,115	$11,324
Total Effect	**0.2**	**$17,768**	**$23,910**	**$32,693**

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

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

7.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation 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 estimates of economic impacts discussed in Section 7.2.4 would lead to modest changes in employment of existing jobs.

7.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 7.2.4.1, 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 sealing central ventilation ducts, 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.

7.2.4.3 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.[43] 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.

7.2.4.4 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).[44] As **Error! Reference source not found.** shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 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 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 55: 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

[43] 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.

[44] 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.

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 does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume will be allocated to net business investment.[45]

7.2.4.5 Incentives for Innovation in Products, Materials, or Processes

The proposed measure incentivizes innovation in building materials, components, and processes by setting sensible mandatory requirements without mandating any specific construction techniques or materials.

7.2.4.6 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.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will 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. Multifamily measures would not impact state buildings, other than state owned multifamily housing.

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 IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 7.1.5 and Appendix E, the Statewide

[45] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 18.

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.

7.2.4.7 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. Renters are more likely to reside in multifamily buildings and are therefore expected to experience a greater impact from the proposed code change than persons generally. Refer to Section 2 for more details addressing energy equity and environmental justice.

7.2.5 Fiscal Impacts

7.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because the measure impacts multifamily buildings only.

7.2.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts because the measure impacts multifamily buildings only.

7.2.5.3 Costs or Savings to Any State Agency

There are no costs or savings to any state agencies because the measure impacts multifamily buildings only, and state agencies are not involved in the enforcement of the measure.

7.2.5.4 Other Nondiscretionary Cost or Savings Imposed on Local Agencies

There are no added nondiscretionary costs or savings to local agencies because the measure impacts multifamily buildings only.

7.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state because the measure impacts multifamily buildings only and would not require federal funding to implement.

7.3 Energy Savings

The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. The Statewide CASE Team interviewed three ATTs, three designers, and two compliance consultants to inform the direction of this measure. The Statewide CASE Team also received feedback and responses to poll questions during the first utility-sponsored stakeholder meetings. See Appendix F for a summary of stakeholder engagement.

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

7.3.1 Energy Savings Methodology

7.3.1.1 Key Assumptions for Energy Savings Analysis

The Statewide CASE Team evaluated using the central ventilation shaft sealing measure using the CBECC compliance software. This measure applies to all multifamily buildings with three or fewer habitable stories, however only the Low-Rise Loaded Corridor prototype was evaluated. The Statewide CASE Team determined that central ventilation was unlikely for the Low-Rise Garden Style building; therefore, this prototype was not analyzed. 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 energy cost impacts.

7.3.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team measured 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 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 GHG emissions. Finally, the Statewide CASE Team calculated LSC savings, formerly known as TDV Energy Cost Savings. LSC Savings are calculated using hourly energy cost metrics 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.[46]

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. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 56.

Table 56: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Low-Rise Loaded Corridor (LRLC)	3	39,264	3-story, 36-unit apartment building. Average dwelling unit size: 960 ft^2. Individual ducted split heat pump. Modified to include a central ventilation shaft.

The Statewide CASE Team estimated LSC, source energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change using prototypical buildings and rulesets from the 2025 Research Version of the CBECC software (California Energy Commission n.d.).

[46] See Hourly Factors for Source Energy, SLCC, and GHG Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[47] 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.

There are no existing requirements in Title 24, Part 6 that cover the central ventilation shaft sealing requirement for low-rise residential buildings. The Statewide CASE Team modified the Standard Design so that it has a central ventilation shaft serving multiple dwelling units. The analysis assumed that the building had central supply ventilation, but each individual dwelling unit had its own exhaust system. Data from Gabel Energy indicates that this is the most common design for low-rise multifamily buildings with central ventilation shafts. Note that, if this analysis had assumed central supply ventilation and central exhaust, energy savings would roughly double, because the supply and exhaust airflows would be the same for a balanced system.

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 57 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume a central ventilation shaft serving multiple dwelling units, with a specified duct leakage rate. The Standard Design uses 25 percent at 25 Pa, which was estimated as the baseline leakage value in the Title 24-2019 Residential IAQ CASE Report.

The Proposed Design assumed 6 percent leakage at 25 Pa (0.1 inches w.c.) for all central ventilation ducts, which is the proposed maximum requirement for ducts servings six or fewer dwelling units. However, it is less stringent than the proposed requirement for central ventilation ducts serving more than six units: no more than 6 percent leakage at 50 Pa (0.2 inches w.c.). Consequently, the modeled energy savings underestimate savings. Since this is a worst-case assumption for savings, the Statewide CASE Team did not repeat analysis under the proposal of 6 percent leakage at 50 Pa.

Table 57: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
LRLC	All	Central ventilation duct leakage	-	25% duct leakage at 25 Pa	6% duct leakage at 25 Pa

[47] 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.

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/y) and therms per year (therms/y). It then applies the 2025 LSC hourly factors to calculate LSC in 2026 PV$, Source Energy factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/y), 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 do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific SLCC hourly factors when calculating energy and energy cost impacts.

Per unit energy impacts for multifamily buildings are presented in savings per dwelling 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.

7.3.1.3 Statewide Energy Savings Methodology

The per unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided (California Energy Commission 2022). The Statewide Construction Forecasts estimate new construction and additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction/additions and existing building stock) 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.

7.3.2 Per Unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 58 The savings presented are from new construction. The per unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per unit savings for the first year are expected to range from 11 to 57 kWh/y and 0 to 0.42 therms/y depending upon climate zone. Demand reductions and increases are expected to range between 0.3 kW and 12.7 kW depending on climate zone. Note that only Climate Zone 16 shows gas savings because the baseline system in all other climates zones is a heat pump.

Table 58: Energy Impacts Per Dwelling Unit — Central Ventilation Shaft Sealing, Loaded Corridor Prototype

Climate Zone	First-year Electricity Savings (kWh)	First-Year Peak Demand Reduction (kW)	First-Year Natural Gas Savings (kBtu)	First-Year Source Energy Savings (kBtu)	First-Year Lifecycle Cost Savings (2026 PV$)
1	49.17	12.69	-	140.91	377.04
2	36.39	10.63	-	107.76	284.77
3	36.34	9.46	-	110.92	283.46

4	37.37	8.57	-	95.98	287.5
5	35.68	9.66	-	101.21	269.5
6	11.54	1.21	-	20.4	80.6
7	14.19	0.42	-	18.43	103.4
8	34.95	1.98	-	47.77	221.08
9	34.31	3.66	-	60.86	231.98
10	40.27	5.81	-	56.17	264.27
11	57.21	11.45	-	114.63	413.8
12	41.49	10.58	-	104.05	320.77
13	52.4	7.86	-	87.14	373.99
14	48.74	10.89	-	106.56	352.18
15	56.57	0.26	-	27.59	335.71
16	14.7	0.36	427.58	401.8	618.08

7.4 Cost and Cost-effectiveness

7.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 7.3.1. LSC hourly factors are a normalized metric to calculate energy cost 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.

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 PV$ and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$. Costs and cost-effectiveness using and 2026 PV$ are presented in Section 7.4 of this report. The CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (Form 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars.

The proposed code change applies to additions, however the Statewide CASE Team determined that the energy savings from central ventilation shaft sealing additions for low-rise building types is negligible; therefore, cost savings for this situation was not analyzed. The proposed code change would not be relevant for alterations.

7.4.2 Energy Cost Savings Results

Per unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over the 30-year period of analysis are presented 2026 PV$ in Table 59.

The LSC methodology allows peak electricity savings to be valued more than electricity savings during nonpeak periods.

Any time code changes impact cost, there is potential to affect DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

Table 59: 2026 PV LSC Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction and Additions — Low-Rise Loaded Corridor

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	$377.04	$0.00	$377.04
2	$284.77	$0.00	$284.77
3	$283.46	$0.00	$283.46
4	$287.50	$0.00	$287.50
5	$269.50	$0.00	$269.50
6	$80.60	$0.00	$80.60
7	$103.40	$0.00	$103.40
8	$221.08	$0.00	$221.08
9	$231.98	$0.00	$231.98
10	$264.27	$0.00	$264.27
11	$413.80	$0.00	$413.80
12	$320.77	$0.00	$320.77
13	$373.99	$0.00	$373.99
14	$352.18	$0.00	$352.18
15	$335.71	$0.00	$335.71
16	$87.80	$530.28	$618.08

7.4.3 Incremental First Cost

The incremental first cost for the central ventilation shaft sealing measure includes the material and labor costs for the duct sealing materials, as well as the labor cost for ATT verification.

For this measure, the Statewide CASE Team assumed central ventilation for supply air and individual dwelling unit exhaust for the high-rise prototype, because project data from Gabel Energy showed that this is the most common scenario for multifamily buildings with three or fewer stories that have a central supply ventilation system. This is also supported by interviews with SMEs.

For the Low-Rise Loaded Corridor prototype, the Statewide CASE Team assumed six shafts with two branches each per floor. The shafts are 8 inch by 18 inch and 27 feet long (serving three floors).

The material cost for this measure is the mastic used to seal the ducts. The cost calculations assumed that the vertical shaft and horizontal branches would require sealing. Manufacturer data reports a cost of $35.95 per gallon, and a coverage of 125 linear feet per gallon. Based on the geometry and quantity of shafts, and accounting for a 10 percent waste allowance, 11 gallons would be required for this building. This equates to a cost of $402.98, or $11.19 per dwelling unit.

The labor cost consists of the contractor labor to apply the duct sealing mastic. The mastic can be applied with a brush or an airless sprayer, which is faster and therefore less costly. The cost

calculation assumed brush application for a conservative estimate. The time required to apply the duct sealing mastic was estimated based on labor time rates for coating application by brush from RS Means: 0.013 hours per linear foot, and 0.012 hours per square foot. The RS Means rate for a sheet metal worker, including overhead and profit, is $105.70 per hour. For the building analyzed, this is a total cost of $1,267.39, or $35.21 per dwelling unit.

To calculate the verification costs, the Statewide CASE Team assumed that two of the six central ventilation systems would be tested, per the sampling requirements for buildings with four or more habitable stories. The labor time assumptions are: 1 hour each for mounting the duct tester fans, 0.25 hours to temporarily seal the openings on each shaft, and 2 hours to run each test. An ATT hourly rate is estimated to be $150 based on stakeholder interviews, meaning the verification cost for this building would be $1,350, or $37.50 per dwelling unit.

The total cost per dwelling unit for the central shaft sealing is the combination of the material, labor, and verification costs: $11.19 + $35.21 + $37.50 = $83.90. The Statewide CASE Team then applied the climate zone labor rate adjustment based on RS Means data across CASE topics.

7.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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 Statewide CASE Team does not anticipate maintenance requirements for this measure within 30 years. Properly applied duct mastic will last the lifetime of the duct assembly. The mastic is applied on the outside of the duct, so it is not in contact with moist air from an exhaust stream.

7.4.5 Cost-effectiveness

This measure proposes a mandatory requirement. As such, a cost analysis is required to demonstrate that the measure is cost-effective over the 30-year period of analysis.

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 savings 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 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 PV costs and cost savings.

Results of the per unit cost-effectiveness analyses are presented in Table 60 for new construction and additions.

The proposed measure saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost-effective in all climate zones except Climate Zone 6.

Table 60: 30-Year Cost-Effectiveness Summary Per Dwelling Unit — New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	B/C Ratio
1	$377.04	$81.55	4.62
2	$284.77	$107.84	2.64
3	$283.46	$95.81	2.96
4	$287.50	$106.72	2.69
5	$269.50	$104.26	2.58
6	$80.60	$81.38	0.99
7	$103.40	$80.99	1.28
8	$221.08	$81.16	2.72
9	$231.98	$81.05	2.86
10	$264.27	$81.27	3.25
11	$413.80	$82.72	5.00
12	$320.77	$83.90	3.82
13	$373.99	$83.17	4.50
14	$352.18	$80.82	4.36
15	$335.71	$80.82	4.15
16	$618.08	$83.73	7.38

a. **Benefits: LSC Savings + Other PV Savings:** Benefits include LSC savings over the period of analysis (California Energy Commission 2016, 51-53). Other savings are discounted at a real (nominal — inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

7.5 First-Year Statewide Impacts

7.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per unit savings, which are presented in Section 7.3.2, 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: Statewide Savings Methodology, as are the Statewide CASE Team's assumptions about the

percentage of new construction, by climate zone and building type, that would be impacted by the proposal .

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

Error! Reference source not found. below present the first-year statewide energy and energy c ost savings from newly constructed buildings and additions by climate zone. Table 61 presents first-year statewide savings from new construction, additions, and alterations.

The Statewide CASE Team determined that central ventilation shafts are uncommon in low-rise multifamily buildings and assumed that 10 percent of the Low-Rise Loaded Corridor prototype would be affected by the proposed code change based on industry judgement. The Statewide CASE Team determined that central ventilation was unlikely for the Low-Rise Garden Style building, and therefore this prototype was not analyzed. Assumptions used to determine the incremental cost estimate are described in Section 7.4.3.

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

Table 61: Statewide Energy and Energy Cost Impacts — New Construction and Additions

Climate Zone	Statewide New Construction & Additions 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 Valued LSC Savings (Million 2026 PV$)
1	5	0.00	0.00	-	0.00	$0.00
2	46	0.00	0.00	-	0.00	$0.01
3	254	0.01	0.00	-	0.03	$0.07
4	113	0.00	0.00	-	0.01	$0.03
5	9	0.00	0.00	-	0.00	$0.00
6	74	0.00	0.00	-	0.00	$0.01
7	170	0.00	0.00	-	0.00	$0.02
8	284	0.01	0.00	-	0.01	$0.06
9	340	0.01	0.00	-	0.02	$0.08
10	142	0.01	0.00	-	0.01	$0.04
11	39	0.00	0.00	-	0.00	$0.02
12	183	0.01	0.00	-	0.02	$0.06
13	33	0.00	0.00	-	0.00	$0.01
14	48	0.00	0.00	-	0.01	$0.02
15	12	0.00	0.00	-	0.00	$0.00

Climate Zone	Statewide New Construction & Additions 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 Valued LSC Savings (Million 2026 PV$)
16	6	0.00	0.00	0.00	0.00	$0.00
Total	**1,758**	**0.06**	**0.01**	**0.00**	**0.13**	**$0.44**

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

Table 62: Statewide Energy and Energy Cost Impacts — New Construction, Additions, and Alterations

Construction Type	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 kBtu)	30-Year Present Valued LSC Savings (PV$ Million)
New Construction & Additions	0.06	0.01	0.00	0.13	0.44
Alterations	-	-	-	-	-
Total	**0.06**	**0.01**	**0.00**	**0.13**	**0.44**

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

7.5.2 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 at an assumed cost of $123.15 per metric ton of carbon dioxide equivalent emissions (metric tons CO_2e). (California Energy Commission 2020)

The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs).[48] The Cost-Effectiveness Analysis presented in Section 7.4 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 63 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 6.89 (metric tons CO_2e) would be avoided.

[48] 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.

Table 63: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/y)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO_2e)	Natural Gas Savings[a] (Million Therms/y)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO_2e)	Total Reduced GHG Emissions[a] (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
Central Ventilation Shaft Sealing	0.1	7	0.00	0.2	7	$848.40
TOTAL	0.1	7	0.00	0.2	7	**$848.40**

a. First-year savings from all newly applicable newly constructed buildings, additions, and alterations completed statewide in 2026.

b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and Source Energy hourly factors by CEC here: https://www.energy.ca.gov/files/2025-energy-code-hourly-factors 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 CEC.

7.5.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

7.5.4 Statewide Material Impacts

The Statewide CASE Team estimated material impacts for the central ventilation duct sealing measure based on the cost calculation discussed in Section 7.4.3. The Statewide CASE Team assumed no material impacts in the baseline case. Additionally, more tape would be used to seal registers during the leakage test, but this analysis does not account for material impacts from tape.

Mastic does not contain any significantly hazardous chemicals and does not pose a significant risk to those handling it or the environment. It is primarily made of ground limestone and hydrated aluminum silicate.

The Statewide CASE Team estimated that the materials impact from central ventilation duct sealing is approximately 11 gallons for the Low-Rise Loaded Corridor prototype, or 0.3 gallons per dwelling unit, as explained in Section 7.4.3. Based on a density of 12.1 pounds per gallon, central ventilation shaft sealing uses about four gallons of mastic per dwelling unit. To extrapolate to statewide impacts, the Statewide CASE Team multiplied the number of units impacted by this measure by the pounds of mastic used per dwelling unit. See Appendix D for more details.

Table 64: First-Year Statewide Impacts on Material Use

Material	Impact	Per unit Impacts (Pounds per Dwelling Unit)	First-Year [a] Statewide Impacts (Pounds)
Mercury	No change	-	-
Lead	No change	-	-

Copper	No change	-	-
Steel	No change	-	-
Plastic	No change	-	-
Mastic	Increase	3.80	6,680

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

7.5.5 Other Non-Energy Impacts

In addition to the energy savings, the proposed requirement would provide indoor air quality benefits by working with the central ventilation shaft balancing requirement in 2022 Title 24, Part 6 to help ensure that each dwelling unit receives the minimum ventilation rate — both at the time of testing and in the future. In addition, the measure would help ensure that central ventilation ducts carrying exhaust air would maintain negative pressure, thereby preventing exhaust air transfer to dwelling units.

7.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice outside of any impacts mentioned in Section 2, therefore reducing the impacts of disparities in DIPs. The measure may benefit DIPs through improved indoor air quality, as improved duct sealing through central ventilation shaft sealing would reduce air leakage between dwelling units, limiting transfer of smoke and contaminants like carbon monoxide from adjacent units. The Statewide CASE Team does not recommend further research or action at this time. See Section 2 for further information.

8. Verification Clean Up

8.1 Measure Description

8.1.1 Proposed Code Change

This measure would extend HERS compliance credits to all applicable multifamily buildings, regardless of number of habitable stories, for:

1. **Low Leakage Air-handling Units**: Verify low leakage air handler and ducts installed and system leakage rate meets or exceeds rate specified on certificate of compliance.
2. **Variable Capacity Heat Pump (VCHP) Compliance Option**: Verify system equipment is listed in CEC low-static pressure systems, non-continuous fan operation, refrigerant charge, low leakage ducts in conditioned space, ductless system in conditioned space, airflow to all habitable spaces, wall-mounted thermostats for zones >150 ft^2, ducted airflow, and air filter pressure drop.

The measure would remove verification requirements for buildings with three or fewer habitable stories, so that the compliance options can be claimed without verification for all applicable multifamily buildings, regardless of number of habitable stories, for:

1. **Verified Energy Efficiency Ratio (EER/EER2)**: Verify system equipment is listed in approved directory and necessary information is provided.
2. **Verified Seasonal Energy Efficiency Ratio (SEER/SEER2)**: Verify system equipment is listed in approved directory and necessary information is provided.
3. **Verified Heating Seasonal Performance Factor (HSPF/HSPF2):** Verify system equipment is listed in approved directory and necessary information is provided.
4. **Rated Heat Pump Capacity Verification**: Verify system equipment is listed in approved directory and heating capacities are greater than or equal to values specified on certificate of compliance.

The measure would also remove compliance options that are not applicable or common in multifamily buildings, including:

1. **Evaporatively Cooled Condensers** — Verify low leakage ducts, refrigerant charge, time delay response, listed equipment, and system efficiencies.
2. **Whole House Fan**: Verify airflow rate and watt draw. Calculate efficacy (w/cfm). Confirm airflow rate and efficacy meet or exceed requirements of certificate of compliance.
3. **Central Fan Ventilation Cooling System**: Verify system airflow and fan efficacy meet or exceed requirements of certificate of compliance.
4. **Pre-Cooling**: Verify installation and programming of a pre-cooling thermostat.

The measure would not modify the process for conducting the verification tests.

The measure would replace mention of “low-rise residential” and “high-rise residential” in the Residential and Nonresidential Appendices with “single family” and “multifamily” and appropriate mention of multifamily buildings up to three habitable stories and four or more habitable stories. The verification clean up measure would also remove references in Residential Reference Appendices to the multifamily chapter for verification of prescriptive bypass duct requirements, which are not allowed in multifamily buildings.

The proposal would not affect additions or alterations.

The relevant measures would need to be added or removed as HERS compliance options in the compliance software.

8.1.2 Justification and Background Information

8.1.2.1 Justification

The aim of this proposal is to align compliance options for all multifamily buildings regardless of number of stories, for streamlined requirements and compliance.

The verification measures proposed for extension to multifamily buildings with four or more habitable stories are already available for dwelling units in multifamily buildings with three or fewer habitable stories. The mechanical systems for individual dwelling units that are eligible for the relevant compliance credits do not differ depending on the number of stories in the building. Expanding the measures to all multifamily buildings would allow more options for compliance using the performance path, while simplifying code language.

The proposal to remove verification requirements for compliance options in multifamily buildings with three or fewer habitable stories that are currently available to buildings with four or greater habitable stories without verification would align requirements across all multifamily buildings, regardless of number of habitable stories. These measures do not include diagnostic testing and can therefore be verified by a building inspector without specific training.

Removal of compliance options that are uncommon in multifamily buildings would streamline the requirements. This removal will also avoid poor compliance and verification challenges that result from developers not claiming these measures and HERS raters not practicing these verifications regularly.

8.1.2.2 Background Information

All the verification tests included in this measure were originally developed as compliance options for single family residential homes and applied to multifamily buildings up to three habitable stories. Multifamily buildings with four or more habitable stories have generally followed the requirements for nonresidential buildings. Therefore, these compliance options were not considered or applied to this building type. HVAC systems serving individual dwelling units in buildings with four or more habitable stories are similar or identical to those in buildings with three or fewer habitable stories, so the same compliance options and verification could apply, regardless of the number of stories in the building. Multifamily buildings have different building practices than single family residential homes, so some of the compliance options are not applicable. For example, a whole house fan is designed to circulate air in an entire home; it is possible to use a whole house fan in each dwelling unit of a multifamily building, but this is uncommon since the technology was designed to meet the needs of a single-family home.

8.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change..[49] See Section 10 of this report for detailed proposed revisions to code language.

8.1.3.1 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 10.2 of this report for marked-up code language.

