Multifamily High Performance Thermal Envelope

2022-MF-ENV-D | Multifamily Envelope | May 2020 DRAFT CASE REPORT

Prepared by TRC

Please submit comments to info@title24stakeholders.com by June 19, 2020.

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Executive Summary

This is a draft report. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented within. When possible, provide supporting data and justifications in addition to comments. Suggested revisions will be considered when refining proposals and analyses. The Final CASE Report will be submitted to the California Energy Commission in August 2020.

Email comments and suggestions to info@title24stakeholders.com by **June 19, 2020**. Comments will not be released for public review or will be anonymized if shared.

Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Efficiency Building Standards (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 and 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 Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2022 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/2022-building-energy-efficiency.

The overall goal of this CASE Report is to present a code change proposal for high performance thermal envelopes in multifamily buildings. The report contains pertinent information supporting the code change.

Measure Description

Background Information

Quality insulation installation (QII) verification has been a part of the Title 24, Part 6 code for more than a decade, and became a prescriptive requirement under the 2019 code cycle for single-family and low-rise multifamily buildings. With the 2022 Title 24, Part 6 update, the Statewide CASE Team proposes to unify low-rise and high-rise residential QII requirements for multifamily buildings to streamline code compliance and create equity across multifamily buildings of all sizes.

Proposed Code Change

The Statewide CASE team proposes an extension of QII requirements to all multifamily buildings up to 40,000 ft^2 of total building conditioned floor area (CFA) and the introduction of prescriptive requirement for snapshot-QII for buildings equal to or greater than 40,000 ft^2 of CFA. Snapshot-QII requires that a HERS Rater verify the insulation and air sealing quality of the building at a snapshot in time as being representative of the building's overall insulation quality. Snapshot-QII requires that HERS Raters/Acceptance Testing Technicians (ATTs) initiate the verification scheduling, verify enough of the thermal envelope to fulfill area verification minimums, and follow a verification failure mitigation process if parts of the envelope fail to comply with the quality installation requirements.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and specifies which sections of Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents would be modified as a result of the proposed change(s).

Table 1: Scope of Code Change Proposal

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Would Compliance Software Be Modified	Modified Compliance Document(s)
QII	Prescriptive	Section 150.1(c)1E TABLE 150.1-B Section 140.3 TABLE 140.3-C	RA 3.5.1 and new 3.5.x	Yes	CEC-CF1R-NCB-01-E CEC-CF2R-ENV-21-HERS-QII-FramingStage CEC-CF3R-ENV-21-HERS-QII-FramingStage CEC-CF2R-ENV-22-HERS-QII-InsulationStage

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Would Compliance Software Be Modified	Modified Compliance Document(s)
					CEC-CF3R-ENV-22-HERS-QII-InsulationStage NRCC-ENV-01-E NRCI-ENV-01-E-Envelope NRCV-ENV-01-Envelope

Market Analysis and Regulatory Assessment

Overall technical feasibility is not a barrier for the proposed QII code requirement. Extending QII verification to high-rise multifamily buildings presents challenges because the third-party verification process for non-mechanical equipment is not used in high-rise projects. Having HERS Raters perform high-rise building verification with a new QII approach is also a departure from current practice.

QII became a prescriptive requirement for single-family and low-rise multifamily buildings under the 2019 code cycle. 2019 Title 24, Part 11 CALGreen includes QII along with energy design ratings as Tier 1 and Tier 2 prerequisites for its performance approach for new construction buildings. Many local ordinances require QII as part of their adoption of CALGreen Tier 1 requirements.

California is the only jurisdiction requiring QII in low-rise multifamily buildings. A number of market initiatives and industry standards have similar intent and scope. These include Residential Energy Services Network's (RESNET) Multifamily Rating (RESNET 2020), ENERGY STAR Multifamily New Construction Certification (Energy Star 2020) , and New York State Energy Research & Development Authority (NYSERDA) Multifamily Performance Program (MPP) (NYSERDA 2020).

Cost Effectiveness

The proposed code change was found to be cost effective for all climate zones where it would be required. The benefit-to-cost (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. The B/C ratio for this measure varies by prototype and climate zone, as show in Table 2. See Section 5 for the methodology, assumptions, and results of the cost-effectiveness analysis. The Statewide CASE team

does not anticipate using the updated final TDV to impact the benefit-to-cost ratio significantly or alter the code change recommendation.

Table 2: Cost Effectiveness Summary

Measure Name	B/C Ratio Range	Cost Effective in Climate Zones
Full-QII	1.1 - 2.9	1-6,8-16
Snapshot-QII	2.9 - 6.7	1-6,8-16

Statewide Energy Impacts: Energy, Water, and Greenhouse Gas (GHG) Emissions Impacts

Table 3 presents the estimated energy and demand impacts of the proposed code change that would be realized statewide during the first 12 months that the 2022 Title 24, Part 6 requirements are in effect. First-year statewide energy impacts are represented by the following metrics: electricity savings in gigawatt-hours per year (GWh/yr), peak electrical demand reduction in megawatts (MW), natural gas savings in million therms per year (million therms/yr), and time dependent valuation (TDV) energy savings in kilo British thermal units per year (TDV kBtu/yr). See Section 6 for more details on the first-year statewide impacts calculated by the Statewide CASE Team. Section 4 contains details on the per-unit energy savings calculated by the Statewide CASE Team.

Table 3: First-Year Statewide Energy and Impacts

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (million therms/yr)	TDV Energy Savings (TDV kBtu/yr)
New Construction	0.15	0.07	0.02	10.12
Additions and Alterations	N/A	N/A	N/A	N/A

Table 4 presents the estimated avoided GHG emissions associated with the proposed code change for the first year in which the standards are in effect. Avoided GHG emissions are measured in metric tonnes of carbon dioxide equivalent (Metric Tonnes CO2e). Assumptions used in developing the GHG savings are provided in Section 6 and Appendix C of this report. The monetary value of avoided GHG emissions is included in TDV cost factors and thus in the cost-effectiveness analysis.

Table 4: First-Year Statewide GHG Emissions Impacts

Measure	Avoided GHG Emissions (Metric Tonnes CO2e/yr)	Monetary Value of Avoided GHG Emissions ($2023)
QII	125	$3,743

Water and Water Quality Impacts

The proposed measure is not expected to have any impacts on water use or water quality, excluding impacts that occur at power plants.

Compliance and Enforcement

Overview of Compliance Process

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors. The compliance process is described in Section 2.5. Impacts that the proposed measure would have on market actors is described in Section 3.3 and Appendix E. The key issues related to compliance and enforcement are summarized below:

- Existing QII verification requirements are for low-rise multifamily buildings only, and contractors working on high-rise multifamily projects may not possess extensive experience and familiarity working with HERS/ATT through verification coordination and process.
- The general contractor and HERS Rater/Acceptance Test Technician (ATT) would coordinate verification visit(s) such that a minimum coverage of wall area is visually accessible at the right construction stages. It is important for the general contractor to communicate, establish expectations, and orchestrate the coordination between framing, insulation, and drywall installers, and other trades whose work depend on adequate access to wall and ceiling spaces.
- The proposed change describes an approach that covers all visually accessible wall areas at appropriate construction points. This is to eliminate the potential loophole of installers arbitrarily picking and choosing a portion of the installation for visual inspections.

Field Verification

The QII measure includes a new snapshot QII field verification for buildings equal or greater than 40,000 ft^2 of CFA. Snapshot QII includes visual inspections of air barrier and insulation verification at various stages of the construction process for all visually accessible thermal envelope surface areas during the visits. This protocol includes a minimum exterior wall area threshold of 20 percent of total wall area for both air-sealing verification, and insulation installation verification. This approach makes QII feasible for large buildings with phased construction. For multifamily buildings up to 40,000 ft^2, the existing full QII verification protocol for low-rise residential buildings would apply. Buildings over 40,000 ft^2 that use metal building construction methods with curtain or spandrel wall assemblies are exempt from the requirement.

1. Introduction

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The overall goal of this CASE Report is to present a code change proposal for QII verification of multifamily buildings. The report contains pertinent information supporting the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with a number of industry stakeholders including manufacturers, builders, utility incentive program managers, Title 24, Part 6 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during a public stakeholder workshop that the

Statewide CASE Team held on August 22, 2019 (S. C. Team 2019) and March 25, 2020 (S. C. Team 2020). The following is a brief summary of the contents of this report:

- Section 2 – 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 3 – In addition to the Market Analysis section, this section includes a review of the current market structure. Section 3.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 4 – Energy Savings presents the per-unit energy, demand reduction, and energy cost 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 energy cost savings.
- Section 5 – This section 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 6 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2022 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 by the State of California. Statewide water consumption impacts are also reported in this section.
- Section 7 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, Compliance Manual, and compliance documents.
- Section 8 – Bibliography presents the resources that the Statewide CASE Team used when developing this report.
- Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.

- Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.
- Appendix C: Environmental Impacts Methodology presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.
- Appendix D: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).
- Appendix E: Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.
- Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.
- Appendix G: Nominal Savings Tables presents the energy cost savings in nominal dollars by building type and climate zone.

2. Measure Description

2.1 Measure Overview

This report proposes updates to QII verification of multifamily buildings. The measure primarily aligns low-rise and high-rise multifamily building QII requirements and secondarily increases energy efficiency level overall.

This measure extends the prescriptive requirements of QII to include high-rise multifamily buildings. QII is currently a prescriptive requirement for multifamily buildings with three or fewer habitable stories in all climate zones except Climate Zone 7. Under the proposed code change, buildings with less than 40,000 ft^2 of conditioned floor area would follow the current QII protocol. Buildings equal to or greater than 40,000 ft^2 would use a new protocol that is more appropriate and cost effective for large buildings that are built and insulated in stages.

The new protocol would allow for a randomized field verification of a portion of thermal envelope's insulation installation quality at a specific snapshot in time and would leverage the verification results as representative of the overall quality. This inspection would occur at approximately 30 percent construction completion stage when portions of the building would have both insulation conditions: (1) framed and sealed but with no insulation, (2) insulated but exposed and unfinished. The snapshot protocol includes a minimum of 20 percent total wall area threshold at each complete stage to be covered during field verification(s).