Section: RA3.1.1

Specific Purpose: The specific purpose is to expand the scope of the air distribution field verification procedures from "low-rise residential buildings" to "single family and multifamily residential buildings."

Necessity: These changes are necessary to expand the Verification of Low Leakage Air-Handling Unit with Sealed and Tested Duct System compliance option to all multifamily buildings to streamline requirements and increase compliance options.

Section: RA3.3

Specific Purpose: The specific purpose is to revise the scope of the space conditioning system airflow rate verification procedures from "low-rise residential buildings" to "single family residential buildings."

Necessity: These changes are necessary to remove the Verification of Central Fan Ventilation Cooling Systems compliance option for multifamily buildings to improve compliance and simplify code language.

8.1.3.2 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 10.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Section: 6.8.2

Specific Purpose: The specific purpose is to remove the verification requirement from the Verified Energy Efficiency Ratio (EER/EER2) and Verified Seasonal Energy Efficiency Ratio (SEER/SEER2) measures and remove the Verified Evaporatively Cooled Condensers verification measure.

Necessity: These changes are necessary to remove the verification requirement for relevant compliance options to align requirements across all multifamily buildings, and remove relevant compliance options from multifamily buildings to improve compliance.

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

Section: Table 28

Specific Purpose: The specific purpose is to remove the “Up to Three Habitable Stories” requirement from the Low-Leakage Air-Handling Units measure.

Necessity: These changes are necessary to apply the Low-Leakage Air-Handling Units compliance option to all multifamily buildings to streamline requirements and increase compliance options.

8.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

Chapter 11 of the Nonresidential and Multifamily Compliance Manual would need to be revised. References to multifamily buildings up to three habitable stories would need to be changed to apply the requirements to all multifamily buildings, and irrelevant measures would need to be removed. Edits would need to be made to section 11.2.1.3 (HERS Verification Documentation), section 11.2.2.1 (Features Requiring HERS Verification), section 11.4.2.13 (Dwelling Unit Performance Approach for Indoor Air Quality and Ventilation), and section 11.5.3.25 (Dwelling Unit Performance Approach for Space Conditioning Systems).

8.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Descriptions of the necessary revisions to each form are presented in Section 10.5.

- LMCC-MCH-E: Update mechanical systems documentation for buildings up to three habitable stories to include relevant compliance options and remove irrelevant compliance options.
- NRCC-MCH-E: Update mechanical system documentation for buildings four or more habitable stories to include relevant compliance options and remove irrelevant compliance options.
- LMCI-MCH-01-E: Update performance approach documentation for buildings up to three habitable stories to include relevant compliance options and remove irrelevant compliance options.
- NRCI-MCH-01-E: Update performance approach documentation for buildings four or more habitable stories to include relevant compliance options and remove irrelevant compliance options.
- LMCI-MCH-(22, 26, 27)- H: Update mechanical systems documentation for buildings up to three habitable stories to include relevant compliance options and remove irrelevant compliance options.
- NRCI-MCH-20-F: Update mechanical systems documentation for buildings four or more habitable stories to include relevant compliance options and remove irrelevant compliance options.
- NRCI-MCH-33-H: New mechanical systems documentation for Variable Capacity Heat Pump (VCHP) Compliance Option
- LMCV-MCH- (22, 26,27)-H: Update mechanical systems documentation for buildings up to three habitable stories to include relevant compliance options and remove irrelevant compliance options.

- NRCV-MCH-04-H: Update mechanical system documentation for buildings four or more habitable stories to include relevant compliance options and remove irrelevant compliance options.
- NRCV-MCH-22-H: New mechanical systems documentation for Variable Capacity Heat Pump (VCHP) Compliance Option

8.1.4 Regulatory Context

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

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

8.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

8.1.4.3 Difference From Existing Model Codes and Industry Standards

There are no known relevant industry standards or model codes.

8.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:** During the design phase, the architect and general contractor would identify which compliance credits to pursue and develop the details and specifications accordingly.
2. **Permit Application Phase:** During the permit phase, the general contractor would include the verification requirements in the certificate of compliance (LMCC or NRCC) and submit it to the building department.
3. **Construction Phase:** During the construction phase, the general contractor documents installation and verification procedures using the certificate of installation (LMCI or NRCI).
4. **Inspection Phase:** During the inspection phase, the HERS Rater conducts verification test and completes the certificate of verification (LMCV or NRCV). The building inspector confirms results are submitted if a compliance option is claimed.

Compliance documents would need to be updated to include relevant compliance options and remove irrelevant compliance options.

8.2 Market Analysis

8.2.1 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. The Statewide CASE Team gathered incremental cost information for complying with the proposed measure, and estimated the market size and measure applicability 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 public stakeholder meetings that the Statewide CASE Team held on February 21, 2023 and May 22, 2023.

Currently for multifamily buildings with three or fewer habitable stories, when designing and modeling, the designer may specify energy efficient measures which may require HERS verification. Properly permitted work will trigger any necessary HERS testing. It is the building owner's right to hire their HERS Rater, but contractors may offer to take that responsibility. The HERS Rater will inspect and interact with the various appropriate features. If the measures fail, the contractor is required to fix the failed systems. The HERS Rater performs tests and measure verification at a minimum of one test or inspection per seven dwellings within a given sample set.

HERS Raters are already performing verification tests in dwelling units in multifamily buildings with three or fewer habitable stories, including mandatory and prescriptive space conditioning measures like duct sealing, and they are familiar with the testing procedures and verification process.

Dwelling units in multifamily buildings with four or more habitable stories may currently claim an EER/SEER/HSPF rating above minimum or a different rated heat pump capacity without HERS verification.

8.2.2 Technical Feasibility and Market Availability

The Statewide CASE Team considered the market availability of HERS Raters to conduct the verifications associated with this measure. While the proposed code change may create additional demand for HERS Raters, this is expected to be modest because the compliance credits are optional and could be conducted by HERS Raters already visiting the building. Additionally, some HERS Rater demand may be alleviated for options where removing field verification is proposed. The Statewide CASE Team also determined that HERS Raters would be able to meet additional demand based on feedback from interviews. The additional verification measures may increase burden on the HERS registry, although this is also expected to be a modest increase.

The verification measures that are proposed to be removed as an option for multifamily buildings are not a common design choice or popular compliance option for that type of building, so removing these options would have little to no impact on the market.

In a survey conducted by the Statewide CASE Team, 10 builders, designers, and contractors involved primarily with multifamily buildings responded with their thoughts on the extension of HERS compliance credits to systems serving individual dwelling units in multifamily buildings with four or more habitable stories. Of these, seven were supportive, stating that the measure

would help maintain the quality of living for the dwellers and drive energy efficiency improvements and adoption of energy conservation measures in more buildings, helping to reduce carbon footprint and energy bills. Some also stated a need for verification to ensure compliance due to the various factors that can affect energy performance and air quality in different types of multifamily dwelling units. One respondent expressed that HERS compliance credits should not be extended to buildings with four or more stories but did not provide a reason. Three respondents noted that pursuing verification compliance credits would increase overall costs, while one responded that the measure will increase demand for compliant equipment and lower the price.

8.2.3 Market Impacts and Economic Assessments

Adoption of this code change proposal would not result in measurable market impacts.

8.2.4 Economic Impacts

Adoption of this code change proposal would not result in measurable economic impacts.

8.2.5 Fiscal Impacts

8.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts because the measure impacts multifamily buildings only.

8.2.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts because the measure impacts multifamily buildings only.

8.2.5.3 Costs or Savings to Any State Agency

There are no costs or savings to any state agencies because the measure impacts multifamily buildings only, and state agencies are not involved in the enforcement of the measure.

8.2.5.4 Other Nondiscretionary Cost or Savings Imposed on Local Agencies

There are no added nondiscretionary costs or savings to local agencies because the measure impacts multifamily buildings only.

8.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state because the measure impacts multifamily buildings only and would not require federal funding to implement.

8.3 Energy Savings

The proposed compliance options will not result in energy savings but will allow for trade-offs in the performance approach. The Statewide CASE Team will estimate the magnitude of these trade-offs in the Final CASE Report.

8.4 Cost and Cost-effectiveness

The code change proposal would not modify the stringency of the existing California Energy Code, so the CEC does not need a complete cost-effectiveness analysis to approve the proposed change. Section 8.4 of the CASE Reports typically presents a detailed cost-

effectiveness analysis. For this proposed change, the Statewide CASE Team is presenting information on the cost implications in lieu of a full cost-effectiveness analysis.

8.4.1 Incremental First Cost

The incremental first cost of verification clean up is equal to the verification cost of HERS verification for the additional multifamily buildings eligible. The Statewide CASE Team assumes an hourly HERS labor cost of $90 per hour. There is potential savings for buildings where a HERS Rater is onsite for unrelated work which would negate travel costs.

Compliance options that are proposed to be removed from the multifamily chapter or proposed to have verification requirements removed would have a negative incremental cost.

8.4.2 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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 compliance options included in this measure are upfront verification tests, and there are no incremental maintenance or replacement costs associated.

8.4.3 Cost-effectiveness

This measure does not propose mandatory requirement or a revision to the primary prescriptive requirements. A cost analysis is not necessary because the measure is not proposed to be part of the baseline level of stringency. The Statewide CASE Team has provided information about the cost-effectiveness of the measure even though the CEC does not require a cost-effectiveness analysis for the measure to be adopted.

8.5 First-Year Statewide Impacts

The code change proposal would not modify the stringency of the existing California Energy Code, so the savings associated with this proposed change are minimal. Typically, the Statewide CASE Team presents a detailed analysis of statewide energy and cost savings associated with the proposed change in Section 8.5 of the CASE Report. As discussed in Section 8.3, although the energy savings are limited, the measure would offer additional pathways to comply with the code.

8.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice. The verification clean up measure addresses performance compliance options only and does not impact the overall energy budget allowance for code compliance. The Statewide CASE Team does not recommend further research or action at this time.

9. Additions and Alterations Clean Up

9.1 Measure Description

9.1.1 Proposed Code Change

The 2022 multifamily restructuring efforts resulted in some gaps and misalignments in the additions, alterations, and repairs chapter. Updating these sections provides an opportunity to streamline code language and structure, and ensure that dwelling units and common use areas are appropriately addressed. This measure would add clarity and would not change the requirements in the multifamily additions, alterations, and repairs chapter. Proposed changes include:

- Adding a mandatory requirements subsection to the additions Section 180.1. This provides a consistent outline with Section 180.2 for alterations.
- Removing generic references to mandatory requirements across additions and alterations sections and including direct references to mandatory requirements for envelope, space conditioning, water heating systems and equipment, mechanical acceptance testing, lighting, elevators, pool and spa systems, and solar readiness.
- Moving mechanical ventilation requirements currently duplicated in the prescriptive and performance requirements to the mandatory sections for additions and for alterations.
- Adding direct references to prescriptive requirements for space conditioning and lighting requirements, and removing generic references from the additions requirements in Section 180.1.
- Adding subsections for dwelling unit and common use area requirements under envelope, lighting, and space conditioning requirements.
- Adding a Table 180.1-A Multifamily Additions Standard Building Design that summarizes prescriptive envelope requirements by climate zone for multifamily additions. This reduces reference to Table 170.2-A and captures requirements not previously presented in table format.
- General language clean up to provide clarity of requirements.

9.1.2 Justification and Background Information

9.1.2.1 Justification

The current structure of the multifamily additions and alterations code language is complex and difficult to effectively navigate. Sections refer broadly back to new construction requirements, which contain only bits and pieces of requirements applicable to additions and alterations. Applicability of requirements to dwelling unit and common use areas are not clear, and requirements are not organized by building component as they are in the new construction requirements.

9.1.2.2 Background Information

Prior to the 2022 code update, the California Statewide Utility Compliance Improvement Team identified opportunities to improve the structure of the residential and nonresidential additions and alterations requirement for ease of understanding, compliance, and enforcement. They

proposed outlines for the residential and nonresidential additions and alterations chapters and recommended that the CEC update these chapters with the 2022 update.

With the 2022 Title 24, Part 6 update, three new multifamily chapters were introduced, consolidating the applicable residential and nonresidential requirements for multifamily dwelling units and common use areas into a single location. The new construction requirements were structured by application to dwelling unit or common use area and by building component, consistent with the residential and nonresidential structures. The additions and alterations chapter retained consistent structure with the residential and nonresidential additions and alterations chapters, and so it did not undergo the recommended reorganization. Pulling the requirements together from the residential and nonresidential 2019 requirements without significant revision resulted in many areas that require more context for clarity, compounding the industry struggles to navigate the multifamily additions and alterations requirements.

9.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the Energy Code, Reference Appendices, ACM Reference Manuals, and compliance documents would be modified by the proposed change.[50] See Section 10 of this report for detailed proposed revisions to code language.

9.1.3.1 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 10.2 of this report for marked-up code language.

Section: 180.0, 180.1, 180.2

Specific Purpose: The specific purpose is to clarify energy efficiency requirements for additions, alterations, and repairs to multifamily buildings.

Necessity: These changes are necessary for efficient compliance and enforcement of energy efficiency design standards previously developed, as directed by the California Public Resources Code Section 25213 and 25402.

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

The proposed code change would not modify the ACM Reference Manual.

9.1.3.3 Summary of Changes to the Nonresidential and Multifamily Compliance Manual

The Statewide CASE Team recommends improvements to Chapter 11 of the Nonresidential and Multifamily Compliance Manual that add clarity and examples to the additions, alterations, and repairs subsections, particularly for the envelope requirements in Section 11.3.6.

9.1.3.4 Summary of Changes to Compliance Forms

The proposed code change would not modify the compliance forms.

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

9.1.4 Regulatory Context

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

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

9.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

9.1.4.3 Difference From Existing Model Codes and Industry Standards

There are no relevant industry standards or model codes.

9.1.5 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 section describes how to comply with the proposed code change. It also describes the compliance verification process. 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:

1. **Design Phase:** The designer or additions and alterations contractor identifies applicable requirements, develops a compliant design, and specifies product or performance requirements, and coordinate with other design team members.
2. **Permit Application Phase:** The designer or additions and alterations contractor submits a permit application. The plans examiner reviews the plans, specifications, and compliance forms (LMCC/NRCC) for compliance per the proposed scope of work.
3. **Construction Phase:** Additions and alterations contractors manage construction or installation, complete installation forms, and (LMCI/NRCI) coordinate applicable HERS/ATT verification and building inspection visits.
4. **Inspection Phase:** HERS Raters, ATTs, and building inspectors verify compliance with the additions and alterations requirements per the scope of the project. HERS Raters complete the certificate of verification (LMCV/NRCV) and ATTs complete the certificate of acceptance (LMCA/NRCA), if applicable. The building inspector issues a certificate of occupancy.

The proposed additions and alterations clean up does not change the compliance and enforcement process, but they would make the requirements applicable by scope of work more easily understandable by designers, energy consultant, contractors, plans examiners, and building inspectors.

9.2 Market Analysis

9.2.1 Current Market Structure

The Statewide CASE Team considered how the proposed standard may impact the market in general as well as individual market actors. In addition to conducting personalized outreach, the

Statewide CASE Team discussed potential market barriers during a public stakeholder meeting that the Statewide CASE Team held on February 21, 2023.

Market actors impacted most heavily by the proposed additions and alterations clean up include:

- **Designers** identify applicable requirements, develop compliant design, and specify product or performance requirements. They also coordinate with other design team members. They complete and review relevant compliance documents and submit for permits.
- **Energy Consultants** perform energy modeling and related calculations, advise designers and contractors, complete compliance documents, and work with the plans examiners and design team to address correction comments.
- **Plans Examiners** utilize standards, tools, and resources to understand applicable requirements and review the plans, specifications, and forms for Title 24, Part 6 compliance.
- **Additions and Alterations Contractors** can act as designer depending. They select and purchase equipment, manage construction or installation, complete installation forms coordinate Title 24, Part 6 verification (HERS/ATT) and inspection visits.
- **Building Inspectors** verify code compliance and proper installation of building features and issue the certificate of occupancy.

9.2.2 Technical Feasibility and Market Availability

The proposed additions and alterations clean up will clarify but not change the requirements. Technical feasibility and market availability are demonstrated through successful application of the additions and alterations requirements under previous iterations of the energy code.

9.2.3 Market Impacts and Economic Assessments

Adoption of this code change proposal would not result in measurable market impacts.

9.2.4 Economic Impacts

Adoption of this code change proposal would not result in measurable economic impacts.

9.2.5 Fiscal Impacts

Adoption of this code change proposal would not result in measurable fiscal impacts to local agencies, school districts, or state agencies.

9.3 Energy Savings

The code change proposal would not modify the stringency of the existing California Energy Code, so there would be no savings on a per unit basis.

9.4 Cost and Cost-effectiveness

The code change proposal would not modify the stringency of the existing California Energy Code, so the CEC does not need a complete cost-effectiveness analysis to approve the proposed change.

9.5 First-Year Statewide Impacts

The code change proposal would not modify the stringency of the existing California Energy Code, so there are no savings associated with this proposed change.

9.6 Addressing Energy Equity and Environmental Justice

Because this is a clean up measure and does not result in changes to code requirements, The Statewide CASE Team does not anticipate impacts on energy equity or environmental justice.

10. Proposed Revisions to Code Language

10.1 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). Language relocated within a 2022 document is marked with purple underlining (new location) and ~~strikethrough~~ (previous location).

10.2 Standards

SUBCHAPTER 10 MULTIFAMILY BUILDINGS — MANDATORY REQUIREMENTS

SECTION 160.1 — MANDATORY REQUIREMENTS FOR BUILDING ENVELOPES

(g) **Slab edge insulation**. Material used for slab edge insulation shall meet the following minimum specifications:

1. Water absorption rate for the insulation material alone without facings no greater than 0.3 percent when tested in accordance with Test Method A — 24-Hour-Immersion of ASTM C272.
2. Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM E96.
3. Concrete slab perimeter insulation shall be protected from physical damage and ultraviolet light deterioration.
4. Insulation for a heated slab floor shall meet the requirements of Section 110.8(g).

SECTION 160.2(b)2C — Multifamily Building Central Ventilation System Field Verification

C. Multifamily building central ventilation system field verification.

i. **Central Ventilation System Duct Sealing**. Ventilation ducts that conform to subsections a and b below shall meet the duct sealing requirements in the California Mechanical Code Section 603.10 and have leakage that is no greater than six percent of the rooftop fan or central fan design airflow rate as confirmed by field verification in accordance with the procedures in Reference Appendix NA7.18.3. The leakage test shall be conducted using a test pressure of 25 Pa (0.1 inches) for ducts serving six or fewer dwelling units and 50 Pa (0.2 inches) for ducts serving more than six dwelling units, and shall measure the leakage of all ductwork between the central fan and the connection point to the in-unit grille or fan.

a. The ventilation ducts serve multiple dwelling units.
b. The ventilation ducts provide continuous airflows or airflows to provide balanced ventilation to meet the requirements specified in Sections 160.2(b)2Aiv or 160.2(b)2Av as applicable.

EXCEPTION to 160.2(b)2C: Multifamily buildings with three or fewer habitable stories in Climate Zone 6 are not required to comply with Section 160.2(b)2C.

SUBCHAPTER 12 MULTIFAMILY BUILDINGS — PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

SECTION 170.1 — PERFORMANCE APPROACH

(d) **Compliance Demonstration Requirements for Performance Standards**.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 which demonstrates, using an approved calculation method, that the building has been designed so that its source energy budget and TDV energy budget do not exceed the Standard Design for the applicable Climate Zone.
2. Field Verification of Individual Dwelling Unit Systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verificationshall be performed in accordance with the applicable requirements in the following subsections, and the results ofthe verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

A. ~~EER/EER2/SEER/SEER2/CEER/HSPF/HSPF2 Rating. When performance compliance requires installation of a space conditioning system with a rating that is greater than the minimum rating required by TABLE 170.2-K or specified for the standard design, the installed system shall be field verified in accordance with theprocedures specified in the applicable sections of Reference Residential Appendix RA3.~~ RESERVED.

B. Variable Capacity Heat Pump (VCHP) Compliance Option. When performance compliance requires installationof a heat pump system that meets all the requirements of the VCHP compliance option specified in the ACM Reference Manual, the system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.4.4.3.

C. Low Leakage Air Handler. When performance compliance requires installation of a low leakage air-handlingunit, the installed air handling unit shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.1.4.3.9.

D. RESERVED.

E. ~~Heat Pump - Rated Heating Capacity. When performance compliance requires installation of a heat pump system, the heating capacity values at 47 degrees F and 17 degrees F shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.4.4.2.~~ RESERVED.

F. ~~Whole House Fan. When performance compliance requires installation of a whole-house fan, the whole housefan ventilation airflow rate and fan efficacy shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.9.~~ RESERVED.

G. ~~Central Fan Ventilation Cooling System. When performance compliance requires installation~~

~~of a central fanventilation cooling system, the installed system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.3.4.~~ RESERVED.

H. Dwelling Unit Enclosure Air Leakage. When performance compliance requires a building enclosure leakage rate that is lower than the standard design, the building enclosure shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.8.

I. Quality Insulation Installation (QII). When performance compliance requires field verification of QII, the building insulation system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.5.

i. When performance compliance includes full QII, field verification shall be in accordance with the procedures in Reference Residential Appendix RA3.5.1.1

ii. When performance compliance includes multifamily QII, field verification shall be in accordance with the procedures in Reference Residential Appendix RA3.5.1.2.

J. ~~Pre-Cooling. When performance compliance requires field verification of the installation and programming ofa Pre-Cooling Thermostat, it shall be field verified in accordance with the procedures in Reference ResidentialAppendix RA3.4.5.~~ RESERVED.

SECTION 170.2 — PRESCRIPTIVE APPROACH

Section 170.2(a)3

3. Fenestration.

A. Vertical fenestration and glazed doors in exterior walls shall comply with subsections i, ii, and iii:

i. Percent fenestration area shall be limited in accordance with the applicable requirements of a and bbelow:

a. A total fenestration area no greater than 20 percent of the conditioned floor area; and

b. A total fenestration area no greater than 40 percent of the gross exterior wall area.

NOTE: Demising walls are not exterior walls, and therefore demising wall area is not part of the gross exterior wall area, and fenestration in demising walls are not part of the fenestration area limitation.

ii. Fenestration properties. Installed fenestration products, including glazed doors, shall have an area- weighted average U-factor, relative solar heat gain coefficient (RSHGC), and ~~Visual~~ Visible Transmittance (VT) meeting the applicable fenestration values in Table 170.2-A and shall be determined in accordance with Sections 110.6(a)2 and 110.6(a)3.

Vertical fenestration in demising walls between conditioned and unconditioned spaces is only required to comply with the area-weighted average U-factor requirement in Table

170.2-A.

Exception 1 to Section 170.2(a)3Aii: For each dwelling unit, up to 3 square feet of new glazing area installed in doors shall not be required to meet the U-factor and RSHGC requirements of Table 170.2-A.

Exception 2 to Section 170.2(a)3Aii: For fenestration containing chromogenic type glazing:

a. The lower-rated labeled U-factor and SHGC shall be used with automatic controls to modulate the amount of solar gain and light transmitted into the space in multiple steps in response to daylight levels or solar intensity;
b. Chromogenic glazing shall be considered separately from other fenestration; and
c. Area-weighted averaging with other fenestration that is not chromatic shall not be permitted and shall be determined in accordance with Section 110.6(a).

Exception 3 to Section 170.2(a)3Aii: For dwelling units containing unrated site-built fenestration that meets the maximum area restriction, the U-factor and SHGC can be determined in accordance with Nonresidential Reference Appendix NA6 or using default values in Table 110.6-A and Table 110.6-B.

Exception 4 to Section 170.2(a)3Aii: Fenestration in dwelling units of buildings that are three habitable stories or fewer in Climate Zones 1, 3, 5 and 16 is not required to comply with the RSHGC requirements.

Exception 5 to Section 170.2(a)3Aii: Fenestration in dwelling units ~~of buildings that are three habitable stories or fewer~~ is not required to comply with the VT requirements.

iii. Shading. Where Table 170.2-A requires a maximum RSHGC, the requirements shall be met with an area- weighted average RSHGC excluding the effects of interior shading, no greater than the applicable value in Table 170.2-A.

For the purposes of this paragraph, the RSHGC of a vertical window is:

a. The solar heat gain coefficient of the window; or
b. Relative solar heat gain coefficient is calculated using Equation 170.2-A, if the window has an overhang that extends beyond each side of the window jamb by a distance equal to the overhang's horizontal projection.

Exception 1 to Section 170.2(a)3Aiiib: An area-weighted average relative solar heat gain coefficient of 0.56 or less shall be used for windows:

I. That are in the first story of exterior walls that form a display perimeter; and
II. For which codes restrict the use of overhangs to shade the windows.

Exception 2 to Section 170.2(a)3Aiiib: For vertical glazing containing chromogenic type glazing:

I. the lower-rate labeled RSHGC shall be used with automatic controls to modulate the amount of heat flow into the space in multiple steps in response to daylight levels or solar intensity; and

II. chromogenic glazing shall be considered separately from other glazing; and

III. area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Note: Demising walls are not exterior walls, and therefore fenestration in demising walls is not subject to SHGC requirements.

$RSHGC = SHGC \times [1 + a \times (2.72^{-PF} - 1) \times (\sin(b \times Az) - c)]$
(Equation 170.2-A) WHERE:

	a	b	c
Overhang	0.150	0.130	5.67
Exterior Horizontal Slat	0.144	0.133	5.13

RSHGC	=	Relative Solar Heat Gain Coefficient.
SHGC	=	Solar Heat Gain Coefficient of the vertical fenestration.
Az	=	Azimuth of the vertical fenestration I degrees.
PF	=	Projection factor as calculated by Equation 140.3-D.

iv. Vertical fenestration shall have an area-weighted average Visible Transmittance (VT) no less than the applicable value in Table 170.2-A, or Equation 170.2-B, as applicable.

Exception 1 to Section 170.2(a)3Aiv: When the window's primary and secondary sidelit daylit zones are completely overlapped by one or more skylit daylit zones, then the window need not comply with Section 170.2(a)3Aiv~~w~~.

Exception 2 to Section 170.2(a)3Aiv: If the window's VT is not within the scope of NFRC 200 or ASTM E972, then the VT shall be calculated according to Reference Nonresidential Appendix NA6.

Exception 3 to Section 170.2(a)3Aiv: For vertical windows containing chromogenic type glazing:

a. The higher rated labeled VT shall be used with automatic controls to modulate the amount of light transmitted into the space in multiple steps in response to daylight levels or solar intensity;

b. Chromogenic glazing shall be considered separately from other glazing; and

c. Area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Exception 4 to Section 170.2(a)3iv: Fenestration in dwelling units ~~of buildings that are three habitable stories or fewer~~ is not required to comply with the VT requirements.

NOTE: Demising walls are not exterior walls, and therefore windows in demising walls are not subject to VT requirements.

$VT \geq 0.11/WWR$ (Equation 170.2-B)

where:

WWR = Window Wall Ratio, the ratio of (i) the total window area of the entire building to (ii) the total gross exterior wall area of the entire building. If the WWR is greater than 0.40, then 0.40 shall be used as the value for WWR in

Equation 170.2-B. VT = Visible Transmittance of

framed window.

Section 170.2(a)5

5. Floors shall meet the following requirements:

   Appendix A: Raised floors shall be insulated such that the floor assembly has an assembly U-factor equal to or less than shown in Table 170.2-A, or shall be insulated between wood framing with insulation having an R-value equal to or greater than shown in Table 170.2-A. B.

   Appendix B: All buildings ~~with three habitable stories or fewer~~ shall have slab floor perimeter insulation installed with ~~a U-factor~~ an F-factor equal to or less than or R-value equal to or greater than shown in Table 170.2-A. The minimum depth of concrete slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.

   Exception to Section 170.2(a)5: Raised-floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Table 170.2-A

Section 170.2(a)6

6. **Quality Insulation Installation.** All buildings ~~up to three habitable stories~~ shall comply with Item i or ii below: ~~the Quality Insulation Installation (QII) requirements shown in TABLE 170.2-A. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5.~~

   A. Multifamily buildings with three or fewer habitable stories shall comply with full QII requirements where shown in Table 170.2-A. Insulation installation shall meet the criteria specified in Reference Appendix RA3.5.1.1.

   B. Multifamily buildings with four or more habitable stories shall comply with Multifamily QII requirements where shown in Table 170.2-A. Insulation installation shall meet the criteria specified in Reference Appendix RA3.5.1.2.

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE — Multifamily Standard Building Design

Walls	Metal-Building, any fire rating	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
	Framed (wood, metal) and other >1hr fire rating	0.059	0.059	0.059	0.059	0.059	0.065	0.065	0.059	0.059	0.059	0.051	0.059	0.059	0.051	0.051	0.051
	Framed (wood, metal) and other, ≤1hr fire rating3	0.051	0.051	0.051	0.051	0.051	0.065	0.065	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
	Mass Light 4,5	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.059 R 17
	Mass Heavy	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.160
Floors/Soffits	Slab Perimeter~~, Three Habitable Stories or less~~ [6]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	~~U~~ F 0.58 R 7.0
	Wood Framed	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19
	Raised Mass	U 0.092 R 8.0	U 0.092 R 8.0	U 0.269 R 0	U 0.269 R 0	U-0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0
	Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.039	0.071	0.071	0.039	0.039	0.039

Quality Insulation Installation (QII) ~~for buildings up to three habitable stories~~		Three or fewer habitable stories	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	NR	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full	~~Yes~~ Full
		Four or more habitable stories	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	NR	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily
Fenestration	Curtain Wall/ Storefront	Maximum U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
		Maximum RSHGC, three or fewer habitable stories	NR	0.26	NR	0.26	NR	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.26	NR
		Maximum RSHGC, four or more habitable stories	0.35	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.26	0.25
		Minimum VT, ~~four or more habitable stories~~ common use area	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
	NAFS 2017 Performance Class AW[5]	Maximum U-factor	0.38	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.38
		Maximum RSHGC, three or less habitable stories	NR	0.24	NR	0.24	NR	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	NR
		Maximum RSHGC, four or more habitable stories	0.35	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
		Minimum VT, ~~four or more habitable stories~~ common use area	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
	All Other Fenestration	Maximum U-factor	0.30	0.30	0.30	0.30	0.30	0.30	0.34	0.34	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Maximum RSHGC, three or less habitable stories	NR	0.23	NR	0.23	NR	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	NR
		Maximum RSHGC, four or more habitable stories	0.35	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
	Maximum Window to Floor Ratio		20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Maximum Window to Wall Ratio		40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
	Maximum Skylight Roof Ratio		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Exterior Doors[6,7]	**Maximum U-factor**	Dwelling Unit Entry	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
		Common Use Area Entry Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
		Common Use Area Entry Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Footnote requirements to TABLE 170.2-A:

1. Install the specified R-value with an air space present between the roofing and the roof deck. Such as standard installation of concrete or clay tile.

2. R-values shown for below roof deck insulation are for wood-frame construction with insulation installed between the framing members. Alternatives including insulation above rafters or above roof deck shall comply with the performance standards.

3. Assembly U-factors for exterior framed walls can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table 4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to be less than or equal to the required maximum U-factor.

4. Mass wall has a heat capacity greater than or equal to 7.0 Btu/h-ft2 .

5. Product must be certified to meet the North American Fenestration Standard/Specification for an Architectural Window (AW).

6. If using F-factor to comply, use Reference Joint Appendices JA4 Table 4.4.7 to determine alternate depth and R-value to be less than or equal to the required maximum F-factor.

~~6.~~ 7. Glazed doors must meet the fenestration requirements.

MULTIFAMILY BUILDINGS — ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING MULTIFAMILY BUILDINGS

SECTION 180.0 — GENERAL

Additions, alterations and repairs to existing attached dwelling units and common use areas in multifamily buildings, existing outdoor lighting for these occupancies, and internally and externally illuminated signs shall meet the mandatory requirements specified in Section~~s 100.0 through 110.10, 160.1, and 160.3 through 170.2 that are applicable to the building project, and~~ 180.1(a) (for additions) or 180.2(a) (for alterations), and either the ~~performance compliance approach (energy budgets) in Section 180.1(b) (for additions) or 180.2(c) (for alterations), or the~~ prescriptive compliance approach in Section 180.1(a) (for additions) or 180.2(b) (for alterations), or the performance compliance approach (energy budgets) in Section 180.1(c) (for additions) or 180.2(c) (for alterations), for the climate zone in which the building is located. Climate zones are shown in Figure 100.1-A.

~~Covered process requirements for additions, alterations and repairs to existing multifamily buildings are specified in Section 141.1.~~

Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120.0 through 141.1.

~~NOTE:~~ For alterations that change the occupancy classification of the building, the requirements specified in Section 180.2 apply to the occupancy after the alterations.

SECTION 180.1 — ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Section~~s 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7~~ 180.1(a); and either Section 180.1~~(a)~~(b) or 180.1~~(b)~~(c).

~~**Exception 2 to Section 180.1:** Additions of 300 square feet or less are exempt from the roofing product requirements of Section 170.2(a)1A.~~

~~**Exception 3 to Section 180.1:** Existing inaccessible piping shall not require insulation as defined under Section~~
~~**160.4(f)2**Aiii.~~

Exception ~~4~~1 to Section 180.1: Space-conditioning system. When heating or cooling will be extended to an addition from the existing system(s), the existing heating and cooling equipment need not comply with Part 6. The heating system capacity must be adequate to meet the minimum requirements of CBC Section 1204.1.

Exception ~~5~~2 to Section 180.1: Space-conditioning system ducts. When any length of duct is extended from an existing duct system to serve the addition, the existing duct system and the extended duct shall meet the applicable requirements specified in Sections 180.2(b)2Ai and 180.2(b)2Aii.

~~**Exception 6 to Section 180.1:** Photovoltaic and battery storage systems, as specified in Sections 170.2(f) through 170.2(h), are not required for additions.~~

~~**Exception 7 to Section 180.1**: Dwelling unit space heating system. New or replacement space~~

~~heating systems serving an addition may be a heat pump or gas heating system.~~

(a) **Mandatory Requirements**

1. **Envelope.**

   A. **Ceiling and roof insulation.** The opaque portions of ceilings and roofs separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Section 160.1(a).

   B. **Wall insulation.** Opaque portions of above grade walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the applicable U-factor requirements of Section 160.1(b).

   C. **Floor and soffit insulation.** The opaque portions of floors and soffits that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable U-factor requirements of Section 160.1(c).

   D. **Vapor retarder.** Vapor retarder shall be installed to meet applicable requirements of Section 160.1(d).

   E. **Fenestration products.** Fenestration separating conditioned space from unconditioned space or outdoors shall meet the requirements of Section 160.1(e).

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, the applicable procedures in the Residential Appendices shall apply.

   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.

      iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided 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 new dwelling unit.

   B. **Local mechanical exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in Sections 160.2(b)2Avi and 160.2(b)2B.

   C. **Common use area** additions shall comply with Item i and either ii or iii.

      i. Air filtration shall meet the requirements of Section 160.2(c)1

      ii. Natural ventilation shall meet the requirements of Section 160.3(c)2

      iii. Mechanical ventilation shall meet the requirements of Section 160.3(c)3.

D. Mechanical ventilation systems for enclosed parking garages in multifamily buildings shall comply with Section 120.6(c).

3. **Space conditioning systems** shall comply with applicable requirements of Subsection A or B below.

   A. **Altered dwelling unit space-conditioning and air distribution systems** shall comply with the applicable requirements I and ii below.

      i. **Dwelling unit thermostats**. All heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat, as specified in Section 110.2(c).

      ii. **Dwelling unit space-conditioning and air distribution systems** shall comply with the applicable requirements of Section 160.3(b)

   B. **Common use area space-conditioning systems** shall comply with the applicable requirements of i and ii below.

      i. **Controls.** Space-conditioning systems shall comply with the applicable requirements of Section 160.3(a)2.

      ii. **Fluid distribution systems; common use area space-conditioning systems**. shall comply with A and B below.

         a. **Pipe insulation.** Altered common use area space-conditioning systems shall comply with the applicable requirements of Section 160.3(c)1A through 160.3(c)1D.

         b. **Air distribution, ducts, and plenum**. Altered common use area space-conditioning systems shall comply with the applicable requirements of Sections 160.3(c)2A through 160.3(c)2F.

4. **Water heating systems and equipment** shall comply with applicable requirements of Section 160.4.

   Exception ~~3~~1 to Section 180.1(a)4: Existing inaccessible piping shall not require insulation as defined under Section 160.4(f)2Aiii.

5. **Mechanical acceptance testing**. Before ~~a~~ an occupancy permit is granted, mechanical systems in common use areas shall be certified as meeting the Acceptance Requirements for Code compliance, as required by Section 160.3(d) and specified by Reference Nonresidential Appendix NA7.

6. **Lighting**.
   A. **Dwelling unit lighting** shall comply with the applicable requirements of Section 110.9, 160.5(a).
   B. **Common use area lighting and controls** shall comply with the applicable requirements of Section 110.9, 160.5(b), and 160.5(e).
   C. **Outdoor lighting and control equipment** shall comply with the applicable requirements of Section 160.5(c) and 160.5(e).
   D. **Sign lighting controls** shall comply with the applicable requirements of Section 160.5(d).

7. **Electric power distribution systems** shall comply with the applicable requirements of

Section 160.6.

8. **Elevators.** Elevators shall meet the applicable requirements of Section 120.6(f).

9. **Pool and spa systems.** Pool and spa systems shall copy with either A or B below.
   A. Pool and spa systems available to multiple tenants or to the public shall comply with the applicable requirements of Section 110.4.
   B. Pool and spa systems installed for exclusive use by a single tenant shall comply with the applicable requirements of Section 150.0(p).

10. **Solar ready.** Additions that increase the area of the roof by more than 2,000 square feet shall comply with the solar ready requirements of Section 160.8

(b) ~~(a)~~ **Prescriptive approach.** The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** ~~160.0, 160.1, and 160.2(c) and (d)~~Section 180.1(a); and ~~160.3 through 170.2~~each of the applicable requirements in this subsection.

1. **Envelope.**

~~A. Additions that are greater than 700 square feet shall meet the requirements of Section 170.2(a), with the following modifications:~~

~~1. Framed walls extension. Extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing.~~

~~2. The maximum allowed fenestration area shall be the greater of 175 square feet or 20 percent of the addition floor area.~~

~~3. When existing siding of a wood-framed wall is not being removed or replaced, cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing shall be installed and continuous insulation is not required.~~

~~4. Additions that consist of the conversion of existing spaces from unconditioned to conditioned space shall not be required to perform the air sealing part of QII when the existing air barrier is not being removed or replaced.~~

~~B. Additions that are 700 square feet or less shall meet the requirements of Section 170.2(a), with the following modifications.~~

~~i. Roof and ceiling insulation in a ventilated attic shall meet one of the following requirements:~~

~~a. In Climate Zones 1, 2, 4, and 8 through 16, achieve an overall assembly U-factor not exceeding 0.025. In wood-framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-38 or greater.~~

~~b. In Climate Zones 3 and 5 through 7, achieve an overall assembly U-factor not exceeding 0.031. In wood-framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-30 or greater.~~

~~ii. Radiant barrier. For buildings three habitable stories or less, r~~Radiant barriers shall be installed in attics with exposed attic deck undersides in ~~Climate Zones 2–15.~~

~~iii. Extensions of existing wood-framed walls may retain the dimensions of~~

~~the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing; and~~

~~iv. Fenestration products must meet the U-factor, RSGHC and VT requirements of Table 180.2-B.~~

~~v. Quality Insulation Installation (QII) requirements of Section 170.2(a)6 do not apply.~~

~~**Exception to Section 180.1(a)1B:** Insulation in an enclosed rafter ceiling shall meet the requirements of Section 160.1(a).~~

~~**Exception to Section 180.1(a)1:** Additions that increase the area of the roof by 2,000 square feet or less are exempt from the solar-ready requirements of Section 160.8.~~

A. **Exterior roof and ceilings**. Exterior roofs and ceilings shall comply with each of the applicable requirements in this subsection:

i. **Roofing products** shall meet the minimum aged solar reflectance and thermal emittance requirements of Table 180.1-A.

Exception ~~2~~1 to Section 180.1(a)Ai: Additions of 300 square feet or less are exempt from the ~~roofing product requirements of Section 170.2(a)1A~~ minimum requirements for solar reflectance and thermal emittance or SRI of Table 180.1-A.

Exception 2 to Section 180.1(a)1Ai: Building integrated photovoltaic panels and building integrated solar thermal panels are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.

Exception 3 to Section 180.1(a)1Ai: Roof constructions with a weight of at least 25 lb/ft² are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.

ii. **Ceiling and roof insulation.** Roofs shall have an overall assembly U-factor no greater than the applicable value in Table 180.1-A, with the following modification:

a. In additions that are 700 square feet or less, in an enclosed rafter ceiling, insulation shall meet the requirements of Section 160.1(a).

iii. **Radiant Barrier**. When required as specified in Table 180.1-A, the radiant barrier shall meet the requirements specified in Section 110.8(j) and shall meet the installation criteria specified in Reference Residential Appendix RA4.

B. **Wall Insulation**

i. Exterior walls shall have an overall assembly U-factor no greater than the applicable value in Table 180.1-A.

Exception 1 to Section 180.1(b)1B: In additions greater than 700 square feet, extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing.

Exception 2 to Section 180.1(b)1B: When existing siding of a wood-framed wall is not being removed or replaced, cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing shall be installed and continuous insulation is not required.

C. **Floors shall meet the following requirements:**

i. Raised floors shall be insulated such that the floor assembly has an assembly U-

factor equal to or less than shown in Table 170.2-A, or shall be insulated between wood framing with insulation having an R-value equal to or greater than shown in Table 180.1-A.

Exception to Section 180.1(b)1C: Raised-floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Table 180.1-A.

ii. All buildings in Climate Zone 16 ~~with three habitable stories or fewer~~ shall have slab floor perimeter insulation installed with an F- factor equal to or less than or R-value equal to or greater than shown in Table 180.1-A. The minimum depth of concrete slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.

D. **QII**. All building additions greater than 700 square feet shall comply with the quality insulation installation (QII) requirements shown in Table 180.1-A. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5.

E. **Fenestration.** Fenestration shall meet with requirements of Section 170.2(a)3, with the following modifications:

i. For additions greater than 700 square feet, the maximum allowed fenestration area shall be the greater of 175 square feet or 20 percent of the addition floor area.

ii. For additions up to 700 square feet, fenestration products must meet the U-factor, RSGHC and VT requirements of Table 180.2-B.

F. **Exterior Doors.** All exterior doors, excluding glazed doors, that separate conditioned space from unconditioned space or from ambient air shall have a U-factor not greater than the applicable value in Table 180.1-A. Glazed doors must comply with the requirements of Section 170.2(a)3A.

Exception to Section 180.1(b)1D: Swinging doors that are required to have fire protection are not required to meet the applicable door value in Table 180.1-A.

TABLE 180.1-A ENVELOPE COMPONENT PACKAGE — Multifamily Additions Standard Building Design

Multifamily Additions			Climate Zone														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attic Roof	Low-Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
		Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
		SRI	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	75	NR	75	NR
	Steep-Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	NR
		Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	0.75	0.75	0.75	0.75	0.75	NR
		SRI	NR	NR	NR	NR	NR	NR	NR	NR	NR	16	16	16	16	16	16	NR
	Roof and Ceiling insulation Maximum U-Factor	700 ft² or less	0.025	0.025	0.031	0.025	0.031	0.031	0.031	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
		More than 700 ft²	0.025	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.025	0.025	0.025	0.025	0.025	0.025
	Radiant Barrier		NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
Non Attic Roof	Low-Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	0.63	0.63	0.63	NR	0.63	0.63	0.63	NR
		Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	0.75	0.75	0.75	NR	0.75	0.75	0.75	NR
		SRI	NR	NR	NR	NR	NR	NR	NR	NR	75	75	75	NR	75	75	75	NR
	Steep-Sloped	Aged Solar Reflectance	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
		Thermal Emittance	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
		SRI	NR	16	16	16	16	16	16	16	16	16	16	16	16	16	16	NR
	Metal Building U-factor		0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
	Wood Framed and Other U-factor		0.028	0.028	0.028	0.034	0.028	0.034	0.034	0.039	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Wall U-Factor	Metal-Building, any fire rating	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
	Framed (wood, metal) and other >1hr fire rating	0.059	0.059	0.059	0.059	0.059	0.065	0.065	0.059	0.059	0.059	0.051	0.059	0.059	0.051	0.051	0.051
	Framed (wood, metal) and other, ≤1hr fire rating[1]	0.051	0.051	0.051	0.051	0.051	0.065	0.065	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
	Mass Light [2]	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.059
	Mass Heavy[2]	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.164
Floors/Soffits U-Factor	Slab Perimeter	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	F 0.58 R 7.0
	Wood Framed	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037
	Raised Mass	0.092	0.092	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.092	0.138	0.092	0.092	0.138	0.092
	Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.039	0.071	0.070	0.039	0.039	0.039
Quality Insulation Installation	Three or fewer habitable stories	Full	Full	Full	Full	Full	Full	NR	Full	Full	Full	Full	Full	Full	Full	Full	Full
	Four or more habitable stories	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	NR	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily	Multifamily
Exterior Doors U-Factor[3]	Dwelling unit entry	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Common Use Area Entry Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
	Common Use Area Entry Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Footnote requirements to TABLE 180.1-A:

1. Assembly U-factors for exterior framed walls can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table

4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to be less than or equal to the required maximum U-factor.