The proposed protocol includes inspecting for air sealing and insulation installation quality in walls, ceilings/attics, and floors over unconditioned spaces. Curtain wall and spandrel wall construction types common in metal buildings are excluded from the inspection protocol and QII requirements because the high variability of insulating methods and materials, panel-connections, and air-sealing requirements inherent across curtain wall products makes a consistent verification process prohibitively difficult to develop and enforce objectively.

In the performance approach, the proposed measure uses the same three derating mechanisms as in the 2019 standards for buildings that do not fulfill the prescriptive standard, and a 50 percent partial credit-back formula for each derating mechanism reflective of the partial nature of the proposed snapshot QII protocol. Larger buildings could opt to take extra performance credit for full-inspection QII, and smaller buildings could use the performance approach to trade off against snapshot QII in lieu of the prescriptively mandated full-inspection. The measure applies to new construction buildings and maintains the same trigger condition for additions and alteration at 700 ft^2. The proposed code change needs compliance software updates to account for appropriate baseline and proposed/improved conditions.

2.2 Measure History

Title 24, Part 6 has included QII HERS verification for more than a decade. Based on data from the HERS registry provided by CalCERTS, thirteen percent of registered multifamily projects took the QII performance credit in 2015-2016. For projects constructed from 2014 through 2019 the number increased to 45 percent for multifamily projects. 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 but climate zone 7. These results were based on lifecycle cost analyses derived from a one in four sampling rate and using an eight-unit garden style multifamily prototype. For the 2022 code cycle, the Statewide CASE Team is proposing QII to apply to all multifamily buildings.

2.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

The Energy Commission is considering consolidation of low- and high-rise multifamily requirements under a new multifamily section(s) in 2022 Title 24, Part 6. Restructuring the standards for multifamily building may also result in revisions to Reference Appendices, ACM Reference Manuals, compliance manuals, and compliance documents. Location and section numbering of the 2022 standards and supporting documents for multifamily buildings depend on the Energy Commission's approach to and acceptance of a unified multifamily section(s). For clarity, the changes proposed in this CASE Report are demonstrated in terms of the 2019 structure and language.

2.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6 as shown below. See Section 7 of this report for marked-up code language.

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE
APPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS

Section 150.1(c)1E

The proposed code change would add a conditioned floor area (CFA) threshold such that buildings at or below 40,000 ft^2 would adhere to current QII requirements and buildings above the threshold would use Snapshot QII.

SECTION 140.3 – PRESCRIPTIVE REQUIREMENTS FOR BUILDING ENVELOPES

Section 150.1(c)1E

TABLE 140.3-C – PRESCRIPTIVE ENVELOPE CRITERIA FOR HIGH-RISE RESIDENTIAL BUILDINGS AND GUEST ROOMS OF HOTEL/MOTEL BUILDINGS

The proposed code change would add a QII requirement across the prescriptive table and add a CFA threshold to delineate the full QII requirement for buildings at or under the 40,000 CFA threshold and snapshot QII for buildings over the CFA threshold.

2.3.2 Summary of Changes to the Reference Appendices

This proposal would modify the sections of the Reference Appendices identified below. See Section 7.3 of this report for the detailed proposed revisions to the text of the reference appendices.

RESIDENTIAL APPENDICES

RA3 RESIDENTIAL FIELD VERIFICAITON AND DIAGNOSTIC TEST PROTOCOLS

Section 3.5 Quality Insulation Installation Procedures

RA3.5.1 Purpose and Scope

The proposed language would add a new Note to describe the 40,000 CFA threshold below which full QII is required, and at and above which Snapshot QII is allowed.

RA3.5.x Snapshot QII Procedures for Select Multifamily Buildings

The proposed code change would add language to describe the Snapshot sampling approach that is different from full QII sampling.

2.3.3 Summary of Changes to the Residential ACM Reference Manual

This proposal would modify the following sections of the Residential ACM Reference Manual as shown below.

RESIDENTIAL ACM REFERENCE MANUAL

Section 2.2.5 Quality Insulation Installation (QII)

The proposed code change would update the insulation R-value derate values for each QII “Component” (i.e. insulation location group) and add a column for “Credit-back” derate values under Residential ACM Reference Manual “Table 3: Modeling Rules for Unverified Insulation Installation Quality”.

2.3.4 Summary of Changes to the Residential Compliance Manual

The proposed code change would modify the following section of the Residential Compliance Manual:

- RA3.5
  3.5.8 Quality Insulation Installation (QII)

The proposed code change would update text descriptions for QII Snapshot requirement and protocols coverage.

See Section 7.5 of this report for the detailed proposed revisions to the text of the compliance manuals.

2.3.5 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised documents are presented in Section 7.6.

- CEC-CF1R-NCB-01-E
- CEC-CF2R-ENV-21-HERS-QII-FramingStage
- CEC-CF3R-ENV-21-HERS-QII-FramingStage
- CEC-CF2R-ENV-22- HERS-QII- InsulationStage
- CEC-CF3R-ENV-22-HERS-QII- InsulationStage
- NRCC-ENV-01-E
- NRCI-ENV-01-E-Envelope
- NRCV-ENV-01-Envelope

The code change would update multifamily building-specific QII compliance documents that reflect changes in the inspection protocol and documentation requirements for the Snapshot QII protocol.

2.4 Regulatory Context

2.4.1 Existing Requirements in the California Energy Code

The current high-rise and low-rise prescriptive requirements for QII are shown in Table 5.

Table 5: 2019 Prescriptive QII Requirements – High-Rise vs. Low-Rise buildings

	High-rise Residential 4+ habitable stories	**Low-rise Residential 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

2.4.2 Relationship to Requirements in Other Parts of the California Building Code

2019 Title 24, Part 11 CALGreen includes QII along with energy design ratings as Tier 1 and Tier 2 prerequisites for its performance approach for newly constructed buildings.

2.4.3 Relationship to Local, State, or Federal Laws

Many local ordinances require QII as part of their adoption of CALGreen Tier 1 requirements. There are no separate, relevant state, or federal laws for the proposed QII measure.

2.4.4 Relationship to Industry Standards

California is the only jurisdiction requiring QII in low-rise multifamily buildings. 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 1 of 7 similar units. For multifamily homes, 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 (TBC) which is designed as a verification procedure similar in scope and method to California's QII. The TBC is a program requirement for all buildings of all heights and sizes. The TBC allows for dwelling unit sampling protocols as set forth by RESNET, and therefore they may be subject to change with RESNET's proposed changes. The TBC allows for considerable subjective discretion by the verifier for dealing with un-inspectable areas (such as behind bathtubs) and collaborative in-person mitigation for field-encountered installation quality failures.

The New York State Energy Research & Development Authority (NYSERDA) implements the Multifamily Performance Program (MPP) (NYSERDA 2020). MPP includes a program implemented verification process similar to California's QII in scope and intention. MPP's insulation verification process uses a snapshot 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 snapshot in time. MPP's inspection, administered by the program implementer directly, allows for considerable subjective discretion by the inspector, no minimal inspected area requirements, and in-person field mitigation of quality lapses.

2018 International Energy Conservation Code (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 contain less details, it shares the same principle as California's QII requirement.

2.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and to mitigate or reduce negative impacts on market actors who are involved in the process. This section describes how to comply with the proposed code change, as well as the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

- **Design Phase:** The design team, including the developer and architect, specifies wall construction type and provide necessary information to populate the Certificate of Compliance (CF1R/NRCC) documents. Pertinent details include frame type, dimensions, cavity and continuous insulation types and R-values, and the overall assembly U-factor.
- **Permit Application Phase:** A design professional completes and submits the Certificate of Compliance (CF1R/NRCC) documents. Product specifications and schedules for framing and insulation components are also submitted as part of the permitting package.
- **Construction Phase:** The general contractor and HERS Rater/Acceptance Test Technician (ATT) would coordinate verification visit(s) such that a minimum coverage of wall area is visually accessible at the right construction stages (at rough-in and again after installation but before drywalls). As such it is important for the general contractor to communicate, establish expectations, and orchestrate the coordination between framing, insulation, and drywall installers, as well as other trades whose work depend on adequate access to wall and ceiling spaces.
- **Inspection Phase:** The general contractor would ensure the insulation installer completes and sign the Certificate of Installation (CF2R/NRCI) documents before or at the verification visit(s). The HERS Raters/ATT would perform verification and take notes of deficiencies and correction notes as applicable. The HERS Raters/ATT would take on the responsibility to populate, sign, and submit the Certificate of Verification (CF3R/NRCV) forms to the registry for building compliance purposes.

Coordination between the trades is needed to facilitate successful field verifications. The construction industry has built up familiarity and understanding of the scope, coverage, and process in current code where QII is a performance credit. Since existing

requirements are for low-rise multifamily buildings only, contractors working on high-rise multifamily projects would not possess the experience and knowledge base unless they participated in LEED for Homes/Green Point Rated and similar voluntary programs, or have also worked with low-rise Title 24, Part 6 projects that have taken the performance credit. As a result, trades would have a moderate learning curve for installing to the quality requirements of and managing coordination with Snapshot QII verification for larger multifamily buildings. The proposed measure depends on and provides reassurance on installation quality, and installers and contractors may benefit from training that disseminate best practices and techniques for efficient installation and verification process. Part of the proposed measure's effectiveness in the field hinges on having compliance enhancement trainings for HERS Raters/ATTs in the near term.

The Statewide CASE Team considered the challenge of installers arbitrarily picking and choosing portions of the installation for visual inspections. The proposed change describes that HERS Rater/ATT should cover all visually accessible wall areas at appropriate construction points to eliminate the potential loophole or gaming. This is as opposed to using a sampling method between dwelling units employed by many other HERS measures.

3. Market Analysis

3.1 Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Team then considered how the proposed standard may impact the market in general as well as individual market actors. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure and identified estimates of market size and measure applicability through research and outreach with stakeholders, including utility program staff, Energy Commission 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 they held on August 22, 2019 (S. C. Team 2019) and March 25, 2020 (S. C. Team 2020).