2. Mass wall has a heat capacity greater than or equal to 7.0 Btu/h-ft2
3. Glazed doors must meet the fenestration requirements.

~~b. **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.~~

~~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.~~

~~iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided 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 new dwelling unit.~~

~~B. **Local mechanical exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in Sections 160.2(b)2Avi and 160.2(b)2B.~~

1. **Space Conditioning Systems**. Space-conditioning systems shall comply with the requirements of A or B, below.
   A. Dwelling unit space conditioning systems shall comply with Section 170.2(c)3, with the following modification:
      i. Dwelling unit space heating system. New or replacement space heating systems serving an addition may be a heat pump or gas heating system.
   B. Common use area space conditioning systems shall comply with Sections 170.2(c)1, 170.2(c)2, and 170.2(c)4.
      i. Sizing and equipment selection shall comply with Section 170.2(c)1.
      ii. Equipment sizing calculations shall comply with Section 170.2(c)2.
      iii. Space-conditioning systems for common use areas shall meet the applicable requirements of Section 170.2(c)4A through Section 170.2(c)4O.
2. **Water heater.** When additional water-heating equipment is installed to serve a dwelling unit as part of the addition, one of the following types of water heaters shall be installed:
   A. A water-heating system that meets the requirements of Section 170.2(d); or
   B. A water-heating system determined by the Executive Director to use no more energy than the one specified in Item A above.
3. **Lighting.**
   A. Common use area interior lighting shall meet the requirements of Sections 170.2(e)1 through 170.2(e)4.

B. Common use area exterior lighting shall meet with requirements of Section 170.2(e)6.

C. Sign lighting shall comply with the requirements of Section 170.2(e)7,

(c) ~~(b)~~**Performance approach.** Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1~~,~~ and 2 ~~and 3~~ below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets as specified in Section 170.1.

2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in TDV energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(~~a~~b). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

Exception to Section 180.1(~~b~~c)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(~~b~~c) are exempt from showing compliance with Section 160.1(b).

~~a. **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(b)3, 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.~~

~~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 the conditioned floor area of the existing dwelling unit 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 comprised of the existing dwelling unit conditioned floor area plus the addition conditioned floor area.~~

~~iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided 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 new dwelling unit.~~

~~B. **Local Mechanical Exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in 160.2(b)2Avi and 160.2(b)2B.~~

SECTION 180.2 — ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet ~~Item (a), and either Item (b) or (c) below:~~ the applicable requirements of Sections 110.0 through 110.9; Sections 180.2(a); and either Section 180.2(b) or 180.2(c).

Exception 1 to Section 180.2: When heating, cooling or service water heating for an alteration is provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110.0 through 110.10; ~~Sections 160.0 through 160.7~~Section 180.2(a); and Section ~~170.2(c) or 170.2(d)~~ 180.2(b) or 180.2(c).

Exception 2 to Section 180.2: When existing heating, cooling or service water-heating systems or components are moved within a building, the existing systems or components need not comply with Sections 110.0 through 110.10; ~~Sections 160.0 through 160.7~~Section 180.2(a); and Section ~~170.2(c) or 170.2(d)~~ 180.2(b) or 180.2(c).

Exception 3 to Section 180.2: Where an existing system with electric reheat is expanded when adding variable air volume (VAV) boxes to serve an alteration, total electric reheat capacity may be expanded not to exceed 20 percent of the existing installed electric capacity in any one permit and the system need not comply with Section 170.2(b)4E. Additional electric reheat capacity in excess of 20 percent may be added subject to the requirements of Section 170.2(b)4E.

~~**Exception 4 to Section 180.2:** The requirements of Section 160.3(a)2H shall not apply to alterations of space-conditioning systems or components.~~

(a) **Mandatory requirements.** Altered components in a multifamily building shall meet the minimum requirements in this section.

1. ~~**Roof/ceiling insulation.** The opaque portions of the roof/ceiling that separate conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Section 180.2(b)1B.~~**Envelope.**

   A. **Ceiling and roof insulation.** The opaque portions of ceilings and roofs separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Section 160.1(a).

   B. **Wall insulation.** For the altered opaque portion of walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items ~~A~~i through ~~D~~iv below:

      i. **Metal building.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.113.

      ii. **Metal framed.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.217.

      iii. **Wood framed and others.** A minimum of R-11 insulation between framing members, or the area- weighted average U-factor of the wall assembly shall not exceed U-0.110.

      iv. **Spandrel panels and curtain walls.** A minimum of R-4, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.280.

      Exception to Section 180.2(a)2: Light and heavy mass walls**.**

   C. **Floor insulation.** For the altered portion of raised floors that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items ~~A~~i~~, through B~~ii, or iii below:

      i. **Raised framed floors.** A minimum of R-11 insulation between framing members, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.071.

      ii. **Raised mass floors.** A minimum of R-6 insulation, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.111.

      iii. **Other floors.** The area-weighted U-factor shall not exceed 0.071

   D. **Vapor retarder**. Vapor retarder shall be installed to meet applicable requirements of Section 160.1(d).

   E. **Fenestration products**. Fenestration separating conditioned space from unconditioned space or outdoors shall meet the requirements of Section 160.1(e)

2. **Mechanical ventilation and indoor air quality**

   A. **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 are required by Section 180.2(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.

i. **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.

ii. **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.

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

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

A. 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)2Aiv 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.

B. 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.

2. **Replacement ventilation fans.** Whole-dwelling unit replacement ventilation fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Sections 7.1 and 7.2. Additionally, when conformance to a specified whole-dwelling unit airflow rate is required for compliance, the replacement fans shall be rated at no less than the airflow rate required for compliance.

3. **Air filters**. If the air filtration device for a whole-dwelling unit ventilation system is altered or replaced, then one of the following Subsections A or B shall be used for compliance.

A. Dwellings that were required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall comply with the air filtration requirements in Section 160.2(b)1.

B. Dwellings that were not required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall not be required to comply with the air filtration requirements specified in Section 160.2(b)1.

b. **Local mechanical exhaust.**

1. **Bathroom local mechanical exhaust**. Altered bathroom local mechanical exhaust systems shall comply with the applicable requirements specified in Section 160.0(b)2Avi.

2. **Kitchen local mechanical exhaust**. If the kitchen local ventilation fan is altered or replaced, then one of the following Subsections A, B, or C shall be used for compliance.

A. Dwellings that were required by a previous building permit to comply with the kitchen local exhaust requirements in Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G shall meet or exceed the applicable airflow or capture efficiency requirements in Section 160.0(b)2Avi.

B. Dwellings that were required by a previous building permit to install a vented kitchen range hood or other kitchen exhaust fan shall install a replacement fan that meets or exceeds the airflow required by the previous building permit, or 100 cfm, whichever is greater.

C. Dwellings that were not required to have a kitchen local ventilation exhaust system according to the conditions in either Subsection 1 or 2 above shall not be required to comply with the requirements of Section 160.0(b)2Avi.

3. **Replacement ventilation fans.** New or replacement local mechanical exhaust fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Section 7.1 and Title 24, Part 6, Section 160.0(b)2Avif. Additionally, when compliance with a specified exhaust airflow rate is required, the replacement fan shall be rated at no less than the airflow rate required for compliance.

B. **Mechanical ventilation systems for common use area** alterations shall comply with the requirements of Section 160.2(c).

C. **Mechanical ventilation systems for enclosed parking garages** in multifamily buildings shall comply with Section 120.6(c).

3. **Space conditioning systems** shall comply with applicable requirements of Section 160.3.

A. **Dwelling unit space-conditioning and air distribution systems** shall comply with the applicable requirements I and ii below.

i. **Dwelling unit thermostats**. All heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat, as specified in Section 110.2(c).

ii. **Dwelling unit space-conditioning and air distribution systems** shall comply with the applicable requirements of Section 160.3(b)

B. **Common use area space-conditioning systems** shall comply with the applicable requirements of i and ii below.

i. **Controls.** Space-conditioning systems shall comply with the applicable requirements of Section 160.3(a)2.

Exception 41 to Section 180.2(b)3A: The requirements of Section 160.3(a)2H shall not apply to alterations of space- conditioning systems or components.

ii. **Fluid distribution systems; common use area space-conditioning systems**. shall comply with A and B below.

a. **Pipe insulation.** Altered common use area space-conditioning systems shall comply with the applicable requirements of Section 160.3(c)1A through 160.3(c)1D.

b. **Air distribution, ducts, and plenum**. Altered common use area space-conditioning systems shall comply with the applicable requirements of Sections 160.3(c)2A through 160.3(c)2F.

4. **Mechanical acceptance testing**. Before an occupancy permit is granted, mechanical systems in common use areas shall be certified as meeting the Acceptance Requirements for Code compliance, as required by Section 160.3(d) and specified by Reference Nonresidential Appendix NA7.
5. **Water heating systems and equipment** shall comply with applicable requirements of Section 160.4.

   Exception 1 to Section 180.1(a)4: Existing inaccessible piping shall not require insulation as defined under Section 160.4(f)2Aiii.
6. **Lighting**.
   A. **Dwelling unit lighting.** The altered lighting system shall meet the lighting requirements of Section 160.5(a). The altered luminaires shall meet the luminaire efficacy requirements of Section 160.5(a) and Table 160.5-A. Where existing screw base sockets are present in ceiling-recessed luminaires, removal of these sockets is not required, provided that new JA8 compliant trim kits or lamps designed for use with recessed downlights or luminaires are installed.

   B. **Common use area lighting and controls** shall comply with the applicable requirements of Sections 110.9, 160.5(b), and 160.5(e).

      Exception to Section 180.2(b)6B: When the requirements of Section 160.5(b)4D are triggered by the addition of skylights to an existing building and the lighting system is not recircuited, the daylighting control need not meet the multi-level requirements in Section 160.5(b)4D.

   C. **Outdoor lighting and control equipment** shall comply with the applicable requirements of Sections 110.9, 160.5(c), and 160.5(e).

   D. **Sign lighting controls** shall comply with the applicable requirements of Sections 110.9 and 160.5(d).
7. **Electric power distribution systems.** Alterations to existing electrical power distribution systems shall meet the applicable requirements of the following sections:

   A. **Service electrical metering**. New or replacement electrical service equipment shall meet the requirements of Section 160.6(a) applicable to the electrical power distribution system altered; and

   B. **Separation of electrical circuits for electrical energy monitoring**. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(b); and

   C. **Voltage drop**. For alterations of feeders and branch circuits where the alteration includes addition, modification or replacement of both feeders and branch circuits, the altered circuits shall meet the requirements of Section 160.6(c); and

   D. **Exception to Section 180.2(b)4Bviic**: Voltage drop permitted by California Electrical Code Sections 647.4, 695.6 and 695.7.

   E. **Circuit controls for 120-volt receptacles and controlled receptacles**. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(d).
8. **Elevators.** Elevators shall meet the applicable requirements of Section 120.6(f).

9. **Pool and spa systems**.
   A. Pool and spa systems available to multiple tenants or to the public shall comply with the applicable requirements of Section 110.4.
   B. Pool and spa systems installed for exclusive use by a single tenant shall comply with the applicable requirements of Section 150.0(p).

(b) **Prescriptive approach.** The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9; Section 180.2(a) ~~and all applicable requirements of Sections 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~~; and

1. **Envelope.**

   A. **Roof alterations**. Existing roofs being replaced, recovered or recoated of a multifamily building shall meet the requirements of Section 110.8(i). For roofs with more than 50 percent of the roof area or more than 2,000 square feet of roof, whichever is less, being altered, the requirements of i and iii below apply:

      i. Low-sloped roofs in Climate Zones 2, 4, and 6 through 15 shall have a minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.

      Exception to Section 180.2(b)1Ai: The aged solar reflectance requirement can be met by using insulation at the roof deck specified in Table 180.2-A.

Table 180.2-A Roof/Ceiling Insulation Tradeoff for Low-Sloped Aged Solar Reflectance

Minimum Aged Solar Reflectance	Roof Deck Continuous Insulation R-value (Climate Zones 6-7)	Roof Deck Continuous Insulation R-value (Climate Zones 2, 4, 8-15)
0.60	2	16
0.55	4	18
0.50	6	20
0.45	8	22
No requirement	10	24

      ii. Steep-sloped roofs in Climate Zones 4 and 8 through 15 shall have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

      Exception to Section 180.2(b)1Aii: The following shall be considered equivalent to Subsection ii:

      I. Buildings with ceiling assemblies with a U-factor lower than or equal to 0.025 or that are insulated with at least R-38 ceiling insulation in an attic; or

      II. Buildings with a radiant barrier in the attic, where the radiant barrier is not installed directly above spaced sheathing, meeting the requirements of Section 170.2(a)1C; or

      III. Buildings that have no ducts in the attic in Climate Zones 2, 4, 9, 10, 12 and 14; or

      IV. Buildings with R-2 or greater continuous insulation above or below the roof deck.

      Exception 1 to Sections 180.2(b)1Ai and ii: Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

      Exception 2 to Sections 180.2(b)1Ai and ii: Roof constructions with a weight of at least 25 lb/ft^2 are not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

      iii. For low-sloped roofs, the area of the roof recover or roof replacement shall be insulated to R-14 continuous insulation or a U-factor of 0.039 in Climate Zones 1, 2, 4, and 8 through 16.

Exception 1 to Section 180.2(b)1Aiii: Roof recovers with new R-10 insulation added above deck do not need to be insulated to meet R-14.

Exception 2 to Section 180.2(b)1Aiii: When existing mechanical equipment located on the roof will not be disconnected and lifted, insulation added may be limited to the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing to remain in accordance with the manufacturer's instructions.

Exception 3 to Section 180.2(b)1Aiii: At the drains and other low points, tapered insulation with a thermal resistance less than R-14 may be used, provided that insulation thickness is increased at the high points of the roof so that the average thermal resistance equals or exceeds R-14.

Exception 4 to Section 180.2(b)1Aiii: The area of the roof recoat is not required to be insulated.

B. **Roof/ceiling insulation**.

i. **Attic roof**. Vented attics shall meet the following:

a. In Climate Zones 1 through 4 and 8 through 16, insulation shall be installed to achieve a weighted U-factor of 0.020 or insulation installed at the ceiling level shall result in an installed thermal resistance of R-49 or greater for the insulation alone; and

Exception to Section 180.2(b)1Bia: In Climate Zones 1, 3, 4 and 9, dwelling units with at least R-19 existing insulation installed at the ceiling level**.**

b. In Climate Zones 2 and 11 through 16, air seal all accessible areas of the ceiling plane between the attic and the conditioned space in accordance with Section 110.7; and

Exception 1 to Section 180.2(b)1Bib: Dwelling units with at least R-19 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bib: Dwelling units with atmospherically vented space heating or water-heating combustion appliances located inside the pressure boundary of the dwelling unit.

c. In Climate Zones 1 through 4 and 8 through 16, recessed downlight luminaires in the ceiling shall be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation contact must be replaced or fitted with a fireproof cover that allows for insulation to be installed directly over the cover; and
Exception to Section 180.2(b)1Bic: In Climate Zones 1 through 4 and 8 through 10, dwelling units with at least R-19 existing insulation installed at the ceiling level.

d. Attic ventilation shall comply with the California Building Code requirements.

Exception 1 to Section 180.2(b)1Bi: Dwelling units with at least R-38 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bi: Dwelling units where the alteration would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.
Exception 3 to Section 180.2(b)1Bi: Dwelling units with knob and tube wiring located in the vented attic.

Exception 4 to Section 180.2(b)1Bi: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation, provided such installation does not violate Section 806.3 of Title 24, Part 2.5.

Exception 5 to Section 180.2(b)1Bi: Where the attic space above the altered dwelling unit is shared with other dwelling units and the requirements of Section 180.2(b)1Bi are not triggered for the other dwelling units.

C. Fenestration alterations other than repair shall meet the requirements of Items i and ii below:

Note: Glass replaced in an existing sash and frame or sashes replaced in an existing frame are considered repairs. In these cases, Section 180.2(b) requires that the replacement be at least equivalent to the original in performance.

i. All added and replacement ~~F~~fenestration products ~~installed to replace existing fenestration products of the same total area~~ shall meet either a or b:

a. The maximum U-factor, RSHGC and VT requirements of Table 180.2-B, or

b. The area-weighted U-factor and RSHGC of Table 170.2-A.

~~**Exception 1 to Section 180.2(b)1Ci:** In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 180.2-B shall not apply.~~

ii. Alterations that add vertical fenestration and skylight area shall meet the total fenestration area requirements of Section 170.2(a)3. ~~and the U-factor, RSHGC and VT requirements of Table 180.2-B~~.

Exception 1 to Section 180.2(b)1C~~ii~~: Alterations that add vertical fenestration area of up to 50 square feet shall not be required to meet the total fenestration area requirements of Sections 170.2(a)3, nor the U-factor, RSHGC and VT requirements of Table 180.2-B, for the added vertical fenestration.

Exception 2 to Section 180.2(b)1C: In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 180.2-B shall not apply to the replaced vertical fenestration.

Exception 3 to Section 180.2(b)1C: Alterations that add or replace skylight area of up to 50 square feet shall not be required to meet the total fenestration area requirements of Sections 170.2(a)3, nor the U-factor, SHGC and VT requirements of Table 180.2-B.

~~**Exception 2 to Section 180.2(b)1Cii:** Alterations that add up to 16 square feet of new skylight area per dwelling unit with a maximum U-factor of 0.55 and a maximum RSHGC of 0.30 shall not be required to meet the total fenestration area requirements of Section 170.2(a)3.~~

D. **Exterior doors.** ~~Alterations that add exterior door area shall meet the U-factor requirement of Section 170.2(a)4.~~ All exterior doors, excluding glazed doors, that separate conditioned space from unconditioned space or from ambient air shall have a U-factor not greater than the applicable value in Table 180.1-A. Glazed doors must comply with the requirements of Section 170.2(a)3A.

Exception to Section 180.2(b)1D: Swinging doors that are required to have fire protection are not required to meet the applicable door value in Table 180.1-A.

Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum RSHGC

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Curtainwall / Storefront / Window Wall and Glazed Doors[1]	U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
Curtainwall / Storefront / Window Wall and Glazed Doors[1]	RSHGC	0.35	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25
Curtainwall / Storefront / Window Wall and Glazed Doors[1]	VT[2]	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
NAFS 2017 Performance Class AW Window — Fixed[1]	U-factor	0.38	0.38	0.38	0.38	0.38	0.47	0.47	0.41	0.41	0.38	0.38	0.38	0.38	0.38	0.38	0.38
NAFS 2017 Performance Class AW Window — Fixed[1]	RSHGC	0.35	0.25	0.25	0.25	0.25	0.31	0.31	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NAFS 2017 Performance Class AW Window — Fixed[1]	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
NAFS 2017 Performance Class AW Window –Operable[1]	U-factor	0.43	0.43	0.43	0.43	0.43	0.47	0.47	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
NAFS 2017 Performance Class AW Window –Operable[1]	RSHGC	0.35	0.24	0.24	0.24	0.24	0.31	0.31	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
NAFS 2017Performance Class AW Window –Operable[1]	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
ll Other Windows nd Glazed Doors[1]	U-factor	0.30	0.30	0.30	0.30	0.30	0.30	0.34	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
ll Other Windows nd Glazed Doors[1]	RSHGC	0.35	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
~~Skylights, 3 habitable stories and fewer~~	~~U-factor~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~
~~Skylights, 3 habitable stories and fewer~~	~~RSHGC~~	~~NA~~	~~0.23~~	~~NA~~	~~0.23~~	~~NA~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~0.30~~	~~NA~~

Skylights~~, 4 habitable stories and greater~~	U-factor	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Skylights~~, 4 habitable stories and greater~~	~~R~~SHGC	~~0.35~~ NA	0.25	~~0.25~~ NA	0.25	~~0.25~~ NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	~~0.25~~ NA
Skylights serving common use areas~~, 4 habitable stories and greater~~	VT[2]	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Footnotes to TABLE 180.2-B

1. For fenestration installed in buildings with three or fewer habitable stories, there is no SHGC requirement in Climate Zones 1, 3, 5, and 16.
2. Minimum VT requirements for fenestration other than skylights do ~~to~~ not apply to multifamily buildings 3 habitable stories or less

2. **Space-conditioning systems.**

A. **Space-conditioning systems serving dwelling units**.

i. **Entirely new or complete replacement space-conditioning systems** installed as part of an alteration shall include all the system heating or cooling equipment, including but not limited to condensing unit, cooling or heating coil, and air handler for split systems; or complete replacement of a packaged unit; plus entirely new or replacement duct system [Section 180.2(b)2Aiib]. Entirely new or complete replacement space-conditioning systems shall meet the requirements of Sections 160.2(a)1, 160.3(a)1, 160.3(b)1 through 3, 160.3(b)5, 160.3(b)6, 160.3(c)1, 170.2(c)3B, 180.2(b)2Av, and Table 180.2-C.

ii. **Altered duct systems—duct sealing**: In all climate zones, when more than 25 feet of new or replacement space-conditioning system ducts are installed, the ducts shall comply with the applicable requirements of Subsections a and b below. New ducts located in unconditioned space shall meet the applicable requirements of Sections 160.3(b)5A through J and the duct insulation requirements of Table 180.2-C, and

I. The altered duct system, regardless of location, shall be sealed as confirmed through field verification and diagnostic testing in accordance with all applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1, utilizing the leakage compliance criteria specified in Subsection I or II below.

TABLE 180.2-C DUCT INSULATION R-VALUE

Climate Zone	3, 5 through 7	1, 2, 4, 8 through 16
Duct R-Value	R-6	R-8

I. **Entirely new or complete replacement duct system.** If the new ducts form an entirely new or complete replacement duct system directly connected to the air handler, the duct system shall meet one of the following requirements:

A. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1, or

B. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.

Entirely new or complete replacement duct systems installed as part of an alteration are 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 handler, coil, plenums and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Entirely new or complete replacement duct systems shall also conform to the requirements of Sections 160.2(a)1 and 1**60.3(b)5L**. If the air handler and ducts are located within a vented attic, the requirements of Section 180.2(b)1Bi shall also be met.

II. **Extension of an existing duct system.** If the new ducts are an extension of an existing duct system serving multifamily dwellings, the combined new and existing duct system shall meet one of the following requirements:

A. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

B. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

C. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2AiicI or II then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified HERS Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception to Section 180.2(b)2AiiaII: duct sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos.

Exception 1 to 180.2(b)2Aii: The HERS Rater field verification and HERS Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

iii. **Altered space-conditioning system—duct sealing.** In all climate zones, when a space-conditioning system serving a multifamily dwelling is altered by the installation or replacement of space- conditioning system equipment, including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil, the duct system that is connected to the altered space-conditioning system equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1 and the leakage compliance criteria specified in Subsection a, b or c below.

I. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

II. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

III. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2Aiiia or b, then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified HERS Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception 1 to Section 180.2(b)2Aiii: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in Reference Residential Appendix RA3.1.

Exception 2 to Section 180.2(b)2Aiii: duct sealing. Duct systems with less than 40 linear feet as determined by visual inspection.

Exception 3 to Section 180.2(b)2Aiii: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos.

Exception 4 to Section 180.2(b)2Aiii: The HERS Rater field verification and HERS Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

iv. **Altered space-conditioning system mechanical cooling.** When a space-conditioning system is an air conditioner or heat pump that is altered by the installation or replacement of refrigerant-containing system components such as the compressor, condensing coil, evaporator coil, refrigerant metering device or refrigerant piping, the altered system shall comply with the following requirements:

a. All thermostats associated with the system shall be replaced with setback thermostats meeting the requirements of Section 110.2(c).

b. In Climate Zones 2, 8, 9, 10, 11, 12, 13, 14 and 15, air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted package systems, small duct high velocity air systems, and minisplit systems, shall comply with Subsections I and II, unless the system is of a type that cannot be verified using the specified procedures. Systems that cannot comply with the requirements of Section 180.2(b)2Aivb shall comply with Section 180.2(b)2Aivc.

Exception to Section 180.2(b)2Aivb: Entirely new or complete replacement packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to have refrigerant charge confirmed through field verification and diagnostic testing. The installer of these packaged systems shall certify that the packaged system was pre-charged at the factory and has not been altered in a way that would affect the charge. Ducted systems shall comply with the minimum system airflow rate requirement in Section 180.2(b)2AivbI, provided that the system is of a type that can be verified using the procedure specified in RA3.3 or an approved alternative in RA1.

I. The minimum system airflow rate shall comply with the applicable Subsection A or B below as confirmed through field verification and diagnostic testing in accordance with the procedures specified in Reference Residential Appendix Section RA3.3 or an approved alternative procedure as specified in Section RA1.
   A. Small duct high velocity systems shall demonstrate a minimum system airflow rate greater than or equal to 250 cfm per ton of nominal cooling capacity; or
   B. All other air-cooled air conditioner or air-source heat pump systems shall demonstrate a minimum system airflow rate greater than or equal to 300 cfm per ton of nominal cooling capacity.

Exception 1 to Section 180.2(b)2AivbI: Systems unable to comply with the minimum airflow rate requirement shall demonstrate compliance using the procedures in Section RA3.3.3.1.5, and the system's thermostat shall conform to the specifications in Section 110.12.

Exception 2 to Section 180.2(b)2AivbI: Entirely new or complete replacement space- conditioning systems, as specified by Section 180.2(b)2Ai, without zoning dampers may comply with the minimum airflow rate by meeting the applicable requirements in Table 160.3-A or 160.3-B as

confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 160.2(a)1C for the system air filter device(s) shall conform to the requirements given in Tables 160.3-A and 160.3-B.

II. The installer shall charge the system according to manufacturer's specifications. Refrigerant charge shall be verified according to one of the following options, as applicable.
   A. The installer and rater shall perform the standard charge verification procedure as specified in Reference Residential Appendix Section RA3.2.2, or an approved alternative procedure as specified in Section RA1; or
   B. The system shall be equipped with a fault indicator display (FID) device that meets the specifications of Reference Joint Appendix JA6. The installer shall verify the refrigerant charge and FID device in accordance with the procedures in Reference Residential Appendix Section RA3.4.2. The HERS Rater shall verify FID device in accordance with the procedures in Section RA3.4.2; or
   C. The installer shall perform the weigh-in charging procedure as specified by Reference Residential Appendix Section RA3.2.3.1, provided the system is of a type that can be verified using the RA3.2.2 standard charge verification procedure and RA3.3 airflow rate verification procedure or approved alternatives in RA1. The HERS Rater shall verify the charge using RA3.2.2 and RA3.3 or approved alternatives in RA1.

Exception 1 to Section 180.2(b)2AivbII: When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to demonstrate compliance, the installer may elect to utilize the HERS Rater verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the HERS Rater verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Section 110.12. Ducted systems shall comply with the minimum system airflow rate requirements in Section 180.2(b)2AivbI.

EXCEPTION 2 to Section 180.2(b)2Aivb: The HERS Rater field verification and HERS Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

v. **Altered Space-Heating System.** Altered or replacement space-heating systems shall not use electric resistance as the primary heat source.

EXCEPTION 1 to Section 180.2(b)2Av: Non-ducted electric resistance space heating systems if the existing space heating system is electric resistance.

EXCEPTION 2 to Section 180.2(b)2Av: Ducted electric resistance space heating systems if the existing space heating system is electric resistance and a ducted space cooling system is not being replaced or installed.

EXCEPTION 3 to Section 180.2(b)2Av: Electric resistance space heating systems, if the existing space heating system is electric resistance in Climate Zones 6, 7, 8, or 15.

B. **Common Use Area Space Conditioning Systems**

i. New or Replacement Space-Conditioning Systems or Components other than new or replacement space-conditioning system ducts shall meet the requirements of Sections 170.2(c)1, 2, and 4, applicable to the systems or components being altered. For compliance with Section 170.2(c)4A, additional fan power adjustment credits are available as specified in TABLE 180.2-D.

Exception 1 to Section 180.2(b)2Bi. Section 180.2(b)2Av does not apply to replacement of electric reheat of equivalent or lower capacity electric resistance space heaters when natural gas is not available.

Exception 2 to Section 180.2(b)2Bi: Section 170.2(c)4L is not applicable to new or replacement space-conditioning systems.

Exception 3 to Section 180.2(b)2Bi: Section 170.2(c)4Ci is applicable to systems, other than single package air-cooled commercial unitary air conditioners and heat pumps, with cooling capacity less than 54,000 Btu/h.

TABLE 180.2-D Fan Power Limitation Pressure Drop Adjustment

Airflow	Multi-Zone VAV Systems[1] ≤5,000 cfm	Multi-Zone VAV Systems[1] >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems[1] >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Supply Fan System Additional Allowance	0.135	0.114	0.105	0.139	0.12	0.107
Supply Fan System Additional Allowance In Unit with Adapter Curb	0.033	0.033	0.043	0.000	0.000	0.000
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance	0.07	0.061	0.054	0.07	0.062	0.055
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance In Unit with Adapter Curb	0.016	0.017	0.022	0.000	0.000	0.000

Footnotes to Table 180.2-D:

1. See FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV) for the definition of a Multi-Zone VAV System.

~~**Exception 1 to Section 180.2(b)2Bi.** Section 180.2(b)2Av does not apply to replacement of electric reheat of equivalent or lower capacity electric resistance space heaters when natural gas is not available.~~

~~**Exception 2 to Section 180.2(b)2Bi:** Section 170.2(c)4L is not applicable to new or replacement~~

~~space-conditioning systems.~~
~~**Exception 3 to Section 180.2(b)2Bi:** Section 170.2(c)4Ci is applicable to systems, other than single package air-cooled commercial unitary air conditioners and heat pumps, with cooling capacity less than 54,000 Btu/h.~~

ii. **Altered duct systems.** When new or replacement space-conditioning system ducts are installed to serve an existing building, the new ducts shall meet the requirements of Section 160.3(c)2 and meet a or b below:

a. Reserved.

b. Entirely new or replacement duct systems installed as part of an alteration shall be leakage-tested in accordance with Section 160.2(c)2H. Entirely new or replacement duct systems installed as part of an alteration shall be constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the building's existing duct system, including registers, grilles, boots, air handlers, coils, plenums, and ducts, if the reused parts are accessible and can be sealed to prevent leakage.

EXCEPTION 1 to Section 180.2(b)2Biib: When it is not possible to achieve the duct leakage criteria in Section 180.2(b)2Biib, all accessible leaks shall be sealed and verified through a visual inspection and a smoke test performed by a certified HERS Rater utilizing the methods specified in Reference Nonresidential Appendix NA2.1.4.2.2a.

EXCEPTION 2 to Section 180.2(b)2Biib: Duct Sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos are exempt from the requirements of subsection 180.2(b)2Biib.

c. If the new ducts are an extension of an existing duct system, the combined new and existing duct system meets the criteria in Subsections I, II, and III below. The duct system shall be sealed to a leakage rate not to exceed 15 percent of the nominal air handler airflow rate as confirmed through field verification and diagnostic testing, in accordance with the applicable procedures in Reference Nonresidential Appendices NA1 and NA2:

I. The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system; and

II. The space conditioning system serves less than 5,000 square feet of conditioned floor area; and

III. The combined surface area of the ducts located in the following spaces is more than 25 percent of the total surface area of the entire duct system:

A. Outdoors;

B. In a space directly under a roof that

C. Has a U-factor greater than the U-factor of the ceiling, or if the roof does not meet the requirements of Section 170.2(a)1B, or

D. Has fixed vents or openings to the outside or unconditioned spaces; or

E. In an unconditioned crawl space; or

F. In other unconditioned spaces.

iii. **Altered space-conditioning systems.** When a space-conditioning system is altered by the installation or replacement of space-conditioning system equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil:

a. For all altered units where the existing thermostat does not comply with the requirements for demand responsive controls specified in Section 110.12, the existing thermostat shall be replaced with a demand responsive thermostat that complies with Section 110.12. All newly installed space-conditioning systems requiring a thermostat

shall be equipped with a demand responsive thermostat that complies with Section 110.12; and

b. The duct system that is connected to the new or replaced space-conditioning system equipment shall be sealed, if the duct system meets the criteria of Section 170.2(c)4Ji, as confirmed through field verification and diagnostic testing, in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Nonresidential Appendix NA2, and conforming to the applicable leakage compliance criteria in Section 180.2(b)2Bii.

Exception 1 to Section 180.2(b)2Biiib: duct sealing. Buildings altered so that the duct system no longer meets the criteria of Section 170.2(c)4Ji are exempt from the requirements of Subsection 180.2(b)2Biiib.

Exception 2 to Section 180.2(b)2Biiib: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in the Reference Nonresidential Appendix NA2 are exempt from the requirements of Subsection 180.2(b)2Biiib.

Exception 3 to Section 180.2(b)2Biiib: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos are exempt from the requirements of Subsection 180.2(b)2Biiib.

3. **Hot water systems**. Altered or replacement water-heating systems or components serving individual dwelling units shall meet the applicable requirements below:

   A. **Pipe insulation.** For newly installed piping and existing accessible piping, the insulation requirements of Section 160.4(f) shall be met.

   B. **Distribution system.** For recirculation distribution system serving individual dwelling units, only demand recirculation systems with manual on/off control as specified in Reference Appendix RA4.4.9 shall be installed.

   C. **Water-heating system.** The water-heating system shall meet one of the following:
      i. A natural gas or propane water-heating system; or
      ii. A single heat pump water heater. The storage tank shall not be located outdoors and shall be placed on an incompressible, rigid insulated surface with a minimum thermal resistance of R-10. The water heater shall be installed with a communication interface that either meets the requirements of Section 110.12(a) or has an ANSI/CTA-2045-B communication port; or
      iii. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher; or
      iv. If the existing water heater is an electric resistance water heater, a consumer electric water heater.
      v. A water-heating system determined by the Executive Director to use no more energy than the one specified in Sections 180.2(b)3Ci through iii above; or if no natural gas is connected to the existing water heater location, a water-heating system determined by the Executive Director to use no more energy than the one specified in Section 180.2(b)3Civ above.

4. **Lighting**.

   ~~A. **Dwelling unit lighting.** The altered lighting system shall meet the lighting requirements of Section 160.5(a). The altered luminaires shall meet the luminaire efficacy requirements of Section 160.5(a) and Table 160.5-A. Where existing screw base sockets are present in ceiling-recessed luminaires, removal of these sockets is not required, provided that new JA8 compliant trim kits or lamps designed for use with recessed downlights or luminaires are installed.~~

   ~~B. **Common use area—lighting, sign lighting, and electrical power distribution systems.**~~

A. **Common use area indoor lighting.** Spaces with lighting systems installed for the first time shall meet the applicable requirements of Sections ~~110.9, 160.5(b)1, 160.5(b)2, 160.5(b)3, 160.5(b)4, 160.5(c), 160.5(e),~~ 170.2(b), and 170.2(e)1 through 170.2(e)~~6~~4.

~~i. When the requirements of Section 160.5(b)4D are triggered by the addition of skylights to an existing building and the lighting system is not recircuited, the daylighting control need not meet the multi-level requirements in Section 160.5(b)4D.~~

~~ii. New internally and externally illuminated signs shall meet the requirements of Sections 110.9, 160.5(d) and 170.2(e)7.~~

ii. Altered indoor lighting systems. Alterations to indoor lighting systems that include 10% or more of the luminaires serving an enclosed space shall meet the requirements of a, b or c below:

a. The alteration shall comply with the indoor lighting power requirements specified in Sections 170.2(e)1 through 4 and the lighting control requirements specified in Table 180.2-E; or

b. The alteration shall not exceed 80% of the indoor lighting power requirements specified in Section 170.2(e)1 through 4, and shall comply with the lighting control requirements specified in Table 180.2-E; or

c. The alteration shall be a one-for-one luminaire alteration within a building or tenant space of 5,000 square feet or less, the total wattage of the altered luminaires shall be at least 40% lower compared to their total pre-alteration wattage and the alteration shall comply with the lighting control requirements specified in Table 180.2-E.

Alterations to indoor lighting systems shall not prevent the operation of existing, unaltered controls, and shall not alter controls to remove functions specified in Section 160.5(b)4.

Alterations to lighting wiring are considered alterations to the lighting system. Alterations to indoor lighting systems are not required to separate existing general, floor, wall, display or decorative lighting on shared circuits or controls. New or completely replaced lighting circuits shall comply with the control separation requirements of Sections 160.5(b)4Aiv and 160.5(b)4Cid.

Exception 1 to Section 180.2(b)4~~Biv~~A: Alteration of portable luminaires, luminaires affixed to moveable partitions, or lighting excluded as specified in Section 170.2(e)2C.

Exception 2 to Section 180.2(b)4~~Biv~~A: Any enclosed space with only one luminaire.

Exception 3 to Section 180.2(b)4~~Biv~~A: Any alteration that would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.

Exception 4 to Section 180.2(b)4~~Biv~~A: Acceptance testing requirements of Section 160.5(e) are not required for alterations where lighting controls are added to control 20 or fewer luminaires.

Exception 5 to Section 180.2(b)4~~Biv~~A: Any alteration limited to adding lighting controls or replacing lamps, ballasts or drivers.

Exception 6 to Section 180.2(b)4~~Biv~~A: One-for-one luminaire alteration of up to 50 luminaires either per complete floor of the building or per complete tenant space, per annum.

B. **Common use area outdoor lighting.** Alterations to existing outdoor lighting systems in a lighting application listed in Table 170.2-R or 170.2-S shall meet the applicable requirements of Sections 160.5(b)1, 160.5(b)2, 160.5(b)3, 160.5(c)1 and 160.5(e), and:

i. In alterations that increase the connected lighting load, the added or altered luminaires shall meet the applicable requirements of Section 160.5(c)2 and the requirements of Section 170.2(e)6 for general hardscape lighting or for the specific lighting applications containing the alterations; and

ii. In alterations that do not increase the connected lighting load, where 10 percent or more of the existing luminaires are replaced in a general hardscape or a specific lighting application, the alterations shall meet the following requirements:

a. In parking lots and outdoor sales lots where the bottom of the luminaire is mounted 24 feet or less above the ground, the replacement luminaires shall comply with Section 160.5(c)2A and Section 160.5(c)2C;

b. For parking lots and outdoor sales lots where the bottom of the luminaire is mounted greater than 24 feet above the ground and for all other lighting applications, the replacement luminaires shall comply with Section 160.5(c)2A and either comply with Section 160.5(c)2B or be controlled by lighting control systems, including motion sensors, that automatically reduce lighting power by at least 40 percent in response to the area being vacated of occupants; and
Exception to Section 180.2(b)4B~~v~~bii~~b~~: Alterations where less than 5 existing luminaires are replaced.

c. In alterations that do not increase the connected lighting load, where 50 percent or more of the existing luminaires are replaced in general hardscape or a specific application, the replacement luminaires shall meet the requirements of Subsection b above and the requirements of Section 170.2(e)6 for general hardscape lighting or specific lighting applications containing the alterations.
Exception 1 to Section 180.2(b)4B~~v~~cii~~c~~: Alterations where the replacement luminaires have at least 40 percent lower power consumption compared to the original luminaires are not required to comply with the lighting power allowances of Section 170.2(e)6.
Exception 2 to Section 180.2(b)4B~~v~~cii~~c~~: Alterations where less than 5 existing luminaires are replaced.

Exception 3 to Section 180.2(b)4B~~v~~ii: Acceptance testing requirements of Section 160.5(e) are not required for alterations where controls are added to 20 or fewer luminaires.

C. **Sign Lighting**.

i. New internally and externally illuminated signs shall meet the requirements of Sections ~~110.9, 160.5(d) and~~ 170.2(e)7.

ii. Alterations to existing internally and externally illuminated signs that increase the connected lighting load, replace and rewire more than 50 percent of the ballasts, or relocate the sign to a different location on the same site or on a different site shall meet the requirements of Section 170.2(e)7.

Exception to Section 180.2(b)4~~Bvi~~Cii: Replacement of parts of an existing sign, including replacing lamps, the sign face or ballasts, that do not require rewiring or that are done at a time other than when the sign is relocated, is not an alteration subject to the requirements of Section 180.2(b)4~~ Bvi~~Cii.

~~vii. Alterations to existing electrical power distribution systems shall meet the~~

applicable requirements of the following sections:

a. **Service electrical metering**. New or replacement electrical service equipment shall meet the requirements of Section 160.6(a) applicable to the electrical power distribution system altered; and

b. **Separation of electrical circuits for electrical energy monitoring**. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(b); and

c. **Voltage drop**. For alterations of feeders and branch circuits where the alteration includes addition, modification or replacement of both feeders and branch circuits, the altered circuits shall meet the requirements of Section 160.6(c); and
Exception to Section 180.2(b)4Bviic: Voltage drop permitted by California Electrical Code Sections 647.4, 695.6 and 695.7.

d. **Circuit controls for 120-volt receptacles and controlled receptacles**. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(d).

TABLE 180.2-E Control Requirements for Indoor Lighting System Alterations for Common Use Areas

Control Specifications	**Projects complying with Section 180.2(b)4Biva**	**Projects complying with Sections 180.2(b)4Bivb or 180.2(b)4Bivc**
Manual Area Controls 160.5(b)4Ai	Required	Required
Manual Area Controls 160.5(b)4Aii	Required	Required
Manual Area Controls 160.5(b)4Aii	Only required for new or completely replaced circuits	Only required for new or completely replaced circuits
Multi-Level Controls 160.5(b)4B	Required	Not Required
Automatic Shut Off Controls 160.5(c)4Ci	Required; 160.5(b)4Cid only required for new or completely replaced circuits	Required; 160.5(b)4Cid only required for new or completely replaced circuits
Automatic Shut Off Controls 160.5(c)4Cii	Required	Required
Automatic Shut Off Controls 160.5(c)4Cii	Required	Required
Automatic Shut Off Controls 160.5(c)4Civ	Required	Required
Automatic Shut Off Controls 160.5(b)4Cv	Required	Required
Automatic Shut Off Controls 160.5(b)4Cvi	Required	Required

Automatic Shut Off Controls 160.5(b)4Cvii	Required	Required
Daylighting Controls 160.5(b)4D	Required	Not Required
Demand Responsive Controls 160.5(b)4E	Required	Not Required

3. **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 are 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.

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.

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 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.

4. 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)2Aiv 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.