Various market actors make energy efficiency decisions for multifamily buildings throughout the construction process—from design concept to construction. The general roles of market actors in construction process shown in Figure 1:

- Developer 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).
- Energy consultants document Title 24, Part 6 requirements and conduct energy modeling for the performance approach.
- Building inspectors, with specialized support from HERS Raters (for residential projects), and ATTs (for nonresidential projects) conduct Title 24, Part 6 compliance verification.

Within the multifamily sector, there is high variability in the structure, level of coordination, and formalization of the design process. Generally, larger buildings follow a more formalized process and coordinated design team, while smaller buildings may be designed under a more fluid process and less coordinated team.

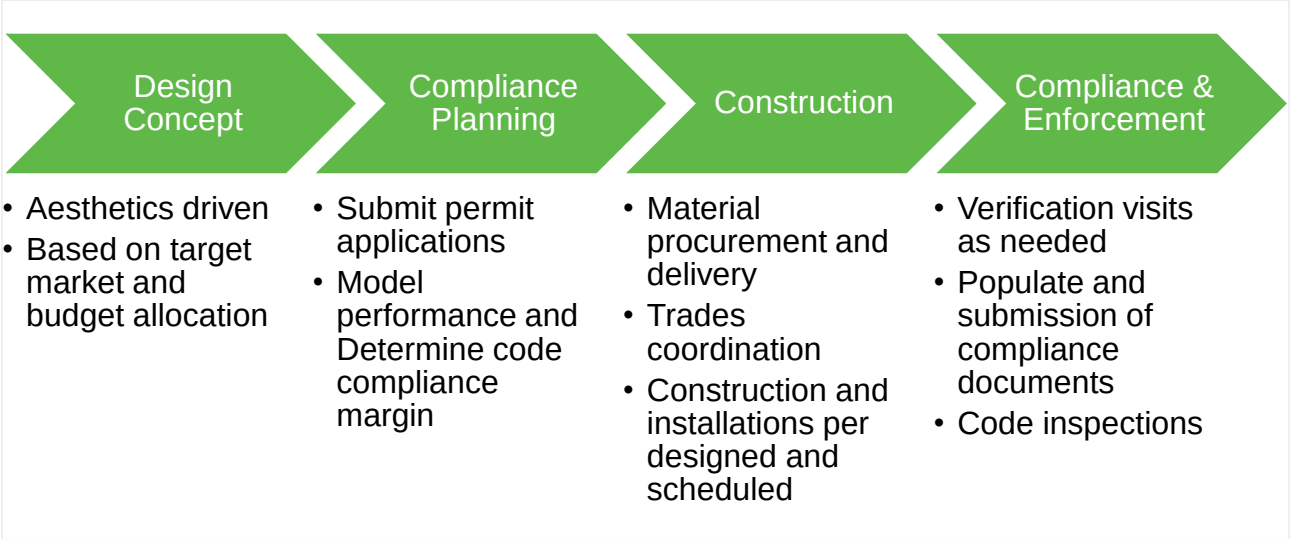

Figure 1: Multifamily Construction Process

The energy consultant often decides in consultation with the rest of the design team whether to include QII to improve compliance margin using the performance approach, or as required if using the prescriptive approach (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: an air-seal stage after framing when stud bays are exposed, and an 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 cavity stud bays 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 manufacturer's instructions, without compressions, gaps, or voids, filling the cavity's volume in its entirety.

The 2019 residential standards 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 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, in order to capture the entirety of the envelope. This is particularly likely for larger buildings and buildings with a more complicated envelope.

Due to the added costs of multiple inspections and trade-timing coordination, the Statewide CASE Team anticipates that larger projects are more likely to choose to avoid full QII verification using the performance approach and make up the energy

difference with other measures. 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.

3.2 Technical Feasibility, Market Availability, and Current Practices

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. However, extending QII verification to high-rise multifamily buildings presents challenges because the third-party verification process for non-mechanical equipment is not used in high-rise projects. Having HERS Raters perform high-rise building verification with a new QII approach is also a departure from current practice.

The energy savings from the proposed QII code change 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 16 SMEs. The SMEs represent views and experience from market actors including manufacturers, insulation installers, designers, energy consultants, HERS Raters, and voluntary efficiency program implementers. Details on the stakeholder engagement activities are in Appendix F.

In most cases, the proposed code change leverages existing requirements and applies them across all multifamily buildings, rather than a subset based on the number of habitable stories (three or fewer for the current residential code and four or more for nonresidential code). The dynamics of these challenges and potential solutions are described below.

3.2.1 Technical Feasibility

The Statewide CASE Team proposes to extend QII verification to high-rise multifamily buildings, which had in previous codes applied to low-rise buildings either prescriptively

or for performance credit. There are two critical challenges in applying QII to all multifamily buildings:

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

The following section explains those challenges in more detail and describes the Statewide CASE Team's approach, research findings, and rationale for this proposal relative to those challenges.

3.2.1.1 Verification for Larger Buildings

SMEs described challenges in inspecting larger multifamily buildings. Experts varied in their sense of what constitutes a large multifamily building, but it is generally in the range of 40 units or greater. 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 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.

The current QII verification protocol relies on two inspection points, each intended to visually verify 100 percent of the building's insulated thermal envelope (walls, attic/roof, and floors over unconditioned space) in a single visit. One inspection point is for air sealing of the envelope with all cavities un-insulated 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. 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 explored options for inspection protocols that could capture the intention of QII for these larger buildings while reducing the costs and challenges. Such options necessarily rely on inspecting only a portion of the building's total envelope. Subject matter experts emphasized that randomization was necessary to

prevent cherry-picking of the verification—e.g. the inspected section is known to the builder ahead of time and can be installed to a higher quality standard than unverified portions. The Team reviewed the following three options and determined that the Snapshot -QII option was best.

1. **Snapshot QII:** The verifier goes to the site at a time of their choosing, within a defined window of the construction schedule of 20 percent to 40 percent drywall (or other interior finishes) installed. At this point portions of the envelope are typically accessible for air-sealing inspection, cavity insulation installation inspection, and continuous insulation layer inspection. The verifier inspects the entirety of the envelope in whatever stage it exists at that snapshot in time. The air seal and insulation installation quality are then considered representative of the sections that could not be observed/were not yet complete. Minimum percent-of-total-area requirements are in place for each inspection point to ensure the verifier views enough of the envelope to fairly deem it as representative of the building as a whole. This inspection concept is inspired by the verification procedure used by New York State Energy Research and Development Authority's Multifamily Performance Program, a voluntary above-code incentive program.
2. **In-building unit sampling:** The verifier follows a unit-by-unit sampling protocol. One-in-seven is the industry standard in use by RESNET HERS and ENERGY STAR® insulation grading protocols. It is also used by California's HERS system broadly for most measures, and for building-by-building sampling for QII. Units are selected at random and inspected in their entirety at each verification point (air seal and insulation installation). Protocols mandate that sample group selection is required to account for cross-representation of apartment types (such as corner units, top and bottom floor units, and by bedroom count). If a unit fails its inspection, the failure must be mitigated then re-inspected, and a different apartment of the same sample unit type must be added to the inspection list.
3. **Percent of total envelope:** The verifier conducts inspections at random times until they have verified minimal thresholds of the percent of total envelope for each inspection stage. Industry standard is 20 percent of the total envelope, which is still under development by RESNET HERS for a new insulation grading method to start in 2021. Once the threshold is reached, the verifier stops the inspection, even if other portions of the building could also be inspected.

In-unit sampling was rejected for three reasons:

- Experts expressed that unit scheduling allows cherry picking of installation quality of the inspected units,
- Early installation of cabinets, shower stalls, or similar would often interfere with the complete percent inspection of a given unit, and

- The failure mitigation process too often cascades, not because the next selected unit failed, but because it was not at the right stage to be inspected.

These same reasons are why RESNET is creating a percent of total envelope process. The Statewide CASE Team rejected the percent of total envelope method because it has not yet been tested or vetted for functionality. Additionally, the fact that inspection stops once 20 percent is reached seems to still allow for cherry picking by installers to present best-in-class sections first. Of the considered options, Snapshot QII inspection reduces cherry picking, minimizes site visits, and minimizes scheduling coordination and access challenges.

Metric and Threshold for Full QII and Snapshot QII Requirements

To determine a suitable Snapshot QII approach, the Statewide CASE Team considered multiple metrics and specific criteria to serve as the differentiating threshold between buildings that use full-QII and those that use Snapshot-QII as their verification protocol. The metrics include conditioned floor area (CFA), dwelling unit floor area, number of dwelling units, number of stories, thermal envelope surface area, as well as multi-criteria combinations. The Statewide CASE Team's decision to use CFA 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.

The Statewide CASE Team formulated the CFA metric 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. The Statewide CASE Team determined that 40,000 ft^2 was an appropriate dividing line between the two verification options.

Surface Area Minimum Backstops and Verification Timing for Snapshot-QII

The proposed Snapshot-protocol requires a minimum threshold of 20 percent of total wall surface area for each QII verification point: air sealing and insulation installation. Additionally, the proposed protocol recommends that the verification be timed between when 20 percent to 40 percent of the project's drywall has been installed. The Statewide CASE Team determined these two metrics and criteria concurrently, based on SME input, as being the mostly likely to allow the verifier to view the whole building in a single day, and observe meaningfully representative sample sizes of wall in that day.

The Statewide CASE Team decided against minimum area thresholds for floor-above-unconditioned space assemblies and attic or roof assemblies. This was because SMEs agreed that wall insulation and wall cavity sealing are the most likely locations to be installed incorrectly, and because adding a second threshold introduces an

unnecessary second layer of complexity to the protocol and process without proportional benefits.

3.2.1.2 Mitigation Options

The proposed snapshot-QII method retains some challenges regarding mitigation after a verification reveals improperly air-sealed or insulated wall segments. In those cases, the builder can correct the installation defect in the inspected wall section but does not have the opportunity to show that the un-inspected sections of the walls were not also installed below the appropriate quality standard, as some portions have already been sealed off with internal finishing surfaces.

SMEs agreed that it was important for the mitigation option to be both more difficult to conduct and a more rigorous standard. However, the mitigation option cannot be so cumbersome as to make an initial inspection failure mitigation prohibitive. There are no solutions that fulfill these divergent criteria perfectly. The Statewide CASE Team proposes the following option as being the best available: as soon as a field failure is noted the verifier switches the inspection methods to mirror full-QII Standards for every portion of the thermal envelope that can still be inspected at both the air sealing, and insulation installation levels. The proposed process is as follows.

1) The specific instance of defective air-sealing or insulation must be repaired and re-inspected
2) The verifier takes records of the current state of assembly completion for each portion of the thermal envelope
3) The verifier inspects for air-sealing compliance at 100 percent inspection of all portions of the thermal envelope that remain inspectable or would be inspectable at any point throughout the duration of construction
4) The verifier inspects for insulation installation compliance at 100 percent inspection of all portions of the thermal envelope that remain inspectable or would be inspectable at any point throughout the duration of construction

This mitigation pathway does mean that completely concealed insulation installation defects would remain in the building, which is not ideal but essentially unavoidable without a drastic and cost-prohibitive mitigation rule. The Statewide CASE Team recommends a 50 percent credit back with a cavity insulation derated by 15 percent, the same treatment as successful Snapshot-QII, would apply if all remaining inspectable portions of the thermal envelope successfully passes the verification.

The Statewide CASE Team, at the suggestion of stakeholder feedback, considered the use of thermal imaging cameras as a closed-insulation confirmation tool in these cases. Such cameras, when operated properly, can show voids, gaps, compressions, and

evidence of air-sealing failures in closed-off insulation cavities. Ultimately, The Statewide CASE Team rejected their use for the following reasons:

- Proper operation of thermal imaging cameras takes training and experience, with wide variability in operating mechanics between different camera models.
- Setting up a shot that can be interpreted objectively requires defining acceptable image angle, distance to target, and temperature range captured. The temperature range captured ideally is varied based on ambient air temperatures.
- Interpreting a thermal image can be subjective in nature, with experts appropriately disagreeing with each other in certain cases as to what a thermal image is showing. The overall challenge is one of codifying thermal camera use and image interpretation in an objective, replicable manner.

The Statewide CASE Team determined that those challenges were too substantial and therefore did not elect to leverage thermal cameras as a confirmation tool as part of our proposed protocol.

3.2.2 Market Availability and Current Practices

The Energy Commission oversees the HERS Providers who train and certify HERS Raters. CalCERTS and ConSol Home Energy Efficiency Rating Services Inc. (CHEERS) are the two HERS Providers. CalCERTS (CalCERTS n.d.) reported having more than 600 active Raters providing 5,600 home ratings in 2018. ATT personnel currently performs compliance verification for lighting and mechanical systems in high-rise multifamily buildings but not for envelope related measures such as the proposed snapshot 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 take advantage of the QII performance credit for buildings. PG&E's above-code multifamily incentive program CMFNH (CMFNH n.d.) data shows 29 of 94 unique buildings—just over 30 percent of participating low-rise 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 Snapshot QII documentation from this larger quantity of buildings. Likewise, they are confident in their ability to develop and deliver HERS Rater trainings for the new protocol, and the availability of enough Raters to serve the expanded market base.

Additionally, this proposed code change would require building developers who previously did not interreact with HERS Raters or the HERS registries to start. Many of the mid-rise multifamily builders this would impact do however have experience with the California HERS process on projects of three stories or fewer, and therefore are unlikely to encounter challenges with hiring HERS raters for their mid-rise projects nor interacting with the registry. Builders that have no experience with the HERS system would face a learning curve to build relationships with HERS Raters, contracting practices, and HERS Registry interactions.

3.2.2.1 Current Practices and Performance Compliance Mechanisms

There is no clear consensus on the current quality of insulation installation in multifamily buildings. Some experts stated that the current low-rise building derate levels are too strict, and unverified insulation in larger multifamily buildings is of higher caliber than in small multifamily buildings or single-family homes, while others stated that the quality is likely similar. None of the contacted experts knew of research, data, or other sources to directly verify their presumptions. Similarly, the Statewide CASE Team did not find data or research to support multifamily specific derate factors.

The Residential ACM Reference Manual includes three locational-based derate mechanisms for unverified insulation installation quality:

1. A 30 percent derate of the cavity insulation for walls, attic roofs, flat or cathedral ceilings (non-attic), and in floors or overhangs over unconditioned space.
2. A variable derate of attic floor insulation using the formula 1 (0.96-0.00347xR). This equates to an 18 percent derate for R-38 attic floors.
3. Added heat flow between the conditioned zone and the attic zone.

These derate mechanisms result in a best estimate of the efficacy of typically installed insulation on the whole, and they are not meant to directly represent specific defects in the insulation installation. Buildings that take QII credit as a HERS measure are presumed to have perfectly installed insulation and are not subject to any of the derate mechanisms. Nonresidential code does not currently have any derate mechanisms or any other means to reflect presumed differences between verified and unverified insulation. Therefore, extending QII to multifamily high-rise buildings warrants introducing appropriate derate mechanisms into the nonresidential software.

The residential derate factors listed above were developed based on single-family norms. The Statewide CASE Team sought data and expert opinion to determine if

different derate mechanisms would be more appropriate for multifamily buildings. The Statewide CASE Team reviewed insulation grading tools used by RESNET (Institute 2020) and sought data and research findings to establish multifamily insulation quality norms. All experts with whom the Statewide CASE Team spoke agreed that typical insulation installation for multifamily buildings, without verification, leaves room for improvement, and it would be appropriate to derate its efficacy in the performance approach. Expert opinion was, however, mixed regarding the application of the current residential derate mechanisms to multifamily buildings generally, and mid-rise or high-rise buildings in particular.

The best available data continues to be the original residential code data, and the Statewide CASE Team's proposal extends the same derate factors currently used in residential software to all multifamily buildings.

It is also necessary to determine how to treat buildings that conduct the proposed snapshot QII verification. Due to its partial-inspection nature, it is both possible and likely that verified buildings have insulation quality defects in some uninspected locations. Those defects should be reflected in the ACM Reference Manual by only crediting back a portion of the unverified derate. As there is no empirical data to guide such a determination, the Statewide CASE Team believes the proposal of crediting back half of the derate factors across all three mechanisms is reasonable.

3.2.2.2 Special Scenarios for Snapshot QII

Adopting a Snapshot QII verification protocol for larger multifamily buildings warrants consideration of select aspects from full QII requirements would be hard to implement. These considerations are described in the rest of the section.

Insulated Headers

The current residential QII protocol requires the installation and verification of insulated headers on all external windows and doors. Subject matter experts conveyed frustration and dissatisfaction with this requirement, which was added with the 2019 Standards. The experts perceive the insulated header verification requirement as ancillary to the core purpose of QII, as it mandates additional insulation rather than verifying insulation quality. Insulated headers are uncommon in multifamily construction. Therefore, this proposal recommends eliminating the insulated header requirements for multifamily buildings that take the full-QII inspection and as a basis standard for the proposed snapshot QII.

External Insulation Inspection from the Ground

The full-QII protocol includes a visual inspection of external rigid insulation installation quality. For taller buildings safe access to inspect this insulation may not be possible. Experts confirmed that installation quality failures of rigid external insulation are rare,

and those that do exist would take the form of missing sections or wide gaps between panels, which would be visible from the ground. The Statewide CASE Team proposes Snapshot-QII protocols and full-QII protocols to explicitly allow for the inspection of exposed rigid insulation from the ground at a distance regardless of the building height.

Curtain Wall Construction Inspections

The Statewide CASE Team's interviews indicate that insulation installation practices in curtain wall, including spandrel, construction present multiple difficulties for the development of a consistent and objective verification protocol. In some cases, the insulation is factory-installed and shipped completely sealed. Cavities, panel connection points, and insulation materials are non-standardized. The timing and logistics of curtain wall assembly, connection and air sealing, insulation installation, and installation of interior finishes inconsistent, making it difficult to standardize air sealing and insulation installation quality verification protocols. The Statewide CASE Team proposes that curtain wall assemblies be exempt from all QII requirements, derating, and credit-back variations for both full- and snapshot-QII protocols.

3.3 Market Impacts and Economic Assessments

3.3.1 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 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 5).2 In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector.The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction (industrial sector).

Table 5: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll ($)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

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

The proposed change to QII measure would likely affect residential 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 building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 6 shows the residential building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Builders would be newly required to contract HERS Raters/ATT, to interact with the data registries, and to support coordination and logistics between Raters and general contractors and trades. Builders that follow an integrated design approach and help communicate across their contractors and trades would be best situated to comply with the standards with minimal impacts or interruptions.

QII exists to confirm that cavity air sealing and insulation installation methods are done to the manufacturer's installation guidelines. Therefore, this proposed code change does not directly increase the builder or their contractor's effort, time, or costs. However, it is known that in common market practice, insulation is installed to a lower quality. Therefore, this proposal could be construed as requiring a higher degree of care, effort, and quality control by builders on their trades including framers, insulators, drywall installers, plumbers, and cabinet installers. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.4 Economic Impacts.

Table 6: Size of the California Residential Building Industry by Subsector

Residential Building Subsector	Establishments	Employment	Annual Payroll ($)
New single family general contractors	10,968	55,592	$3,684,569,780
New multifamily general contractors	406	5,333	$490,673,677
New housing for-sale builders	180	2,719	$279,587,102
Residential Remodelers	11,122	52,133	$2,973,873,865
Residential poured foundation contractors	1,185	14,296	$742,859,062
Residential Structural Steel Contractors	215	3,216	$208,594,015
Residential Framing Contractors	657	23,690	$992,914,238
Residential Masonry Contractors	1,108	8,984	$440,322,016
Residential glass and glazing contractors	577	3,660	$202,699,594
Residential Roofing Contractors	2,208	16,814	$813,935,273
Residential Siding Contractors	208	1,894	$83,733,218
Other Residential Exterior Contractors	465	2,666	$160,334,249
Residential Electrical Contractors	6,095	37,933	$2,175,638,943
Residential plumbing and HVAC contractors	8,086	66,177	$3,778,328,951
Other Residential Equipment Contractors	263	1,331	$71,792,746
Residential Drywall Contractors	1,694	28,250	$1,369,125,850
Residential Painting Contractors	4,220	24,833	$1,044,837,513
Residential Flooring Contractors	1,734	9,198	$449,248,717
Residential tile and terrazzo contractors	1,569	10,771	$496,749,894
Residential Finish Carpentry Contractors	2,173	14,461	$725,338,325
Other Residential Finishing Contractors	533	3,855	$194,916,224
Residential Site Preparation Contractors	1,265	11,130	$725,842,052
All other residential trade contractors	2,356	21,280	$1,165,394,146

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

3.3.2 Impact on Building Designers and Energy Consultants

This proposal constitutes no impact on building designers. The Snapshot QII verification process is only to confirm that the building, as designed for, is air sealed and insulated as per the design specifications and manufacturer's guidelines.