5. 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. **Replacement ventilation fans.** Whole-dwelling unit replacement ventilation fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Sections 7.1 and 7.2. Additionally, when conformance to a specified whole-dwelling unit airflow rate is required for compliance, the

~~replacement fans shall be rated at no less than the airflow rate required for compliance.~~

~~c. **Air filters**. If the air filtration device for a whole-dwelling unit ventilation system is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance.~~

~~1. Dwellings that were required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall comply with the air filtration requirements in Section 160.2(b)1.~~

~~2. Dwellings that were not required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall not be required to comply with the air filtration requirements specified in Section 160.2(b)1.~~

~~ii. **Local mechanical exhaust**.~~

~~a. **Bathroom local mechanical exhaust**. Altered bathroom local mechanical exhaust systems shall comply with the applicable requirements specified in Section 160.0(b)2Avi.~~

~~b. **Kitchen local mechanical exhaust**. If the kitchen local ventilation fan is altered or replaced, then one of the following Subsections 1, 2 or 3 shall be used for compliance.~~

~~1. Dwellings that were required by a previous building permit to comply with the kitchen local exhaust requirements in Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G shall meet or exceed the applicable airflow or capture efficiency requirements in Section 160.0(b)2Avi.~~

~~2. Dwellings that were required by a previous building permit to install a vented kitchen range hood or other kitchen exhaust fan shall install a replacement fan that meets or exceeds the airflow required by the previous building permit, or 100 cfm, whichever is greater.~~

~~3. Dwellings that were not required to have a kitchen local ventilation exhaust system according to the conditions in either Subsection 1 or 2 above shall not be required to comply with the requirements of Section 160.0(b)2Avi.~~

~~c. **Replacement ventilation fans.** New or replacement local mechanical exhaust fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Section 7.1 and Title 24, Part 6, Section 160.0(b)2Avif. Additionally, when compliance with a specified exhaust airflow rate is required, the replacement fan shall be rated at no less than the airflow rate required for compliance.~~

(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~~2 below.

~~1. 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.~~

1. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken shall be verified by a qualified third party.
2. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in the applicable Residential or Nonresidential ACM Approval Manual.

EXCEPTION 1 to Section 180.2(c): Any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements in Section 170.2.

EXCEPTION 2 to Section 180.2(c): Where the space in the attic or rafter area is not large enough to accommodate the required R-value, the entire space shall be filled with insulation provided such installation does not violate Section 1203.2 of Title 24, Part 2.

10.3 Reference Appendices

Appendix RA2 — Residential HERS Verification, Testing, and Documentation Procedures

Table RA2-1 — Summary of Measures Requiring Field Verification and Diagnostic Testing

Measure Title	Description	Procedure(s)
	Duct Measures	
Duct Sealing	Component Packages require that space conditioning ducts be sealed. If sealed andtested ducts are claimed for compliance, field verification and diagnostic testing is required to verify that approved duct system materials are utilized, and that duct leakage meets the specified criteria.	RA3.1.4.3
Duct Location, SurfaceArea and R-value	Compliance credit can be taken for improved duct location, surface area and R-value. Field verification is required to verify that the duct system was installed according to the design, including location, size and length of ducts, duct insulation R-value and installation of buried ducts.[1] For buried ducts measures, Duct Sealing and High QualityInsulation Installation (QII) is required.	RA3.1.4.1
Verification of low leakage ducts located entirely in conditionedspace	Duct system location shall be verified by visual inspection and diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the outside when measured in accordance with Reference Residential Appendix Section RA3.1.4.3.8. Field Verification for ducts in conditioned space is required. Duct sealing isrequired.	RA3.1.4.3.8
Low Leakage Air-handling Units	Compliance credit can be taken for installation of a factory sealed air handling unit tested by the manufacturer and certified to the Commission to have met the requirements for a Low Leakage Air-Handling Unit. Field verification of the air handler'smodel number is required. Duct Sealing is required.	RA3.1.4.3.9
Verification of ReturnDuct Design	Verification to confirm that the return duct design conform to the applicable criteriagiven in TABLE 150.0-B, TABLE 150.0-C, TABLE 160.3-A, or TABLE 160.3-B.	RA3.1.4.4

Verification of Air FilterDevice Design	Verification to confirm that the air filter devices conform to the requirements given inapplicable Standards Sections 150.0(m)12 or 160.2(b)1.	RA3.1.4.5
Verification of Prescriptive Bypass Duct Requirements	Verification to confirm zonally controlled systems comply with the bypass ductrequirements in Section 150.1(c)13 or 170.2(c)3C.	RA3.1.4.6
	Air Conditioning Measures	
Improved RefrigerantCharge	Component Packages require in some climate zones that air-cooled air conditioners andair-source heat pumps be diagnostically tested in the field to verify that the system has the correct refrigerant charge. For the performance method, the Proposed Design is modeled with less efficiency if diagnostic testing and field verification is not performed.The system must also meet the prerequisite minimum System Airflow requirement.	RA3.3 RA3.2 RA1.2
Installation of FaultIndicator Display	Component Packages specify that a Fault Indicator Display can be installed as an alternative to refrigerant charge testing. The existence of a Fault Indicator Display hasthe same calculated benefit as refrigerant charge testing. Field verification is required.	RA3.4.2
Verified System Airflow	When compliance requires verified system airflow greater than or equal to a specifiedcriterion, field verification and diagnostic testing is required.	RA3.3
Air-handling Unit Fan Efficacy	When compliance requires verified fan efficacy (Watt/cfm) less than or equal to aspecified criterion, field verification and diagnostic testing is required.	RA3.3
Verified Energy Efficiency Ratio (EER/EER2)	Compliance credit can be taken for increased EER/EER2 by installation of specific air conditioner or heat pump models. Field verification is required in single family residential only.[2]	RA3.4.3 RA3.4.4.1
Verified Seasonal Energy Efficiency Ratio(SEER/SEER2)	HERS Rater field verification of the SEER/SEER2 rating is required for some systems in single family residential only.	RA3.4.3 RA3.4.4.1
Rated Heat Pump Capacity Verification	When performance compliance uses a heat pump, the rated capacity of the installedsystem shall be verified to be greater than or equal to the specified value. Verification is required for single family residential only.	RA3.4.4.2
Evaporatively CooledCondensers	Compliance credit can be taken for installation of evaporatively cooled condensers. Field verification of duct leakage is required. Field verification of refrigerant charge isrequired. Field verification of EER/EER2 is required. This measure is applicable to single family residential only.	RA3.1.4.3, RA3.2 RA3.4.3. RA3.4.4.1
Variable Capacity HeatPump (VCHP) Compliance Option	When performance compliance uses the VCHP compliance option, the system shall befield verified to confirm it meets the eligibility requirements.	RA3.4.4.3
	Ventilation Cooling Measures	
Whole House Fan	When performance compliance uses a whole house fan, the installed whole house fan airflow rate (cfm) and fan efficacy (W/cfm) shall be verified to be equal to or better than the specified values. This measure is applicable to single family residential only.	RA3.9
Central Fan Ventilation Cooling System	When performance compliance uses a central fan ventilation cooling system (CFVCS), the installed CFVCS ventilation airflow rate (cfm) and fan efficacy (W/cfm) shall be verified to be equal to or better than the specified values. This measure is applicable to single family residential only.	RA3.3.4
	Mechanical Ventilation Measures for Improved Indoor Air Quality	
Continuous Whole-Building Mechanical Ventilation Airflow	Measurement of whole-building mechanical ventilation is mandatory for newly constructed buildings.	RA3.7.4.1
Intermittent Whole-Building Mechanical Ventilation Airflow	Measurement of whole-building mechanical ventilation is mandatory for newly constructed buildings.	RA3.7.4.2
Kitchen Local Mechanical Exhaust Verification	Verification of kitchen local mechanical exhaust is mandatory for newly constructed buildings.	RA3.7.4.3

Heat Recovery Ventilation (HRV) or Energy Recovery Ventilation (ERV) Rated Performance Verification	When performance compliance requires verification of the HRV/ERV fan efficacy (W/cfm) or heat recovery efficiency, then the installed ventilation system shall be verified.	RA3.7.4.4
	Building Envelope Measures	
Building Envelope Air Leakage	Compliance credit can be taken for reduced building envelope air leakage. Field verification and diagnostic testing is required. Multifamily dwelling units are required to have enclosure leakage verified when supply or exhaust ventilation systems are installed.	RA3.8
Quality Insulation Installation (QII)	Compliance Software recognizes standard and improved envelope construction. Quality Insulation Installation is a prescriptive measure in all climate zones for newly constructed buildings and additions greater than 700 square feet, except low-rise multifamily buildings in Climate Zone 7. Field verification is required.	RA3.5
Quality Insulation Installation for Spray Polyurethane Foam (SPF) Insulation	A HERS Rater shall verify the installation of SPF insulation whenever R-values other than the default R-value per inch are used for compliance.	RA3.5.6
	Single Family Domestic Hot Water Measures	
Verified Pipe InsulationCredit (PIC-H)	Inspection to verify that all hot water piping in non-recirculating systems is insulatedand that corners and tees are fully insulated. No piping should be visible due to insulation voids with the exception of the last segment of piping that penetrate walls and delivers hot water to the sink, appliance, etc.	RA3.6.3.
Verified Parallel Piping (PP-H)	Inspection that requires that the measured length of piping between the water heater and single central manifold does not exceed five feet	RA3.6.4
Verified Compact Hot Water Distribution System Expanded Credit (CHWDS-H-EX)	Field verification to insure that the eligibility criteria specified in RA 3.6.5 are met.	RA3.6.5
Demand Recirculation: Manual Control (RDRmc-H)	Inspection to verify that all recirculating hot water piping is insulated and that corners and tees are fully insulated. No piping should be visible due to insulation voids	RA3.6.6
Demand Recirculation: Sensor Control(RDRsc-H)	Inspection to verify that all recirculating hot water piping is insulated and that corners and tees are fully insulated. No piping should be visible due to insulation voids.	RA3.6.7
Verified Drain Water Heat Recovery System (DWHR-H)	Inspection to verify that the DWHR unit(s) and installation configuration match the compliance document and the DWHR(s) is certified to the Commission to have met the requirements.	RA3.6,9
	Multi Family Domestic Hot Water Heating Measures	
Multiple Recirculation Loop Design for DHW Systems Serving Multiple Dwelling Units	Inspection that a central DHW system serving a building with more than eight dwelling units has at least two recirculation loops, each serving roughly the same number of dwelling units. These recirculation loops may the same water heating equipment or be connected to independent water heating equipment.	RA3.6.8
Verified Drain Water Heat Recovery System (DWHR-H)	Inspection to verify that the DWHR unit(s) and installation configuration match the compliance document and the DWHR(s) is certified to the Commission to have met the requirements.	RA3.6.9

1. Note: Compliance credit for increased duct insulation R-value (not buried ducts) may be taken without field verification if the R-value is the same throughout the building, and for ducts located in crawlspaces and garages where all registers are either in the floor or within 2 feet of thefloor. These two credits may be taken subject only to enforcement agency inspection.

2. Note: The requirement for verification of a high EER/EER2 does not apply to equipment rated only with an EER/EER2.

RA3 RESIDENTIAL FIELD VERIFICATION AND DIAGNOSTIC TEST PROTOCOLS

RA3.1 Field Verification and Diagnostic Testing of Air Distribution Systems

RA3.1.1 Purpose and Scope

RA3.1 contains procedures for measuring the air leakage in forced air distribution systems as well as procedures for verifying duct location, duct surface area, duct R-value, return duct design, return grille design, and air filter installation.
RA3.1 applies to air distribution systems in both new and existing ~~low-rise~~ single family and multifamily residential buildings.

RA3.3 Field Verification and Diagnostic Testing of Forced Air System Airflow Rate, Fan Watt Draw, and Determination of Fan Efficacy.

RA3.3 contains procedures for:

(a) Verification of improved system airflow rate (cfm) in ducted split system and packagedspace conditioning systems serving ~~low-rise~~ single family and multifamily residential buildings.

(b) Verification of reduced fan power (Watt) draw achieved through improved air distributionsystem design, including more efficient motors and ducts that have less resistance to airflow.

(c) Determination of fan efficacy (Watt/cfm) utilizing simultaneous measurement of systemWatt draw and airflow rate.

RA3.3.4 Verification of Central Fan Ventilation Cooling Systems (CFVCS)

When field verification and diagnostic testing of a central fan ventilation cooling system is required for compliance credit for the performance standards set forth in Standards Section150.1(b), the CFVCS shall be verified according to the procedures in this section. Central fan ventilation cooling is not applicable to multifamily buildings.

RA3.4.4.1 Rated Space Conditioning System Equipment Verification Procedure

When installation of specific matched system equipment is necessary for compliance with requirements for higher than minimum values for system HSPF/HSPF2, SEER/SEER2, or EER/EER2,the installed system equipment shall be verified according to the procedure specified in this section. Verification is not required for multifamily buildings. The verification shall utilize certified rating data from the AHRI Directory of Certified Product Performance at http://www.ahridirectory.org or another directory of certified product performance ratings approved by the Energy Commission for determining compliance.

RA3.4.4.2 Rated Heat Pump Capacity Verification Procedure

When heat pump systems are installed, and verification of the installed heat pump system capacity is required, the installed heat pump equipment shall be verified according to the procedure specified in this section. Verification is not required for multifamily buildings. The verification shall utilize certified rating data from theAHRI Directory of Certified Product Performance at http://www.ahridirectory.org or another directory of certified product performance ratings approved by the Energy Commission for determining compliance (product directory).

RA 3.5 Quality Insulation Installation Procedures

RA3.5.1 Purpose and Scope

RA3.5.1.1 QII Procedures for Single family and Select Multifamily Buildings

RA3.5 is a procedure for verifying the quality of insulation installation and air leakage control used in low-rise residential buildings. This procedure is to be followed by the insulation installer and a qualified Home Energy Rating System (HERS) rater must verify its conformance for meeting the requirements of Sections 150.1(c) or 170.2(a)6, and 110.7of the Standards.
The procedure applies to wood and metal construction of framed and non-framed envelope assemblies. Framed assemblies include wall stud cavities, roof/ceiling assemblies, and floors typically insulated with: (1) batts of mineral fiber and mineral wool; (2) loose-fill materials of mineral fiber, mineral wool, and cellulose; (3) spray polyurethane foam; and, (4) rigid board sheathing materials. Non-framed assemblies include wall, roof/ceiling, and floors constructed of structural insulated panels and insulated concrete forms.
Note 1: For newly constructed buildings, this procedure applies to the entire thermal envelope of the building. In many instances, residential homes would use several types of insulation material, even in the same framed assembly. Each insulation material and the integrity of air leakage control for the building's entire thermal envelope must be verified by the HERS Rater for the home to comply with the Standards.
Note 2: Structural bracing, tie-downs, and framing of steel or specialized framing used to meet structural requirements of the California Building Code (CBC) are allowed. These areas shall be called out on the building plans with diagrams and/or specific design drawings indicating the R-value amount and fastening method to be used. All structural framing areas shall be insulated in a manner that resists thermal bridging from the outside to the inside of the assembly separating conditioned from unconditioned space. The insulation and air barrier integrity shall be verified by the HERS Rater.

RA3.5.1.2 Multifamily QII Procedures

Multifamily buildings with four or more habitable stories shall use the Multifamily QII verification procedure to fulfill prescriptive requirements. Multifamily buildings with three or fewer habitable stories may elect to use Multifamily QII verification for reduced compliance credit using the performance approach. Multifamily QII requires verification of all insulating materials of the thermal envelope that can be verified at the time of each verification visit. Buildings using panelized curtain wall construction methods, rather than cavity framed methods, are exempted from prescriptive multifamily-QII requirements.

During each verification visit, the HERS Rater shall verify all thermal envelope air sealing and insulating materials visually available. The HERS Rater must directly observe 100 percent of the wall area of the first habitable story and 100 percent of the wall area and ceiling area of the last habitable story. The HERS Rater must also directly observe at minimum 15 percent of the building's remaining total gross wall area to verify framing cavity air sealing quality, and 15 percent of the building's remaining total gross wall area to verify insulation installation quality. If each of these 15 percent minimums cannot be met in a single visit, the verifier shall return at subsequent dates until the minimum requirements are achieved. To determine the required amount of wall area to inspect, the HERS Rater shall review the compliance forms for the total exterior wall area and exterior wall area on each floor. If the wall area of the first and last floors is less than 15% of the total wall area, HERS Rater shall identify the number of additional floors required for verification.

Requirements detailed in RA3.5.1 through 3.5.8 apply with the following variations:

- Verification of external insulation, regardless of the building heights, may be done by observation from the ground level at a distance.

If field verification of air sealing and insulation in any of the sampled portions results in a failure, the HERS Rater shall enter the failure into the HERS data registry. Installers shall take corrective action, and the HERS Rater shall re-check the corrective action. If a failure is observed on the first habitable story of the building, the failure must be corrected. If a failure is observed on a subsequent floor, the failure must be corrected, and the HERS Rater shall verify 100 percent of the building's remaining wall area that is still visually accessible. The building passes inspection if the HERS Rater verifies that the corrective action was successful during re-check, and if all visually accessible remaining wall area meets the verification requirements.

Note 1: For newly constructed multifamily buildings, dwelling unit-based sampling methods are not allowed for QII compliance. Multifamily building with three or fewer habitable stories must follow the same full QII protocols and methods as single family buildings with direct verification of each insulating layer of the entire thermal envelope. Multifamily buildings with four or more habitable stories may follow the Multifamily QII or the full QII verification procedure.

Note 2: Insulated header verification is not required for QII in multifamily buildings.

RA3.9 Field Verification and Diagnostic Testing of Whole House Fans (WHF)

RA3.9.1 Purpose and Scope

RA3.9 contains procedures for measurement of WHF systems in single family buildings:

(a) Measurement of WHF airflow rate to confirm compliance with the airflow rate requirements specified in the performance standards set forth in Standards section150.1(b).

(b) Measurement of WHF Watt draw.

(c) Calculation of WHF efficacy (w/cfm) utilizing simultaneous measurement of WHF Wattdraw and airflow rate.

NA7.1 Purpose and Scope

This appendix defines acceptance procedures that must be completed on certain controls and equipment before the installation is deemed to be in compliance with the Standards. These requirements apply to all newly installed equipment for which there are acceptance requirements in new and existing buildings. The procedures apply to nonresidential, ~~high-rise residential,~~ multifamily, hotel/motel buildings and covered processes as defined by the California Energy Commission's Energy Efficiency Standards for Nonresidential Buildings (Standards). The purposeof the acceptance tests is to assure:

- The presence of equipment or building components according to the specifications in the compliance documents.
- Installation quality and proper functioning of the controls and equipment to meet the intent of the design and the Standards.

Modifications and additions to these acceptance requirements needed to improve clarity or to better ensure proper installation and functionality may be approved by the Energy Commission.

10.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual for the following measures: Slab Perimeter Insulation, Visible Transmittance, Skylight Properties, Central Ventilation Shaft Sealing, and Additions and Alterations Clean Up.

RESIDENTIAL ACM REFERENCE MANUAL

Section 2.2.5 Quality Insulation Installation (QII)

The compliance software user may specify quality insulation installation (QII) for the proposed design as "Verified, full QII", "Verified, Multifamily QII" or "Unverified"~~yes or no~~. Based on the QII selection, t~~T~~he effective R-value of cavity insulation is reduced as shown in *Table 3* ~~in buildings with no QII~~. When set to ~~no~~"Unverified", framed walls, ceilings, and floors are modeled with added winter heat flow between the conditioned zone and attic to represent construction cavities open to the attic. "Verified, full QII" implies no derate while "Verified, Multifamily QII" applies a 15% derate

factor on the effective R-value. QII does not affect the performance of continuous sheathing in any construction.

PROPOSED DESIGN

The compliance software user may specify compliance with QII. The default is "~~no~~Unverified" for QII.

STANDARD DESIGN

The standard design is ~~modeled with~~ "~~yes~~Verified, full QII" ~~for verified QII~~ for newly constructed single family residential buildings and additions greater than 700 ft2 in all climate zones.
The standard design is "Verified, full QII" for newly constructed multifamily buildings with three or fewer habitable stories and additions greater than 700 ft^2 in all Climate Zones except Climate Zone 7.
The standard design is "Verified, Multifamily QII" for newly constructed multifamily buildings with four or more habitable stories in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no requirement.)
The standard design for multifamily buildings in Climate Zone 7 is "Unverified" for new construction and additions.

VERIFICATION AND REPORTING

The presence of QII is reported in the HERS required verification listings on the ~~CF1R~~LMCC or NRCC. Both "Verified, full QII" and "Verified, Multifamily QII" are ~~is~~ certified by the installer and field verified to comply with RA3.5. Credit for "Verified, full QII" and "Verified, Multifamily QII" applies to ceilings/attics, knee walls, exterior walls, and exterior floors.

For alterations to existing pre-1978 construction, if the existing wall construction is assumed to have no insulation, no wall degradation is assumed for the existing wall.

Table 3: Modeling Rules for Unverified and Verified Insulation Installation Quality

Component	~~Modification~~ Unverified (default)	Verified, full QII	Verified, Multifamily QII
Walls, Floors, Attic Roofs, Cathedral Ceilings	Multiply the cavity insulation R-value/inch by 0.7.	No derate.	Multiply the cavity insulation R-value/inch by 0.85.
Ceilings Below Attic	Multiply the blown and batt insulation R-value/inch by 0.96-0.00347*R.	No derate.	No derate.
Ceilings Below Attic	Add a heat flow from the conditioned zone to the attic of 0.015 times the area of the ceiling below attic times (the conditioned zone temperature — attic temperature) whenever the attic is colder than the conditioned space.	No additional heat flow.	No additional heat flow.

6.7.4 Quality Insulation Installation ~~For Building Up To Three Habitable Stories~~

The compliance software user may specify quality insulation installation (QII) for the proposed design as "Verified, full QII", "Verified, Multifamily QII" or "Unverified." ~~"yes" or "no."~~ Based on QII selection, t~~T~~he effective R-value of cavity insulation is reduced, as shown in Table 16 ~~in buildings with no QII~~. When set to "Unverified~~no~~," framed walls, ceilings, and floors are modeled with added winter heat flow between the conditioned zone and attic to represent construction cavities open to the attic. "Verified, full QII" implies no derate while "Verified, Multifamily QII" applies a 15% derate factor on the effective R-value. QII does not affect the performance of continuous sheathing in any construction.

PROPOSED DESIGN

The compliance software user may specify compliance with QII. The default is "Unverified~~no~~" for QII. This results in a 30% derating applied to the cavity insulation.

STANDARD DESIGN

~~The standard design is modeled with "yes" for verified QII for newly constructed multifamily buildings and additions greater than 700 square feet in Climate Zones 1-6 and 8-16 (Climate Zone 7 has no QII for multifamily buildings). This results in the removal of the 30% derating to the cavity insulation.~~

The standard design is "Verified, full QII" for newly constructed multifamily buildings with three or fewer habitable stories and additions greater than 700 ft2 in all Climate Zones except Climate Zone 7.