Adjusting design practices to comply with changing building codes practices 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 in order to remain compliant with changes to design practices and building codes.

Energy consultants would need to advise their clients when QII is prescriptively required. Likewise, when using the performance approach, they help guide the builder on code compliance levels between the options of no QII, Snapshot QII, and full QII and help determine which level of QII to choose. The energy consultant often takes on a critical role of communicating with the builder, contracting trades, and HERS Raters regarding the inclusion of QII for compliance and supporting coordination and logistics for the verification itself. With this proposal, this role would expand to more multifamily buildings, and include new elements related to the Snapshot QII verification process.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 6: California Building Designer and Energy Consultant Sectors shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The code change proposals the Statewide CASE Team is proposing for the 2022 code cycle would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for Snapshot QII verification to affect firms that focus on multifamily construction.

There is not a North American Industry Classification System (NAICS)[1] code specific for energy consultants. Instead, businesses that focus on consulting related to building

[1] 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

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.[2] 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 6 provides an upper bound indication of the size of this sector in California.

Table 6: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (millions $)
Building Inspection Services[a]	824	3,145	$223.9

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

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

3.3.3 Impact on Occupational Safety and Health

The proposal does not impact occupational safety and health.

3.3.4 Impact on Building Owners and Occupants

The proposal does not impact building owners or occupants. All inspections are conducted before occupancy. Building owners and occupants should observe higher levels of thermal comfort and lower energy costs.

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

SMEs agree that QII is significantly easier to comply with using certain insulating materials over others. Spray foam, rigid continuous insulation layers, and blown-in-batt fiberglass or cellulose have higher QII compliance rates than rolled batts. Therefore, that demand for those materials may adjust accordingly.

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comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[2] 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.

3.3.6 Impact on Building Inspectors

Since HERS Raters/ATT already work as an extension of building departments, their expanded use into multifamily buildings four stories or greater has minimal impact on how building inspectors coordinate and approach aspect of inspection related to the thermal envelope for these buildings.

3.3.7 Impact on Statewide Employment

As described in Sections 3.3.1 through 3.3.6, the Statewide CASE Team anticipates a modest increase in the use of HERS Raters/ATT, thus increasing their employment numbers. In Section 3.4, the Statewide CASE Team estimated the proposed change in QII would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in QII would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.4 Economic Impacts

3.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate the proposal Snapshot QII measure would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 3.4 would lead to modest changes in employment of existing jobs.

3.4.2 Creation or Elimination of Businesses in California

The proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to which buildings are subject to QII 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 new businesses being created, nor existing businesses being eliminated due to the proposed code changes to Title 24, Part 6.

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[3] Therefore, the Statewide CASE Team does not anticipate that the proposal measure to 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.

3.4.4 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).[4] As Table 7 shows. between 2015 and 2019, NPDI as a percentage of corporate profits ranged from 26 to 35 percent, and the average was 31 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 7: 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
2015	609.245	1,740.349	35%
2016	455.980	1,739.838	26%
2017	509.276	1,813.552	28%
2018	618.247	1,843.713	34%
2019	580.849	1,826.971	32%
		5-Year Average	**31%**

Source: (Federal Reserve Economic Data 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 in any directly or indirectly affected sectors of California's economy.

[3] 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.

[4] 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.

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

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

3.4.5.1 Cost to the State

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

3.4.5.2 Cost to Local Governments

All revisions 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 2022 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 2.5 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.

3.4.6 Impacts on Specific Persons

The Statewide CASE Team does not expect the proposed code changes to have a measurable impact on the any specific groups including low-income households and communities, first-time home buyers, renters, seniors, families, or rural communities.

4. Energy Savings

4.1 Key Assumptions for Energy Savings Analysis

As of the Draft CASE Report's date of publication, the Energy Commission has not released the final 2022 TDV factors that are used to evaluate TDV energy savings and cost effectiveness. The energy and cost analysis presented in this report used the TDV factors that were released in the 2022 CBECC-Com and CBECC-Res research version that was released in December 2019. These TDV factors were consistent with the TDV factors that the Energy Commission presented during their public workshop on compliance metrics held October 17, 2019. (California Energy Commission 2019) The electricity TDV factors did not include the 15 percent retail adder and the natural gas TDV factors did not include the impact of methane leakage on the building site, updates that the Energy Commission presented during their workshop on March 27, 2020 (California Energy Commission 2020). Presentations from Bruce Wilcox and NORESCO during the March 27, 2020 workshop indicated that the 15 percent retail adder and methane leakage would result in most energy efficiency measures having slightly higher TDV energy and energy cost savings than using the TDV factors without these refinements. As a result, the TDV energy savings presented in this report are lower than the values that would have been obtained using TDV with the 15 percent retail adder and methane leakage, and the proposed code changes will be more cost effective using the revised TDV. The Energy Commission notified the Statewide CASE Team on April 21, 2020 that they were investigating further refinements to TDV factors using 20-year global warming potential (GWP) values instead of the 100-year GWP values that were used to derive the current TDV factors. It is anticipated that the 20-year GWP values may increase the TDV factors slightly making proposed changes that improve energy efficiency more cost effective. Energy savings presented in kWh and therms are not affected by TDV or demand factors.

When the Energy Commission releases the final TDV factors, the Statewide CASE Team will consider the need to re-evaluate energy savings and cost-effectiveness analyses using the final TDV factors for the results that will be presented in the Final CASE Report.

The Energy Commission is developing a source energy metric (energy design rating or EDR 1) for the 2022 code cycle. As of the date this Draft CASE Report was published, the source energy metric has not been finalized and the Energy Commission has not provided guidance on analyses they would like to see regarding the impact of proposed code changes relative to the source energy metric. Pending guidance from the Energy Commission, the Final CASE Reports may include analyses on the source energy metric. The prototypes are modeled with one of three derate factors 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. Though each prototype is of a specific CFA, the Statewide CASE Team modeled all derate factors to be able to determine savings, at a per dwelling unit level, for buildings above and below the 40,000 ft^2 CFA threshold. The three derate factors and their scenario applications within the savings analysis are the following:

1. **30 percent derate:** This is the baseline standard for all mid-rise mixed use and high-rise mixed use scenarios, representing unverified insulation quality for buildings of four or more habitable stories. This is also the baseline for the low-rise loaded corridor scenario in climate zone 7 where QII is not required.
2. **15 percent derate:** This is the proposed standard for the low-rise loaded corridor, mid-rise mixed use, and high-rise mixed-use scenarios representing building equal to or greater than 40,000 ft^2 of CFA.
3. **0 percent derate:** This is the proposed standard for mid-rise mixed buildings with less than 40,000 ft^2 of CFA. This is the baseline standard for the low-rise loaded corridor scenarios representing full-QII inspections (in climate zones 1-6, 8-16).

4.2 Energy Savings Methodology

4.2.1 Energy Savings Methodology per Prototypical Building

The Energy Commission 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 (TRC 2019). The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 8.

Table 8: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (ft^2)	Description
LowRiseGarden	2	7,680	8-unit residential building with, slab on-grade foundation, wood framed wall construction and a sloped roof. Window to Wall Ratio 0.15
LoadedCorridor	3	40,000	36-unit residential building with slab on-grade foundation, wood framed wall construction, and a flat roof. Window to Wall Ratio 0.25. Dwelling units flank and central corridor and common area spaces included on bottom floor.
MidRiseMixedUse	5	113,100	88-unit building with 4-story residential plus 1-story commercial. Concrete podium construction with underground parking, wood framed wall construction, and flat roof. Window to Wall Ratio-0.10 (ground floor) 0.25 (residential floors).
HighRiseMixedUse	10	125,400	117-unit building with 9-story residential + 1-story commercial. Concrete podium construction with underground parking, steel framed wall construction, and a flat roof. Window to Wall Ratio-0.10 (ground floor) 0.40 (residential floors).

The Statewide CASE Team estimated energy and demand impacts by simulating the proposed code change using the 2022 Research Version of the California Building Energy Code Compliance software for residential buildings (CBECC-Res 2022.0.2) and for commercial buildings (CBECC-Com 2022.0.1).

CBECC-Com generates two models based on user inputs: the Standard Design and the Proposed Design.[5] The Standard Design represents the geometry of the design that the builder would like to build and inserts a defined set of features that result in an energy budget that is minimally compliant with 2019 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2019 Residential and

[5] 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.

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.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. 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 2019 Title 24, Part 6 requirements.

CBECC-Com 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 2022 time dependent valuation (TDV) factors to calculate annual energy use in kilo British thermal units per year (TDV kBtu/yr) and annual peak electricity demand reductions measured in kilowatts (kW). CBECC-Com/Res also generates TDV energy cost savings values measured in 2023 present value dollars (2023 PV$) and nominal dollars.

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 TDV 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.

There are no existing requirements in Title 24, Part 6 that covers the QII requirement for mid-rise and high-rise residential buildings. 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 assumes 50 percent credit back with a cavity insulation derated by 15 percent. This is done for all climate zones by climate zone 7 where there are QII is not required.