The standard design is "Verified, Multifamily QII" for newly constructed multifamily buildings with four or more habitable stories in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no requirement.)

The standard design for multifamily buildings in Climate Zone 7 is "Unverified." for new construction and additions.

VERIFICATION AND REPORTING

The presence of QII is reported in the HERS required verification listings on the LMCC. Both "Verified, full QII" and "Verified, Multifamily QII" are ~~is~~ certified by the installer and field verified to comply with RA3.5. Credit for "Verified, full QII" and "Verified, Multifamily QII" applies to ceilings/attics, knee walls, exterior walls, and exterior floors.

For alterations to existing pre-1978 construction, if the existing wall construction is assumed to have no insulation, no wall degradation is assumed for the existing wall.

Table 20: Modeling Rules for Unverified and Verified Insulation Installation Quality

Component	~~Modification~~ Unverified (default)	Verified, full QII	Verified, Multifamily QII
Walls, Floors, Attic Roofs, Cathedral Ceilings	Multiply the cavity insulation R-value/inch by 0.7.	No derate.	Multiply the cavity insulation R-value/inch by 0.85.
Ceilings Below Attic	Multiply the blown and batt insulation R-value/inch by 0.96-0.00347*R.	No derate.	No derate.
Ceilings Below Attic	Add a heat flow from the conditioned zone to the attic of 0.015 times the area of the ceiling below attic times (the conditioned zone temperature — attic temperature) whenever the attic is colder than the conditioned space.	No additional heat flow.	No additional heat flow.

6.8.1 Heating Subsystems

~~Verified~~ Heating Seasonal Performance Factor (HSPF and HSPF2)

PROPOSED DESIGN

The software allows the user to specify the HSPF/HSPF2 value for heat pump equipment.

STANDARD DESIGN

The standard design is the minimum allowable HSPF for the type of heat pump equipment modeled in the proposed design, based on the applicable Appliance Efficiency Regulations. For central-heating and cooling equipment, the minimum efficiency is 8.0 HSPF/6.7 HSPF2 for packaged heat pumps or 8.2 HSPF/7.5 HSPF2 for split heat pumps.

VERIFICATION AND REPORTING

If an HSPF/HSPF2 for the proposed design is higher than the default minimum efficiency modeled in software, the HSPF/HSPF2 ~~requires field verification. The HSPF/HSPF2 rating is verified using rating data from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory of Certified Product Performance website or another directory of certified product performance ratings~~

~~approved by the CEC for determining compliance. Verified SEER/SEER2~~ is reported in the ~~HERS-required verification listings on the~~ LMCC.

Table 26: Summary of Space Conditioning Measures Requiring Verification

Measure	Description	Procedures
Verified Refrigerant Charge	Air-cooled air-conditioners and air-source heat pumps must be tested diagnostically to verify that the system has the correct refrigerant charge. The system must also meet the system airflow requirement.	RA1.2, RA3.2
Verified Fault Indicator Display	A fault indicator display can be installed as an alternative to refrigerant charge testing.	RA3.4.2
Verified System Airflow	When compliance requires verified system airflow greater than or equal to a specified criterion.	RA3.3
Verified Air-Handling Unit Fan Efficacy	To verify that fan efficacy (watt/CFM) is less than or equal to a specified criterion.	RA3.3
~~Verified HSPF/HSPF2, SEER/SEER2 or EER/EER2~~	~~Credit for increased efficiency by installation of specific air-conditioner or heat pump models.~~	~~RA3.4.4.1~~
~~Verified Heat Pump Capacity~~	~~Optional verification of heat-pump system capacity.~~	~~RA3.4.4.2~~
~~Evaporatively Cooled Condensers~~	~~Must be combined with duct leakage testing, refrigerant charge, and verified EER/EER2.~~	~~RA3.1.4.3, RA3.2, RA3.4.3, RA3.4.4.1~~
~~Whole-House Fan~~	~~When verification of the whole-house fan is selected or required, airflow, watt draw, and capacity are verified.~~	~~RA3.9~~
~~Central Fan Ventilation Cooling System~~	~~When compliance includes this type of ventilation cooling, airflow and fan efficacy are verified.~~	~~RA3.3.4~~

~~Verified~~ Energy Efficiency Ratio (EER/EER2) ~~For Buildings Up To Three Habitable Stories~~

PROPOSED DESIGN

Software shall allow the user the option to enter an EER/EER2 rating for central cooling equipment. For equipment that is rated only with an EER/EER2 (room air-conditioners), the user will enter the

EER/EER2. The Appliance Efficiency Regulations require a minimum SEER/SEER2 and EER/EER2 for central cooling equipment. ~~Only if a value higher than a default minimum EER/EER2 is used is it reported as a HERS-verified measure.~~

STANDARD DESIGN

The standard design is based on the default minimum efficiency EER/EER2 for the type of cooling equipment modeled in the proposed design, based on the applicable Appliance Efficiency Regulations. The standard design for central air-conditioning equipment is 11.7 EER/11.2 EER2 for split systems.

VERIFICATION AND REPORTING

If an EER/EER2 higher than the default minimum efficiency is modeled in software, the EER/EER2 ~~requires field verification. The EER/EER2 rating is verified using rating data from AHRI Directory of Certified Product Performance website or another directory of certified product performance ratings approved by the CEC for determining compliance. Verified EER~~ is reported in the ~~HERS-required verification listings on the~~ LMCC.

~~Verified~~ Seasonal Energy Efficiency Ratio (SEER/SEER2) ~~For Buildings Up To Three Habitable Stories~~

PROPOSED DESIGN

The software allows the user to specify the SEER/SEER2 value.

STANDARD DESIGN

The standard design is based on the default minimum efficiency SEER/SEER2 for the type of cooling equipment modeled in the proposed design, based on the applicable Appliance Efficiency Regulations. For central-cooling equipment, the minimum efficiency is 14 SEER/13.8 SEER2 for split systems.

VERIFICATION AND REPORTING

If a SEER/SEER2 higher than the default minimum efficiency is modeled in software, the SEER/SEER2 ~~requires field verification. The higher-than-minimum SEER/SEER2 rating is verified using rating data from AHRI Directory of Certified Product Performance website or another directory of certified product performance ratings approved by the CEC for determining compliance. Verified SEER/SEER2~~ is reported in the ~~HERS-required verification listings on the~~ LMCC.

~~Verified Evaporatively Cooled Condensers For Buildings Up To Three Habitable Stories~~

~~PROPOSED DESIGN~~

~~Software shall allow users to specify an evaporatively cooled condensing unit. The installation must comply with the requirements of Reference Appendices, Residential Appendix RA4.3.2 to ensure the predicted energy savings are achieved. This credit must be combined with verified refrigerant charge testing, EER/EER2, and duct leakage testing.~~

~~STANDARD DESIGN~~

~~The standard design is based on a split-system air-conditioner meeting the requirements of §170.2(c) and Table 170.2-K.~~

~~VERIFICATION AND REPORTING~~

~~An evaporatively-cooled condensing unit, verified EER/EER2, and duct leakage testing are reported in the HERS-required verification listings on the LMCC.~~

Table 28: Summary of Verified Distribution Systems

Measure	Description	Procedures
Multifamily Buildings Up to Three Habitable Stories Verified Duct Sealing	Mandatory measures require that space-conditioning ducts be sealed. Field verification and diagnostic testing are required to verify that approved duct system materials are used and that duct leakage meets the specified criteria.	RA3.1.4.3
Multifamily Buildings Up to Three Habitable Stories Verified Duct Location, Reduced Surface Area and R-value	Compliance credit can be taken for improved supply duct location, reduced surface area, and R-value. Field verification is required to verify that the duct system was installed according to the duct design, including location, size and length of ducts, duct insulation R- value, and installation of buried ducts.[1] For buried duct measures, verified QII is required, as well as duct sealing.	RA3.1.4.1, 3.1.4.1.1
Multifamily Buildings Up to Three Habitable Stories Low-Leakage Ducts in Conditioned Space	When the standards specify use of the procedures in Reference Appendices, Residential Appendix RA3.1.4.3.8 to determine if the space-conditioning system ducts are entirely in directly conditioned space, the duct system location is verified by diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the outside when measured in accordance with Reference Appendices, Residential Appendix RA3.1.4.3.8. Field verification for ducts in conditioned space is required. Duct sealing is required.	RA3.1.4.3.8
Multifamily Buildings Up to Three Habitable Stories Hydronic Delivery in Conditioned Space	Compliance credit can be taken for hydronic delivery systems with no ducting or piping in unconditioned space. For radiant ceiling panels, the verifications in Reference Appendices, Residential Appendix RA3.4.5 must be completed to qualify.	RA3.4.5
Multifamily Buildings ~~Up to Three Habitable Stories~~ Low-Leakage Air-Handling Units	Compliance credit can be taken for installing a factory-sealed air-handling unit tested by the manufacturer and certified to the CEC to have met the requirements for a low-leakage air-handling unit. Field verification of the air handler model number is required. Duct sealing is required.	RA3.1.4.3.9
Multifamily	Verification to confirm that the return duct design	RA3.1.4.4

Measure	Description	Procedures
Buildings Up to Three Habitable Stories Verified Return Duct Design	conforms to the criteria given in Table 160.3-A or Table 160.3-B. as an alternative to meeting 0.45 or 0.58 W/CFM fan efficacy of §160.3(b)5L.	
Multifamily Buildings Up to Three Habitable Stories Verified Bypass Duct Condition	Verification to determine if system is zonally controlled and confirm that bypass ducts condition modeled matches installation.	RA3.1.4.6

6.12.4 Existing + Addition + Alteration Approach

QII

STANDARD DESIGN

For multifamily buildings up to three habitable stories, the standard design includes full QII for additions greater than 700 ft^2 in multifamily building in Climate Zones 1-6 and 8- 16(§180.1[a]1Bv).

For multifamily buildings four or more habitable stories, the standard design includes Multifamily QII for additions greater than 700 ft^2 in multifamily building in Climate Zones 1-6 and 8- 16(§180.1[a]1Bv).

The provisions of §180.1(a)1Aiv, as applied to converting an existing unconditioned space to conditioned space, are accommodations made by the HERS rater in the field. No adjustments to the energy budget are made.

Fenestration

Table 45: Standard Design for Fenestration (in Walls and Roofs)

Proposed Design Fenestration Type	Addition < 400 ft^2	Addition > 400 and < 700 ft^2	Addition > 700 ft^2	Altered
Vertical Glazing: Area and Orientation	75 ft^2 or 30%	Min of 20% WWR or 40% WFR	Min of 20% WWR or 40% WFR	Min of 20% WWR or 40% WFR

West Facing Maximum Allowed	CZ 2, 4, 6 - 15=60 ft^2	CZ 2, 4, 6 - 15=60 ft^2	CZ 2, 4, 6 - 15=70 ft^2 or 5%	NR
Vertical Glazing: U-Factor	CZ 1-6, 8- 16 = 0.30 CZ 7 = 0.34	CZ 1-6, 8- 16 = 0.30 CZ 7 = 0.34	CZ 1-6, 9- 16 = 0.30 CZ 7, 8 = 0.34	CZ 1-6, 8-16 = 0.30 CZ 7 = 0.34
Vertical Glazing: SHGC	CZ 1 = 0.35 CZ 2-16 = 0.23	CZ 1 = 0.35 CZ 2-16 = 0.23	CZ 1 = 0.35 CZ 2-16 = 0.23	CZ 1 = 0.35 CZ 2-16 = 0.23
Skylight: Area and Orientation	5%	5%	5%	5%
Skylight: U-Factor	0.30	0.30	0.30	0.55
Skylight: SHGC	CZ 2, 4, 6 - 15=~~0.23~~ 0.25 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 - 15=~~0.23~~ 0.25 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 - 15=0.23 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 - 15=~~0.30~~ 0.25 CZ 1,3 5 & 16=0.35

10.5 Compliance Documents

The following sections describe the compliance document revisions necessary for each measure.

Slab Perimeter Insulation

Compliance documents LMCC-ENV-01, CEC-NRCC-ENV-E, and NRCI-ENV-E would need to be revised. The proposed code change would change the field regarding slab edge insulation in the Envelope Certificate of Compliance forms to remove language about this field only applying to low-rise buildings. The proposed code change would also add a field regarding slab edge insulation to the Envelope Component Approach Certificate of Installation form used for multifamily buildings with four or more habitable stories (NRCI-ENV-E) to document installation of slab edge insulation, as is documented in LMCI-ENV-22-H for multifamily buildings with three or fewer habitable stories.

Visible Transmittance

The proposed code change would not modify the compliance documents.

Skylight Properties

Compliance documents LMCC-ENV, NRCC-ENV, LMCI-ENV, NRCI-ENV, and NRCA-ENV would need to be revised. The proposed code change would modify the certificate of compliance forms (LMCC-ENV and NRCC-ENV), certificate of installation forms (LMCI-ENV and NRCI-ENV), and certificate of acceptance form (NRCA-ENV) to align fields with the proposed values, categories, and exceptions.

Multifamily QII

The proposed code change would revise the following Compliance documents:

- LMCC-ENV-01-E
- LMCI-ENV-21-H QII — Air Infiltration Sealing — Framing Stage
- LMCI-ENV-22- H QII — Insulation Installation
- LMCV-ENV-21-H QII — Air Infiltration Sealing — Framing Stage
- LMCV-ENV-22-H QII — Insulation Installation
- NRCC-ENV-E

The proposed code change would update the QII specific entries in the Certificate of Compliance (LMCC/NRCC) documents to reflect applicable full vs. Multifamily QII options based on number of habitable stories. For buildings with three or fewer habitable stories, Certificates of Installations (LMCI) and Verifications (LMCV) need updates that reflect full and Multifamily QII requirement and respective protocols. For buildings with four or more habitable stories, Certificates of Installations (NRCI) and Verifications (NRCV) would need to be created to reflect full and Multifamily QII requirements and respective protocols.

Central Ventilation Shaft Sealing

Compliance documents LMCC-MCH-01-E, LMCI-MCH-27-H, and LMCV-MCH-27-H would need to be revised to reflect the central shaft sealing requirements.

Verification Clean Up

Compliance documents LMCC-MCH-01-E and NRCC-MCH-01-E would need to be revised to update mechanical system documentation for buildings four or more habitable stories to include relevant compliance options.

The following forms would need to be updated or created for the measures to be extended as compliance options for buildings with four or more habitable stories:

- Low Leakage Air-handling Units
  - NRCI-MCH-20-F
  - NRCV-MCH-04-H
- Variable Capacity Heat Pump (VCHP) Compliance Option
  - NRCI-MCH-33-H (new)
  - NRCV-MCH-33-H (new)

The following forms would need to be updated to remove verification requirements for the measures in buildings with three or fewer habitable stories:

- Verified Energy Efficiency Ratio (EER/EER2), Verified Seasonal Energy Efficiency Ratio (SEER/SEER2), Verified Heating Seasonal Performance Factor (HSPF/HSPF2), Rated Heat Pump Capacity Verification
  - LMCI-MCH-26-H

    - LMCV-MCH-26-H

The following forms would need to be updated to remove the measures in multifamily buildings with three or fewer habitable stories:

- Evaporatively Cooled Condensers
    - LMCI-MCH-26-H
    - LMCV-MCH-26-H
- Whole House Fan
    - LMCI-MCH-27-H
    - LMCV-MCH-27-H
- Central Fan Ventilation Cooling System
    - LMCI-MCH-22-H
    - LMCV-MCH-22-H

Additions and Alterations Clean Up

The proposed code change would not modify the compliance documents.

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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).

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. Table 65 through **Error! Reference source not found.** present the number of dwelling units for each measure, both newly constructed and existing, that the Statewide CASE Team assumed will be impacted by the proposed code change during the first year the 2025 code is in effect.

The Statewide CASE Team did not estimate statewide savings for the skylight properties, visible transmittance, verification clean up, and additions and alterations clean up measures.

Table 65: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone — Slab Perimeter Insulation

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
16	187	2.9%	5.4	28,066	0%	0
TOTAL	**53,268**		**5.4**	**4,469,912**		**0**

The Multifamily QII measure would impact all new construction Mid-Rise Mixed Use and High-Rise Mixed Use prototypes, excluding those in Climate Zone 7. Existing building stock would not be impacted.

Table 66: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone — Multifamily QII

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	63%	91	17,558	0%	0
2	1,391	63%	876	105,894	0%	0
3	7,699	63%	4,850	553,186	0%	0
4	3,417	63%	2,153	288,786	0%	0
5	285	63%	180	45,671	0%	0
6	2,243	63%	1,413	322,513	0%	0
7	5,156	0%	0	307,272	0%	0
8	8,600	63%	5,418	515,137	0%	0
9	10,302	63%	6,490	1,117,605	0%	0
10	4,306	63%	2,713	329,302	0%	0
11	1,173	63%	739	85,339	0%	0
12	5,537	63%	3,488	471,876	0%	0
13	1,009	63%	636	157,075	0%	0
14	1,446	63%	911	83,480	0%	0
15	373	63%	235	41,152	0%	0
16	187	63%	118	28,066	0%	0
TOTAL	**53,268**		**30,311**	**4,469,912**		**0**

The central ventilation duct sealing requirement will only impact multifamily buildings with three or fewer habitable stories with central ventilation ducts. The Statewide CASE Team determined that central ventilation was unlikely for the Low-Rise Garden Style building, and therefore this prototype was not analyzed. The Statewide CASE Team used industry judgment to assume that 10 percent of the Low-Rise Loaded Corridor prototypes use central ventilation ducts. Existing building stock would not be impacted.

Table 67: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone — Central Ventilation Shaft Sealing

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	3%	5	17,558	0%	0

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
2	1,391	3%	46	105,894	0%	0
3	7,699	3%	254	553,186	0%	0
4	3,417	3%	113	288,786	0%	0
5	285	3%	9	45,671	0%	0
6	2,243	3%	74	322,513	0%	0
7	5,156	3%	170	307,272	0%	0
8	8,600	3%	284	515,137	0%	0
9	10,302	3%	340	1,117,605	0%	0
10	4,306	3%	142	329,302	0%	0
11	1,173	3%	39	85,339	0%	0
12	5,537	3%	183	471,876	0%	0
13	1,009	3%	33	157,075	0%	0
14	1,446	3%	48	83,480	0%	0
15	373	3%	12	41,152	0%	0
16	187	3%	6	28,066	0%	0
TOTAL	**53,268**		**1,758**	**4,469,912**		**0**

Appendix B: Embedded Electricity in Water Methodology

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

Appendix C: CBECC Software Specification

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for multifamily buildings, along with the supporting documentation that the CEC staff and the technical support contractors would need to approve and implement the software revisions.

Technical Basis for Software Change

The Multifamily Restructuring proposal aims to align requirements across all multifamily buildings, regardless of number of stories. The software should be updated to reflect the recommended defaults and standard design for multifamily buildings. The software should also be updated to appropriately capture the options available to multifamily buildings.

Description of Software Change

Background Information for Software Change

The Multifamily Restructuring proposal aims to align requirements across all multifamily buildings, regardless of number of stories. The necessary changes to the software are summarized below.

The proposed code changes for Slab Perimeter Insulation and Skylight Properties would need to be incorporated into the software to accommodate updates to the Standard Design to match new prescriptive requirements. The Central Ventilation Shaft Sealing proposal would incorporate new defaults to reflect the proposed mandatory requirements.

The Multifamily QII proposal requires the addition of this option for all multifamily buildings. It would also require updates to both the Standard Design and available user inputs.

The Verification Clean Up proposal includes proposed changes to compliance options in three categories. The first category proposes to extend existing HERS compliance credits to all multifamily buildings. These measures would require existing functionality to be available as a user input for buildings with four or more stories in the software. The next category requires no changes to the software as it proposes to allow all multifamily buildings to claim certain compliance options without third-party verification. The final category proposes to remove compliance options for multifamily buildings, which would require disabling the functionality and user inputs for these options in CBECC.

The Visible Transmittance and Additions and Alterations Clean Up measures do not require changes to the software.

Existing CBECC Building Energy Modeling Capabilities

The Multifamily Restructuring measures that require software revisions beyond updates to the standard design are Multifamily QII and Verification Clean Up.

The existing CBECC modeling capabilities for full QII applies a 30 percent insulation derating to multifamily buildings with three or fewer habitable stories where QII is not verified, and no insulation derating where QII is verified. QII verification is a prescriptive requirement for multifamily buildings with three or fewer habitable stories, so the standard design has no

insulation derating. The standard design for multifamily buildings with four or more habitable stories assumes no insulation derating, and QII verification cannot be claimed.

The Verification Cleanup proposal recommends extending compliance options including low leakage air-handling units and variable capacity heat pump (VCHP) to all multifamily buildings. These capabilities currently exist in CBECC and are available only for multifamily buildings with three or fewer habitable stories. This proposal also recommends removing compliance options from all multifamily buildings, including evaporatively cooled condensers, whole house fan, central fan ventilation cooling system, and pre-cooling. These capabilities currently exist in CBECC for multifamily buildings with three or fewer habitable stories.

Summary of Proposed Revisions to CBECC

- Proposed CBECC revisions for updates to standard design and default include:
    - Updating the standard design for multifamily buildings with four or more habitable stories in Climate Zone 16 to include slab perimeter insulation.
    - Updating the standard design for Additions and Alterations in multifamily buildings to include the proposed specifications and exceptions.
    - Updating the default duct leakage value for multifamily buildings with three or fewer habitable stories that use central ventilation systems to reflect the proposed mandatory requirement.
- Proposed CBECC revisions for Multifamily QII include:
    - Introducing a “Multifamily QII” functionality that results in 15 percent insulation derating.
    - Applying a 30 percent insulation derating in multifamily buildings with four or more habitable stories when QII is not verified.
    - Updating the standard design of multifamily buildings with four or more habitable stories to Multifamily QII with 15 percent insulation derating.
    - Allowing Multifamily QII as a user input for multifamily buildings with three or fewer habitable stories for compliance through the performance path.
    - Allowing full QII as a user input for multifamily buildings with four or more habitable stories for compliance through the performance path.
- Proposed CBECC revisions for Verification Clean Up include:
    - Extending the functionality and user inputs for the following compliance options in multifamily buildings with four or more habitable stories:
        - Low leakage air-handling units
        - Variable capacity heat pump (VCHP) compliance option
    - Removing the functionality and user inputs for the following compliance options in all multifamily buildings:
        - Evaporatively cooled condensers
        - Whole house fan
        - Central fan ventilation cooling system
        - Pre-cooling

User Inputs to CBECC

The CBECC user input that should be added for this proposal is Multifamily QII. This functionality should be available for all multifamily buildings and should result in a 15 percent insulation derating. This should be an option in the QII drop-down menu. The current “Yes” option should become “Full QII” and the current “No” option should become “Unverified.”

Simulation Engine Inputs

No change to simulation engine inputs is required.

Simulation Engine Output Variables

No change to simulation engine output variable is required.

Compliance Report

See Section 10.5 for recommended updates to the compliance documents.

Compliance Verification

The code change proposals extend or build upon existing requirements and procedures, so new processes are not necessary. See Appendix E for more information on the compliance verification process.

Testing and Confirming CBECC Building Energy Modeling

Testing should be conducted to confirm the correct values are assigned to the standard design, and that the correct compliance and verification options are available for multifamily buildings.

Description of Changes to ACM Reference Manual

See Section 10.4 for proposed revisions to the ACM Reference Manual.

Appendix D: Environmental Analysis

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (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 will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

The proposal will directly benefit the environment through reduction in energy use, GHG emissions, and other pollutions. The energy and GHG emissions impacts are detailed in the Statewide Energy and Energy Cost Savings Sections 3.5.1, 6.5.1, and 7.5.1, and the Statewide GHG Emissions Reductions Sections 3.5.2, 6.5.2, and 7.5.2.

Direct Adverse Environmental Impacts

The increased usage of materials will adversely impact the environment and result in greater embodied carbon. The material impacts are detailed in the Statewide Material Impacts Sections 3.5.4 and 7.5.4.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team determined that the proposal will not result in significant indirect environmental benefits.

Indirect Adverse Environmental Impacts

The Statewide CASE Team determined that the proposal will not result in significant indirect adverse environmental impacts.

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 this measure would result in significant direct or indirect adverse environmental impacts; therefore, it 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. The alternative is to not pursue this measure. There are no other alternatives to consider that fulfill the purpose of the proposed code change with less adverse environmental effects.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

Embodied Carbon in Materials

Accounting for embodied carbon emissions is important for understanding the full environmental impacts picture of a proposed code change. The embodied carbon in materials analysis accounts specifically for emissions produced during the "cradle-to-gate" 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 measures. The calculation builds off the materials impacts outlined in Appendix A: Statewide Savings Methodology, see section 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).[51, 52] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[53] The Statewide CASE Team chose the industry-wide average for GWP values in the EPDs because the materials accounted for in the statewide calculation will have a range of embodied carbon (e.g. 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 will not specify low embodied carbon products. Therefore, an average is appropriate for a statewide estimate.

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[51] EPDs are documents that disclose a variety of environmental impacts, including embodied carbon emissions. These documents are based on lifecycle assessments on 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/or associations. A manufacturer specific 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/material) but a manufacturer specific EPD only factors one manufacturer.

[52] An industry wide EPD was not used for mercury, lead, copper, plastics, and 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 (IPCC) Fourth Assessment Report.

[53] 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.

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 and additional emissions. If a material's use is decreased, then there is a decrease in embodied carbon impacts and reduced emissions. Table 68 presents estimated first-year GHG emissions impacts associated with embodied carbon.

A comprehensive accounting of buildings' GHG emissions would include operational emissions (e.g., emissions from energy use) and embodied carbon. Title 24, Part 6 addresses energy use in buildings and results in reductions in operational GHG emissions. The Statewide CASE Team has provided embodied carbon impacts of the proposed code changes, which could support an informed dialogue on how operational emissions and embodied emissions be considered together in the future. The information provided in this report is an incomplete accounting of whole-building embodied carbon and does not account for interactive effects that the proposal may have on other elements of the building design or material use. There may be instances where a specific system or component may increase emissions through embodied carbon but enable the building as a whole to have lower total emissions (operational plus building-wide embodied carbon).

Table 68: First-Year Statewide Impacts on Material Use

Material	Impact	Per unit Impacts (Pounds per Dwelling Unit)	First-Year [a] Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Mercury	No change	-	-	-
Lead	No change	-	-	-
Copper	No change	-	-	-
Plastic	No change	-	-	-
Steel [b]	Increase	8.8	48	-0.03
Concrete [c]	Increase	29.8	162	-0.01
Insulation	Increase	8.0	43	-0.05
Mastic	Increase	3.80	6,680	-11
TOTAL	-	-	-	-11.09

a. First-year savings from all buildings completed statewide in 2026.
b. The value of steel was used for galvanized steel sheet metal.
c. The value for concrete was used in place of fiber cement.

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

This appendix discusses how the recommended compliance process, which is described in 3.1.5, 4.1.5, 5.1.5, 6.1.5, 7.1.5, 8.1.5, and 9.1.5, could impact various market actors. The information contained in Table 69 through Table 74, is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. 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.

The multifamily restructuring measures generally target code language simplification for the purpose of streamlining understanding, compliance, and enforcement of the requirements. Most of the measures do not change the compliance and enforcement process. The workflow and market actors also remain the same. Multifamily QII, central ventilation shaft sealing, and verification clean up would introduce extension of existing verification measures across all multifamily buildings. For certain multifamily building types, there would be new inspections and possibly new inspectors.

The following summarizes impacts by measure on the compliance process:

- **Slab edge insulation:** Would add steps for the energy consultant in completing the certificate of compliance documents for multifamily buildings with four or more habitable stories, and the plans examiner would verify this information. Contractors would complete additional steps in completing the certificate of installation documents and inspector verifying this information.
- **Visible Transmittance:** no change in compliance process.
- **Skylight properties:** no change in compliance process.
- **Multifamily QII:** coordination would be required between the HERS Rater, contractors, developers, and consultants. New installation forms, inspection forms and registry requirements would be necessary.
- **Central ventilation shaft sealing:** the project team would develop and implement the central shaft sealing plan, HERS Raters would conduct test and record results, code official would verify results.
- **Verification clean up:** process would now include ATTs, provider registry/database would need to add applicable fields, and training needs to be provided for ATTs on verification procedures and updated compliance documents.
- **Additions and alterations clean up:** no change in compliance process.

Table 69 through Table 74 identify the market actors who will play a role in complying with the proposed change, the tasks for which they will 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.

Table 69: Roles of Market Actors in the Proposed Compliance Process for Slab Perimeter Insulation

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Energy Consultant	• Identifies relevant requirements and/or compliance path options • Coordinates with other team members on requirements • Completes compliance documents LMCC/NRCC-ENV-E for permit application	Additional communication required with design team to ensure they are aware of prescriptive requirements	No significant impact	• Availability of training for architects and designers on importance of accurate and available thermal envelope details being on construction plans • Training on slab insulation design strategies and requirements
Structural Engineer	• Specifies products and construction assemblies that meet energy code • Coordinates with other team members, especially the Energy Consultant, on requirements • Documents energy efficiency specifications, and related details on building plans and schedules	• Coordinates with design team to ensure shared understanding of slab edge design details • Shows the UV protection would hold integrity • Shows the integrity of the floating design	Slab edge insulation specifications included in details and drawings	• Availability of training on importance of accurate and available thermal envelope details being on construction plans • Training on slab insulation design strategies and requirements
General Contractor	• Applies for the building permit • Completes LMCI/NRCI-ENV-E compliance documents	Would install slab edge insulation before concrete is poured	No significant impact	Training on slab insulation design strategies and requirements
Building Inspector	Verifies information on construction documents is consistent with requirements on compliance documentation LMCI/NRCI-ENV-E	Would make multiple site visits, before slab is poured to verify slab edge insulation is being installed, and once slab is complete	Would make multiple site visits, before slab is poured to verify slab edge insulation is being installed, and once slab is complete	Training on slab insulation design strategies and requirements

Table 70: Roles of Market Actors in the Proposed Compliance Process for VT

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect	• Provides window areas and performance specifications • Specifies products and construction assemblies that meet energy code • Coordinates with other design team members, especially the Energy Consultant, on requirements.	No significant impact	No significant impact	N/A
Energy Consultant	• Identifies relevant requirements and/or compliance path options • Coordinates with other design team members on requirements. • Completes compliance documents LMCC/NRCC-ENV-01-E for permit application.	No significant impact	No significant impact	N/A
General Contractor	• Specifies fenestration product when providing cost estimate • Ensures fenestration schedules • Applies for the building permit • Installs fenestration, as designed and specified • Compiles compliance documents of submission prior to the field inspection • Populates the Certificate of Installation LMCI/NRCI-ENV-E to document the characteristics and performance specifications of the installed skylights	No significant impact	No significant impact	N/A
Plans Examiner	• Verifies that specified fenestration meets energy code area and performance requirements.	No significant impact	No significant impact	N/A
Building Inspector	• Verifies that installed fenestration meets energy code areas and performance requirements and match LMCI/NRCI-ENV-E compliance document	No significant impact	No significant impact	N/A

Table 71: Roles of Market Actors in the Proposed Compliance Process for Skylight Properties

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect/ Structural Engineer	• Provides window areas and performance specifications. • Specifies products and construction assemblies that meet energy code. • Coordinates with other design team members, especially the Energy Consultant, on requirements.	No significant impact.	No significant impact.	Availability of training on importance of accurate and available thermal envelope details being on construction plans.
Energy Consultant	• Identifies relevant requirements and/or compliance path options. • Coordinates with other design team members on requirements. • Completes compliance documents LMCC/NRCC-ENV-01-E for permit application.	No significant impact.	No significant impact.	N/A
General Contractor	• Specifies fenestration product when providing cost estimate. • Ensures fenestration schedules. • Applies for the building permit. • Installs skylights, as designed and specified. • Compiles compliance documents of submission prior to the field inspection. • Populates the Certificate of Installation LMCI/NRCI-ENV-E to document the characteristics and performance specifications of the installed skylights.	No significant impact.	No significant impact.	N/A
Plans Examiner	• Verifies that specified skylights meet energy code area and performance requirements.	No significant impact.	No significant impact.	N/A
Building Inspector	• Verifies that installed skylights meet energy code areas and performance requirements and match LMCI/NRCI-ENV-E compliance document.	No significant impact.	No significant impact.	N/A

Table 72: Roles of Market Actors in the Proposed Compliance Process for Multifamily Quality Insulation Installation

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Developer	Specifies wall construction type with architect.	No significant impact.	No significant impact.	No significant impact.
Architect	• Specifies wall construction type with developer. • Provides all information needed to populate Certificate of Compliance LMCC/NRCC-ENV-01-E documents. • Submits Certificate of Compliance LMCC/NRCC-ENV-01-E documents. • Coordinates energy code and fire code requirements with authorities having jurisdiction for rigid continuous insulation. • Specifies products and construction assemblies that meet energy code. • Coordinates with other design team members, especially the Energy Consultant, on requirements.	• Compliance documents LMCC/NRCC-ENV-01-E would include frame type, dimensions, cavity and continuous installation types and R-values, overall assembly U-factor. • Air barriers would need to be identified on plans to show QII is effective.	No significant impact.	• Availability of training on importance of accurate and available thermal envelope details being on construction plans. • High performance products should be included in compliance documentation.
Energy Consultant	• Identifies relevant requirements and compliance option paths. • Coordinates with other design team members on requirements. • Completes compliance documents for permit application. • Complete compliance documents LMCC/NRCC-ENV-01-E for permit application.	Additional communication required with design and construction team to ensure they are aware of requirements.	No significant impact.	Availability of training on importance of accurate and available thermal envelope details being on construction plans.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
General Contractor	• Applies for building permit. • Coordinates with Installers and other trades on communication, expectations, and timing for wall and ceiling access. • Coordinates with HERS Rater for field verification visits for open wall inspections.	Permit application documents to include product specifications, framing schedules, and insulation components.	New compliance documents for high-rise buildings would be needed, including installation, inspection, and registry requirements.	Training for new compliance document requirements would be needed.
Framing/ Insulation/ Drywall Installers	• Performs air sealing. • Installs insulation. • Coordinates with General Contractor and other trades.	Coordinates with General Contractor regarding timing for wall and ceiling access.	No significant impact.	No significant impact.
HERS Rater	• Coordinates with general contractor to schedule HERS verifications. • Would coordinate field verification visits such that wall area is visually accessible at the right construction stages (at rough-in and again after installation but before drywalls).	• Coordinates open wall visits with general contractor. • Verifies air sealing. • Verifies insulation quality. • Would submit the Certificate of Verification.	New compliance documents for high-rise buildings would be needed, including installation, inspection, and registry requirements.	• Training for new compliance document requirements would be needed. • Corrective measures for installation passing should be documented.
Building Inspector	Coordinates energy code and fire code requirements for rigid continuous insulation.	No significant impact.	New compliance documents for high-rise buildings would be needed, including installation, inspection, and registry requirements.	• Training for new compliance document requirements would be needed.

Table 73: Roles of Market Actors in the Proposed Compliance Process Central Ventilation Shaft Sealing

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect	Identifies location of central ventilation shafts.	• Would develop and implement central shaft sealing plan with building owner and builder. • Would develop details and specifications supporting airtight barrier. • Would include in the design documents duct sealing specifications including acceptable materials and minimum site conditions, and outline oversight responsibilities.	No significant impact.	No significant impact.
General Contractor	• Submits design documents showing location of central ventilation shafts and sealing materials with permit application. • Would submit compliance documents LMCC/NRCC-MCH-27-H with permit application.	• Would include sealing materials in design documentation submitted for permit. • Would develop and implement central shaft sealing plan with the architect and building owner procedures via compliance documentation. • Would seal each central ventilation shaft documenting installation and verification.	No significant impact.	No significant impact.
Sheet Metal Installer	• Would apply duct sealant to the seams and joints of the ducts as they are assembled, taking care to cover the seams with sealant of a thickness and width as prescribed by the sealant manufacturer, and ensuring that manufacturer's recommendations for application conditions (such as temperature and moisture) are met.	No significant impact.	No significant impact.	No significant impact.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Building Inspector	• Reviews certificates of verification for all field verification and diagnostic testing measures.	• Would confirm leakage results are submitted and meet requirements.	No significant impact.	No significant impact.
HERS Rater	Conducts HERS verification of dwelling unit leakage, duct sealing, and other HERS requirements.	• Would conduct leakage test and verify leakage does not exceed permissible value. • Perform required testing to confirm compliance. • Verify performance meets code requirements.	No significant impact.	No significant impact.
Mechanical Contractor Installer/ATT	N/A	Would document results per the requirements of the Certificate of Acceptance NRCA-MCH-22-A.	Would document results per the requirements of the Certificate of Acceptance NRCA-MCH-22-A.	No significant impact.

Table 74: Roles of Market Actors in the Proposed Compliance Process for HERS Verification Clean Up

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
General Contractor	• Applies for building permit. • Installs HVAC equipment, or coordinates with subcontractor for HVAC system installation. • Coordinates with HERS Rater for at minimum verification of duct leakage and dwelling unit ventilation. • Makes a copy of all certificates of installation and verification available for building inspection.	Coordinates verification site visits for compliance options.	New or revised NRCC, NRCI, and NRCV forms for compliance options.	No significant impact.
Energy Consultant	• Identifies compliance credits • Prepares NRCC documentation.	Evaluates compliance alternatives.	Models compliance option.	N/A
Architect	Would identify compliance credits to pursue and develop specifications accordingly.	No significant impact.	No significant impact.	No significant impact.
Building Inspector	Reviews NRCIs and NRCVs to confirm compliance.	Would confirm results are submitted for new compliance options claimed.	New or revised NR forms.	No significant impact.
HERS Rater/ ATT	• Coordinates with general contractor to schedule required field verification or diagnostic testing. • Conducts duct leakage testing, dwelling unit ventilation verification, and other selected HERS measures.	• Would coordinate with general contractor for additional visits. • Would complete field verification or diagnostic testing for selected compliance options.	• Compliance and verification process would need to be updated to include ATTs. • Compliance documents would need to be updated. • Updates to ATT provider registry and database with correct fields.	Training ATTs on verification procedures.

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 identify and address issues associated with 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 the Statewide CASE Team asks for feedback during these meetings on:

1. Proposed code changes
2. Draft code language
3. Draft assumptions and results for analyses
4. Data to support assumptions
5. Compliance and enforcement
6. Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for multifamily restructuring via webinar described in Table 75. 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 section of this report.

Table 75: Utility-Sponsored Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Multifamily QII Utility-Sponsored Stakeholder Meeting	Tuesday, February 14, 2023	https://title24stakeholders.com/event/nonresidential-multifamily-and-single family-envelope-utility-sponsored-stakeholder-meeting/
First Round of Multifamily Restructuring for HVAC	Tuesday, February 21, 2023	https://title24stakeholders.com/event/multifamily-restructuring-envelope-hvac-2-compartmentalization-

and Envelope Utility-Sponsored Stakeholder Meeting		and-balanced-ventilation-utility-sponsored-stakeholder-meeting/
Second Round of Multifamily Verification Clean Up Utility-Sponsored Stakeholder Meeting	Monday, May 22, 2023	https://title24stakeholders.com/event/nonresidential-envelope-existing-buildings-and-multifamily-restructuring-utility-sponsored-stakeholder-meeting/

The first round of utility-sponsored stakeholder meetings occurred in February 2023 and 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 in May 2023 and provided updated details on proposed code changes. The second round of meetings introduced early results of energy, cost-effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

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 recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

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 76. The Statewide CASE Team engaged with several types of stakeholders while developing the proposal, including architects, designers, contractors, manufacturers, HERS Raters, ATTs, and compliance consultants. The Statewide CASE Team communicated with others and the list below is not exhaustive.

Table 76: Engaged Stakeholders

Organization/Individual Name	Market Role/ Stakeholder Category

AIRCERT Energy Ratings / Will Simco	HERS Raters or ATTs
Alcal Specialty Contracting / Scott Stanley	Contractor
Anderson Systems / Olaf Villadsen	HERS Raters or ATTs
Birch Point Consulting / Thomas Culp	Energy and Environmental Consultants
CalCERTS / David Choo	HERS Raters or ATTs
David Baker Architects / Katie Ackerly	Architect
David Baker Architects / Billy Forest	Architect
Gabel Energy / Gina Rodda	Energy and Environmental Consultants
Guttman & Blaevoet Consulting Engineers / Ted Tiffany	Designer
Harris & Sloan / Shawn Mayer	Designer
Harris & Sloan / Abe Cubano	Designer
NEMI Inc. (National Energy Management Institute) / Chris Ruch	Compliance Consultant
Nibbi Brothers / Kit Chang	Contractor
Raglen System Balance / Kevin Andrade	HERS Raters or ATTs
Selby Energy / Brian Selby	HERS Raters or ATTs

Appendix G: Energy Cost Savings in Nominal Dollars

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 PV$ and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2026 PV$. Costs and cost-effectiveness using and 2026 PV$ are presented in Sections 3.4, 4.4, 5.4, 6.4, 7.4, 8.4, and 9.4 of this report. This appendix presents energy cost savings in nominal dollars.

Energy cost savings were not evaluated for the VT, verification, and additions and alterations clean up measures.

Table 77: Nominal Lifecycle Energy Cost Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction — Slab Perimeter Insulation — Loaded Corridor, Modified

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
16	-$40	$1,023	$983

Table 78: Nominal Lifecycle Energy Cost Savings Over 30-Year Period of Analysis — Per Dwelling Unit — Alterations — Skylight Properties SHGC — High-Rise Mixed Use

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
1	-$0.24	$17.14	$16.90
3	-$1.21	$20.85	$19.64
5	$0.73	$26.00	$26.72
16	-$7.04	$22.28	$15.24

Table 79: Nominal Lifecycle Energy Cost Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction — Multifamily QII — Mid-Rise Mixed Use

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
1	$82.52	$50.49	$133.01
2	$184.15	$0.00	$184.15
3	$178.07	$0.00	$178.07
4	$338.79	$0.00	$338.79
5	$155.49	$0.00	$155.49
6	$99.69	$0.00	$99.69
7	-	-	-
8	$178.82	$0.00	$178.82

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
9	$105.79	$0.00	$105.79
10	$132.74	$0.00	$132.74
11	$205.58	$0.00	$205.58
12	$268.71	$0.00	$268.71
13	$200.98	$0.00	$200.98
14	$243.48	$0.00	$243.48
15	$222.33	$0.00	$222.33
16	$208.94	$280.72	$489.66

Table 80: Nominal Lifecycle Energy Cost Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction — Multifamily QII — High-Rise Mixed Use

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
1	$73.22	$32.28	$105.50
2	$112.25	$0.00	$112.25
3	$102.31	$0.00	$102.31
4	$180.39	$0.00	$180.39
5	$96.98	$0.00	$96.98
6	$48.53	$0.00	$48.53
7	-	-	-
8	$83.97	$0.00	$83.97
9	$66.98	$0.00	$66.98
10	$76.69	$0.00	$76.69
11	$145.71	$0.00	$145.71
12	$152.99	$0.00	$152.99
13	$132.15	$0.00	$132.15
14	$160.18	$0.00	$160.18
15	$126.70	$0.00	$126.70
16	$110.65	$181.36	$292.01

Table 81: Nominal Lifecycle Energy Cost Savings Over 30-Year Period of Analysis — Per Dwelling Unit — New Construction — Central Ventilation Shaft Sealing — Low-Rise Loaded Corridor

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
1	$852.90	$0.00	$852.90
2	$644.16	$0.00	$644.16

Climate Zone	30-Year Lifecycle Electricity Cost Savings (Nominal $)	30-Year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Lifecycle Energy Cost Savings (Nominal $)
3	$641.20	$0.00	$641.20
4	$650.37	$0.00	$650.37
5	$609.63	$0.00	$609.63
6	$182.48	$0.00	$182.48
7	$233.78	$0.00	$233.78
8	$500.58	$0.00	$500.58
9	$525.27	$0.00	$525.27
10	$598.37	$0.00	$598.37
11	$936.07	$0.00	$936.07
12	$725.61	$0.00	$725.61
13	$846.11	$0.00	$846.11
14	$797.49	$0.00	$797.49
15	$760.23	$0.00	$760.23
16	$198.77	$1,413.08	$1,611.86