4.2.2 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the Energy Commission provided (California Energy Commission Building Standards Office n.d.). The Statewide Construction Forecasts estimate new construction that would occur in 2023, the first year that the 2022 Title 24, Part 6 requirements would be in effect. It also estimates the size of the

total existing building stock in 2023 that the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction and existing building stock) by building type and climate zone. The building types used in the construction forecast, Building Type ID, are not identical to the prototypical building types available in CBECC-Com, so the Energy Commission provided guidance on which prototypical buildings to use for each Building Type ID when calculating statewide energy impacts. Table 9 presents the prototypical buildings and weighting factors that the Energy Commission requested the Statewide CASE Team use for each Building Type ID in the Statewide Construction Forecast.

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

Table 9: Multifamily Building Types and Associated Prototype Weighting

Building Type ID from Statewide Construction Forecast	Building Prototype for Energy Modeling	Weighting Factors for Statewide Impacts Analysis
Multifamily	LowRiseGarden	4%
	LoadedCorridor	33%
	MidRiseMixedUse	58%
	HighRiseMixedUse	5%

4.3 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit for new construction analysis are presented in Table 10 through Table 13. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Energy and demand impact results are presented for the following scenarios:

Energy savings

- Mid-Rise Mixed Use Snapshot QII (30 – 15 percent insulation derate)
- Mid-Rise Mixed Use Full QII (30 – 0 percent insulation derate)
- High-Rise Mixed Use Snapshot QII (30 – 15 percent insulation derate)

Loss of energy savings

- Low-Rise Loaded Corridor Snapshot QII (0 to 15 percent insulation derate)

As shown in Table 10 for the MidRiseMixedUse prototype Snapshot QII scenario, per-unit savings for the first year are expected to range from 0.03 to 14.66 kWh/yr and 0.13 to 1.91 therms/yr depending upon climate zone. Demand reduction impacts are negligible. Energy Savings levels vary by climate zones. Climate zones with large space cooling and/or space heating loads have the largest TDV energy savings.

Table 10: First-Year Energy Impacts Per Dwelling Unit– MidRiseMixedUse Prototype Building – Snapshot QII

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	1.82	0.00	1.58	457.16
2	5.35	0.00	1.10	550.08
3	2.58	0.00	0.97	356.26
4	4.00	0.00	0.63	399.83
5	4.09	0.00	1.02	344.57
6	11.93	0.00	0.76	522.44
7	0.03	0.00	0.28	64
8	5.90	0.00	0.28	338.27
9	5.95	0.00	0.38	371.56
10	7.65	0.00	0.50	430.29
11	7.83	0.00	0.78	546.48
12	7.28	0.00	1.00	614.47
13	12.61	0.01	0.82	700.06
14	7.26	0.00	0.73	515.38
15	14.66	0.00	0.13	542.24
16	5.11	0.00	1.91	655.85

As shown in Table 11 for the MidRiseMixedUse prototype full QII scenario, per-unit savings for the first year are expected to range from -2.27 to 27.22 kWh/yr and 0.07 to 3.47 therms/yr depending upon climate zone. Demand reduction impacts are negligible. Energy Savings levels vary by climate zones. Climate zones with large space cooling and/or space heating loads have the largest TDV energy savings. The TDV energy savings for the full QII scenario are on average 1.8 times the TDV energy savings from the Snapshot QII scenario.

Table 11: First-Year Energy Impacts Per Dwelling Unit– MidRiseMixedUse Prototype Building – Full QII

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	3.36	0.00	2.84	823.06
2	9.78	0.00	1.96	991.55
3	3.65	0.00	1.59	574.11
4	7.53	0.00	1.13	728.08
5	6.01	0.00	1.66	548.28
6	13.92	0.00	0.99	648.40
7	-2.27	0.00	0.07	-36.63
8	10.84	0.01	0.51	618.84
9	10.99	0.01	0.68	682.07
10	14.16	0.01	0.89	786.43
11	14.51	0.01	1.43	1,003.25
12	13.47	0.01	1.81	1,120.08
13	23.09	0.01	1.47	1,278.93
14	13.45	0.01	1.34	950.17
15	27.22	0.01	0.24	1,008.77
16	9.40	0.00	3.47	1,190.76

As shown in Table 12 for the HighRiseMixedUse prototype Snapshot QII scenario, per-unit savings for the first year are expected to range from -0.8 to 9.0 kWh/yr and 0.09 to 2.04 therms/yr depending upon climate zone. Demand reduction impacts are negligible. Energy Savings levels vary by climate zones. Climate zones with large space cooling and/or space heating loads have the largest TDV energy savings. The Statewide CASE Team did not complete energy modeling for climate zone 7 due to modeling limitations imposed by the software related to mandatory minimum code requirements. The Statewide CASE Team, based on consistent savings patterns and cost results from other prototypes is confident that had they been modeled, the HighRiseMixedUse savings for climate zone 7 would also not be cost effective. The TDV energy savings for the HighRiseMixedUse prototype full QII scenario are on average 77 percent the TDV energy savings from the same full QII scenario for MidRiseMixedUse prototype. The lower percentage savings is expected for the HighRiseMixedUse prototype because the building envelope to CFA ratio decreases, and the effect of QII on building energy use decreases.

Table 12: First-Year Energy Impacts Per Dwelling Unit– HighRiseMixedUse Prototype Building – Snapshot QII

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	0.21	0.00	1.52	397.64
2	2.66	0.00	1.00	435.58
3	-0.80	0.00	0.78	222.18
4	1.60	0.00	0.56	293.67
5	0.17	0.00	0.78	197.85
6	3.53	0.00	0.47	239.97
7	-	-	-	-
8	3.15	0.00	0.25	236.87
9	3.40	0.00	0.32	272.45
10	4.81	0.00	0.43	323.79
11	6.99	0.00	1.01	590.45
12	4.41	0.00	0.91	485.42
13	8.73	0.00	0.73	554.76
14	6.09	0.00	0.85	521.00
15	9.00	0.00	0.09	353.16
16	3.15	0.00	2.04	630.54

The proposed code change would also impact requirements on multifamily buildings that are both three habitable stories or lower and at or over 40,000 ft^2 of conditioned floor area. In the 2019 Code these larger multifamily buildings are prescriptively required to fulfill full-QII. With the proposed code change, they would be prescriptively required to fulfill snapshot-QII, resulting in a reduction in energy savings. Those losses are shown in Table 13 below per dwelling unit. Climate zone 7 data is not applicable since QII is not currently required for climate zone 7.

Table 13: First-Year Energy Impacts Per Dwelling Unit– LowRiseLoadedCorridor Prototype Building – Snapshot QII

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-4	0	-2	-725
2	-4	0	-1	-623
3	-2	0	-1	-370
4	-4	0	-1	-449
5	-2	0	-1	-278
6	-1	0	0	-167
7	-11	0	0	-117
8	-5	0	0	-345
9	-5	0	0	-396
10	-7	0	0	-516
11	-11	0	-1	-965
12	-7	0	-1	-779
13	-14	0	-1	-931
14	-11	0	-1	-928
15	-21	0	0	-890
16	-6	0	-2	-968

5. Cost and Cost Effectiveness

5.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the TDV energy cost factors to the energy savings estimates that were derived using the methodology described in Section 4.2. TDV is 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 (30 years for residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 30 years. The TDV cost impacts are presented in 2023 present value dollars and represent the energy cost savings realized over 30 years.

The Statewide CASE Team anticipates a negligible number of instances of additions or alterations larger than 40,000 ft^2. Additions of 700 to 40,000 ft^2 are also rare. The Statewide CASE Team estimates that zero percent of additions and alternations would be impacted by the proposed Snapshot QII measure.

5.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings that are realized over the 30-year period of analysis are presented in 2023 dollars in Table 14 and Table 15.

The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. For the simulations below, there were no significant peak electricity savings.

Table 14: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction - MidRiseMixedUse prototype – Full QII

Climate Zone	30-Year TDV Electricity Cost Savings (2023 PV$)	30-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 30-Year TDV Energy Cost Savings (2023 PV$)
1	15.79	126.60	142.39
2	81.60	89.94	171.54
3	25.79	73.53	99.32
4	73.37	52.58	125.96
5	19.34	75.51	94.85
6	65.37	46.80	112.17
7	-2.45	13.52	11.07
8	82.71	24.35	107.06

Climate Zone	30-Year TDV Electricity Cost Savings (2023 PV$)	30-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 30-Year TDV Energy Cost Savings (2023 PV$)
9	86.05	31.95	118.00
10	94.05	42.00	136.05
11	106.95	66.61	173.56
12	109.62	84.16	193.77
13	152.53	68.73	221.25
14	101.39	62.99	164.38
15	162.98	11.54	174.52
16	47.80	158.20	206.00

Table 15: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction - HighRiseMixedUse prototype – Snapshot QII

Climate Zone	30-Year TDV Electricity Cost Savings (2023 PV$)	30-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 30-Year TDV Energy Cost Savings (2023 PV$)
1	1.11	67.68	68.79
2	29.48	45.87	75.35
3	2.78	35.66	38.44
4	25.03	25.77	50.81
5	-1.11	35.34	34.23
6	19.65	21.86	41.52
7	-	-	-
8	29.30	11.68	40.98
9	31.89	15.24	47.13
10	35.60	20.41	56.02
11	55.26	46.89	102.15
12	41.72	42.26	83.98
13	61.75	34.23	95.97
14	50.06	40.07	90.13
15	56.74	4.36	61.10
16	16.50	92.58	109.08

5.3 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 $0.55 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 (i.e. leaning towards the higher end of potential the cost spectrum). 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). Statewide CASE Team received cost method input from a total of seven SMEs. The cost estimate uses the following assumptions:

1. A HERS Rater's field time would be billed at $80 per hour.
    a. The Statewide CASE Team developed and applied the climate zone labor rate adjustment based on RS-MEANS data across CASE topics.
2. The HERS Rater would verify 25 percent of the wall area at each verification point, higher than the proposed 20 percent of minimum required area to reflect the proposal's requirement that all visually accessible areas be verified, even if that goes beyond the minimum.
3. 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).
4. The insulation installation verification would take 30 minutes for a 500 ft^2 of wall area.
    a. These time estimations encompass the average time to conduct wall inspections, attic/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.
5. An average 100-mile round trip travel distance per site visit.
6. A maximum site visit time of 5 hours.

When applied to the prototype buildings, the method results in the following snapshot QII inspection costs per dwelling unit, by climate zone:

Table 16: Incremental Costs for Snapshot QII Inspection per Dwelling Unit

Climate Zone	LoadedCorridor (from full QII)	MidRiseMixedUse	HighRiseMixedUse
1	-$45	$19	$17
2	-$50	$21	$19
3	-$51	$21	$19
4	-$51	$21	$20
5	-$42	$18	$16
6	-$43	$18	$16
7	-$41	$17	$16
8	-$42	$18	$16
9	-$43	$18	$16
10	-$42	$18	$16
11	-$44	$18	$17
12	-$45	$19	$17
13	-$43	$18	$16
14	-$42	$17	$16
15	-$42	$17	$16
16	-$44	$18	$17

The Statewide CASE Team estimated the cost to conduct full-QII using a similar methodology. For this buildup, 100 percent of the wall area would be inspected. The Statewide CASE team accounted for an additional trip per every two otherwise required site visits. This is to account for the extra trips necessary to manage staged construction timing considerations such as seeing wall areas before bathtubs or cabinetry is installed. The Statewide CASE Team did not create an estimate for full QII on the HighRiseMixedUse prototype based on the assumption that negligible instances of high-rise buildings would be under 40,000 ft^2.

For buildings represented by the LowRiseLoadedCorridor prototype, there would be a reduced cost for buildings equal to or larger than 40,000 ft^2 of CFA that are prescriptively required to follow full-QII protocols under the 2019 Title 24, Part 6 Standards and would be required to follow snapshot-QII under this proposed code change.

When applied to the prototype buildings, the method results in the following full-QII inspection costs per dwelling unit, by climate zone:

Table 17: Incremental Costs for Full QII Inspection per Dwelling Unit

Climate Zone	MidRiseMixedUse
1	$79
2	$87
3	$89
4	$90
5	$74
6	$76
7	$72
8	$74
9	$76
10	$74
11	$77
12	$78
13	$76
14	$73
15	$74
16	$77

5.4 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 (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2022 TDV. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

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

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.

5.5 Cost Effectiveness

This measure proposes a 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 Energy Commission establishes the procedures for calculating cost-effectiveness. The Statewide CASE Team collaborated with Energy Commission 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 TDV energy cost savings from electricity and natural gas savings were also included in the evaluation.

There is no change in design costs. Neither costs associated with scheduling and managing the verification process nor potential costs to achieve necessary insulation installation quality are included.

According to the Energy Commission'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 2023 PV costs and cost savings.

Results of the per-unit cost-effectiveness analyses are presented in

Table 18 through Table 21 for each prototype.

Table 18: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – New Construction – MidRiseMixedUse prototype – Snapshot QII

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	79.09	18.67	4.24
2	95.16	20.66	4.61
3	61.63	21.17	2.91
4	69.17	21.37	3.24
5	59.61	17.52	3.40
6	90.38	17.94	5.04
7	-6.34	16.95	NA
8	58.52	17.63	3.32
9	64.28	17.91	3.59
10	74.44	17.63	4.22
11	94.54	18.31	5.16
12	106.30	18.52	5.74
13	121.11	18.02	6.72
14	89.16	17.32	5.15
15	93.81	17.45	5.38
16	113.46	18.33	6.19

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 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. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

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.

Table 19: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – New Construction – MidRiseMixedUse prototype – Full QII

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	142.39	78.80	1.81
2	171.54	87.20	1.97
3	99.32	89.31	1.11
4	125.96	90.20	1.40
5	94.85	73.92	1.28
6	112.17	75.68	1.48
7	11.07	71.51	0.15
8	107.06	74.39	1.44
9	118.00	75.56	1.56
10	136.05	74.39	1.83
11	173.56	77.27	2.25
12	193.77	78.15	2.48
13	221.25	76.03	2.91
14	164.38	73.10	2.25
15	174.52	73.63	2.37
16	206.00	77.33	2.66

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 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. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

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.

Table 20: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – New Construction – HighRiseMixedUse prototype – Snapshot QII

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	68.79	17.08	4.03
2	75.35	18.90	3.99
3	38.44	19.36	1.99
4	50.81	19.55	2.60
5	34.23	16.02	2.14
6	41.52	16.41	2.53
7	-	-	-
8	40.98	16.12	2.54
9	47.13	16.38	2.88
10	56.02	16.12	3.47
11	102.15	16.75	6.10
12	83.98	16.94	4.96
13	95.97	16.48	5.82
14	90.13	15.84	5.69
15	61.10	15.96	3.83
16	109.08	16.76	6.51

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 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. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

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.

For buildings equal to or greater than 40,000 and three habitable stories or fewer, represented by the low-rise loaded corridor prototype, this code proposal demonstrates both a reduced cost and reduced savings as compared to the 2019 Standard Design. Therefore, cost effectiveness requirements do not apply to this scenario. Table 21 is included here for completeness.

For alterations and additions, the proposed code would only impact additions to low rise buildings equal to or greater than 40,000 ft^2 of conditioned floor area, and additions to

high rise buildings greater than 700 ft^2. Based on SME input, the Statewide CASE Team does not anticipate an impactful quantity of these types of additions. There is no evidence that additions equal to or great than 40,000 ft^2 are built at all. If any are built they would incur similar verification costs and energy savings quantities as in new construction. Therefore, the Statewide CASE team did not calculate cost effectiveness specific to alterations and additions.

Table 21: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – New Construction –LowRiseLoadedCorridor prototype – Snapshot QII

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	-125.40	-44.90	-
2	-107.74	-49.69	-
3	-64.09	-50.89	-
4	-77.61	-51.39	-
5	-48.04	-42.12	-
6	-28.94	-43.12	-
7	-20.32	-40.75	-
8	-59.62	-42.39	-
9	-68.59	-43.06	-
10	-89.20	-42.39	-
11	-167.01	-44.03	-
12	-134.80	-44.53	-
13	-161.11	-43.32	-
14	-160.58	-41.65	-
15	-154.05	-41.95	-
16	-167.50	-44.06	-

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 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. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

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.

6. First-Year Statewide Impacts

6.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction by multiplying the per-unit savings, which are presented in Section 4.3, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. The statewide new construction forecast for 2023 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type). For each prototype, The Statewide CASE Team developed the distribution of percentage of new construction dwelling units that are in buildings 1) under 40,000 CFA where full QII is required, 2) at or above 40,000 CFA where Snapshot QII is required, and 3) of a construction type or in a climate zone where QII is not required.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2023. 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 22 to

Table 24

Table 22 presents the first-year statewide energy and energy cost savings from newly constructed buildings by climate zone. The tables show energy and energy cost savings for Snapshot QII, Full QII, and totals across all prototype and scenarios aggregated.

Table 22: Statewide Energy and Energy Cost Impacts – New Construction, Snapshot QII (LowRiseLoadedCorridor, MidRIseMixedUse, HighRiseMixedUse); Buildings < 40,000 CFA

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (dwelling units)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	30-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	131	0.00	(0.00)	0.00	$0.01
2	777	0.00	0.00	0.00	$0.05
3	3,767	0.01	(0.00)	0.00	$0.16
4	1,962	0.01	0.00	0.00	$0.09
5	349	0.00	0.00	0.00	$0.02
6	1,664	0.02	0.00	0.00	$0.12
7	0	0.00	0.00	0.00	$0.00
8	2,339	0.01	0.01	0.00	$0.10
9	5,492	0.02	0.01	0.00	$0.25
10	1,940	0.01	0.01	0.00	$0.10
11	554	0.00	0.00	0.00	$0.03
12	3,128	0.02	0.01	0.00	$0.22
13	913	0.01	0.00	0.00	$0.07
14	415	0.00	0.00	0.00	$0.02
15	270	0.00	0.00	0.00	$0.02
16	167	0.00	0.00	0.00	$0.01
TOTAL	23,867	0.11	0.05	0.01	$1.26

a. First-year savings from all buildings completed statewide in 2023.

Table 23: Statewide Energy and Energy Cost Impacts – New Construction, Full QII (MidRiseMixedUse Only); Buildings ≥ 40,000 CFA

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (dwelling units)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	30-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	20	0.00	0.00	0.00	$0.00
2	119	0.00	0.00	0.00	$0.02
3	575	0.00	(0.00)	0.00	$0.06
4	300	0.00	0.00	0.00	$0.04
5	53	0.00	0.00	0.00	$0.01
6	254	0.00	0.00	0.00	$0.03
7	0	0.00	0.00	0.00	$0.00
8	357	0.00	0.00	0.00	$0.04
9	839	0.01	0.00	0.00	$0.10
10	296	0.00	0.00	0.00	$0.04
11	85	0.00	0.00	0.00	$0.01
12	478	0.01	0.00	0.00	$0.09
13	139	0.00	0.00	0.00	$0.03
14	63	0.00	0.00	0.00	$0.01
15	41	0.00	0.00	0.00	$0.01
16	26	0.00	0.00	0.00	$0.01
TOTAL	3,645	0.04	0.02	0.00	$0.49

a. First-year savings from all buildings completed statewide in 2023.

Table 24: Statewide Energy and Energy Cost Impacts – New Construction, All Scenarios (Snapshot QII and Full QII)

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (dwelling units)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	30-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	151	0.00	(0.00)	0.00	$0.01
2	895	0.00	0.00	0.00	$0.07
3	4,342	0.01	(0.00)	0.00	$0.22
4	2,262	0.01	0.00	0.00	$0.13
5	402	0.00	0.00	0.00	$0.02
6	1,918	0.02	0.00	0.00	$0.15
7	0	0.00	0.00	0.00	$0.00
8	2,696	0.01	0.01	0.00	$0.13
9	6,331	0.03	0.02	0.00	$0.34
10	2,237	0.01	0.01	0.00	$0.14
11	639	0.00	0.00	0.00	$0.05
12	3,605	0.02	0.01	0.00	$0.31
13	1,052	0.01	0.01	0.00	$0.10
14	478	0.00	0.00	0.00	$0.03
15	311	0.00	0.00	0.00	$0.02
16	193	0.00	0.00	0.00	$0.02
TOTAL	27,512	0.15	0.07	0.02	$1.75

a. First-year savings from all buildings completed statewide in 2023.

6.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions assuming the emissions factors specified in the United States Environmental Protection Agency (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion. The electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the State meets the Renewable Portfolio Standard goal of 33 percent renewable electricity generation by 2020.[6] Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42). See Appendix C for additional details on the methodology used to calculate GHG emissions.

Table 25 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 125 metric tonnes of carbon dioxide equivalents (Metric Tonnes CO2e) would be reduced.

Table 25: First-Year Statewide GHG Emissions Impacts – New Construction, All Scenarios

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tonnes CO2e)	Natural Gas Savings[a] (million therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tonnes CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tonnes CO2e)
QII	149,423	36	0.02	89	125

a. First-year savings from all buildings completed statewide in 2023.

b. Assumes the following emission factors: 240.4 MTCO2e/GWh and 5, 454.4 MTCO2e/million therms.

6.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

[6] When evaluating the impact of increasing the Renewable Portfolio Standard from 20 percent renewables by 2020 to 33 percent renewables by 2020, the California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The incremental emissions were calculated by dividing the difference between California emissions in the CARB high and low generation forecasts by the difference between total electricity generated in those two scenarios.

6.4 Statewide Material Impacts

The proposed code change would not result in notable material use impacts.

6.5 Other Non-Energy Impacts

Beyond the energy and GHG emission impacts discussed above, additional impacts from the proposed QII measure include improved comfort for multifamily occupants.

7. Proposed Revisions to Code Language

7.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.2 Standards

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS

Section 150.1(c)1E.

E. All buildings shall comply with the Quality Insulation Installation (QII) requirements shown in TABLE 150.1-A or B. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5. Multifamily buildings with less than 40,000 ft^2 CFA shall comply with full QII requirements, and multifamily buildings of 40,000 ft^2 CFA or larger shall comply with Snapshot QII requirements.

TABLE 150.1-B COMPONENT PACKAGE – Multifamily Standard Building Design

Floors	Slab Perimeter	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U 0.58 R 7.0
	Raised	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
	Concrete Raised	U 0.092 R 8.0	U 0.092 R 8.0	U 0.269 R 0	U 0.269 R 0	U0.269 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
Quality Insulation Installation (QII)		Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

SECTION 140.3 – PRESCRIPTIVE REQUIREMENTS FOR BUILDING ENVELOPES

Section 140.3(a) Envelope Component Requirements.

6 Quality Installation Insulation. All multifamily buildings shall comply with the Quality Insulation Installation (QII) requirements shown in TABLE 140.3-C. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5. Buildings with less than 40,000 ft^2 CFA shall comply with full QII requirements, and buildings of 40,000 ft^2 CFA or larger shall comply with Snapshot QII requirements.

***TABLE 140.3-C** – PRESCRIPTIVE ENVELOPE CRITERIA FOR HIGH-RISE RESIDENTIAL BUILDINGS AND GUEST ROOMS OF HOTEL/MOTEL BUILDINGS*

				Climate Zone															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Envelope	Maximum U-factor	**Roofs/ Ceilings**	Metal Building	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	0.034	0.034	0.034	0.034	0.034	0.049	0.049	0.049	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
		Walls	**Metal Building**	0.113	0.061	0.113	0.061	0.061	0.113	0.113	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.061
			Metal-framed	0.069	0.062	0.082	0.062	0.062	0.069	0.069	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
			Mass Light[1]	0.196	0.170	0.278	0.227	0.440	0.440	0.440	0.440	0.440	0.170	0.170	0.170	0.170	0.170	0.170	0.170
			Mass Heavy[1]	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
			Wood-framed and Other	0.095	0.059	0.110	0.059	0.102	0.110	0.110	0.102	0.059	0.059	0.045	0.059	0.059	0.059	0.042	0.059
		Floors/ Soffits	Raised Mass	0.092	0.092	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.092	0.092	0.092	0.092	0.092	0.058
			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)		Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Roofing Products	**Low-sloped**	Aged Solar Reflectance	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
			Thermal Emittance	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	0.75	0.75
		Steep-Sloped	Aged Solar Reflectance	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
			Thermal Emittance	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	0.75	0.75
	Air Barrier			NR	NR	NR	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ
	Exterior Doors, Maximum U-factor		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
			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

7.3 Reference Appendices

RESIDENTIAL APPENDICES

RA3 RESIDENTIAL FIELD VERIFICATION AND DIAGNOSTIC TEST PROTOCOLS
Section 3.5 Quality Insulation Installation Procedures
RA3.5.1 Purpose and Scope

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), 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.

Note 3: For newly constructed multifamily buildings, dwelling unit-based sampling methods are not allowed for QII compliance. Multifamily building with less than 40,000 ft^2 of conditioned floor area, 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 equal to or larger than 40,000 ft^2 of conditioned floor area, may follow the Snapshot QII or the full QII verification procedure.

RA3.5.x Snapshot QII Procedures for Select Multifamily Buildings

Multifamily buildings with 40,000 ft^2 or more CFA shall use the Snapshot QII verification procedure to fulfill prescriptive requirements. Multifamily buildings below this threshold may elect to use Snapshot QII verification methods for reduced compliance using the performance approach. Snapshot QII requires verification of all insulating materials of

the thermal envelope, but only those aspects of quality insulation installation that can be verified at the snapshot in time of the verification date(s). Buildings using panelized curtain wall construction methods, rather than cavity framed methods are exempted from prescriptive snapshot-QII requirements without verification.

During each verification visit, the HERS Rater shall verify all thermal envelope air sealing and insulating materials visually available during the visit. The HERS Rater must directly observe at minimum 20 percent of the building's total gross wall area to verify framing cavity air sealing quality, and 20 percent of the building's total gross wall area to verify insulation installation quality. If these 20 percent minimums at both construction stages cannot be met in a single day's visit, the verifier shall return at subsequent dates until the minimum requirements are achieved.

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.
- Insulated header verification is omitted from the Snapshot QII protocol.

If field verification of air sealing and insulation in any of the sampled portions results in a failure, the HERS Rater or ATT shall enter the failure into the HERS or ATT data registry. Installers shall take corrective action, and the HERS Rater or ATT shall re-check the corrective action. In addition, the building then becomes subject to verification of 100 percent of remaining wall area that are still visually accessible. The building is deemed to Pass if the HERS Rater or ATT verifies that the corrective action was successful during re-check, and if all visually accessible remaining wall area meets the verification requirements.

7.4 ACM Reference Manual

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, Snapshot QII" or "Unverified"~~yes or no~~. The 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, Snapshot QII" introduced a 15% derate 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" for QII.

STANDARD DESIGN

The standard design is modeled with "yes" for verified QII for newly constructed single-family low-rise houses and additions greater than 700 ft^2 in all climate zones except climate zone 7~~,~~

The standard design is "Verified, full QII" ~~f~~for newly constructed multifamily ~~low-rise residential~~ buildings smaller than 40,000 ft^2 CFA and additions greater than 700 ft2 in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no requirement ~~for multifamily buildings~~.) The standard design is "Verified, Snapshot QII" for newly constructed multifamily buildings with 40,000 ft^2 CFA or larger 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 "no" for new construction and additions.

~~fFor multifamily low-rise residential buildings and additions equal to greater than 700 ft^2 in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no QII for multifamily buildings.)~~

VERIFICATION AND REPORTING

The presence of QII is reported in the HERS required verification listings on the CF1R. Both "Verified, full QII" and "Verified, Snapshot QII" are ~~is~~ certified by the installer and field verified to comply with RA3.5. Credit for "Verified, full QII" and "Verified, Snapshot 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, Snapshot 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.

7.5 Compliance Manuals

Section 3.5.8 of the Residential Compliance Manual needs the following revisions.

The proposed code change would add clarifying explanations for the 40,000 CFA threshold above which Snapshot QII protocol is prescriptively required for multifamily buildings. The proposed change would provide descriptions on the scope and special cases for Snapshot QII protocols. These descriptions would present compliance software's cavity insulation R-value derating rules under full and Snapshot QII scenarios.

7.6 Compliance Documents

The proposed code change would revise the following Compliance documents:

- CEC-CF1R-NCB-01-E
- CEC-CF2R-ENV-21-HERS-QII-FramingStage
- CEC-CF3R-ENV-21-HERS-QII-FramingStage
- CEC-CF2R-ENV-22- HERS-QII- InsulationStage
- CEC-CF3R-ENV-22-HERS-QII- InsulationStage
- NRCC-ENV-01-E
- NRCI-ENV-01-E-Envelope
- NRCV-ENV-01-Envelope

The proposed code change would update the QII specific entries in the Certificate of Compliance (CR1R/NRCC) documents to reflect applicable full vs. Snapshot options based on building CFA. Certificates of Installations (CF2R/NRCI) and Verifications (CR3R/NRCV) need updates that reflect full and Snapshot QII requirement and respective protocols.

8. Bibliography

n.d. http://bees.archenergy.com/Documents/Software/CBECC-Com_2016.3.0_SP1_Prototypes.zip.

BW Research Partnership. 2016. *Advanced Energy Jobs in California: Results of the 2016 California Advanced Energy.* Advanced Energy Economy Institute.

CalCERTS. n.d. Accessed January 2019. https://www.calcerts.com/.

California Air Resouces Board. 2019. "Global Warming Potentials." https://www.arb.ca.gov/cc/inventory/background/gwp.htm#transition.

California Department of Water Resources. 2016. "California Counties by Hydrologic Regions." Accessed April 3, 2016. http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf.

California Energy Commission. 2015. *2016 Building Energy Efficiency Standards: Frequently Asked Questions.* http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/2016_Building_Energy_Efficiency_Standards_FAQ.pdf.

—. 2020. *2020 Workshops and Meetings.* https://ww2.energy.ca.gov/title24/2022standards/prerulemaking/documents/.

California Energy Commission Building Standards Office. n.d. *Public Participation in the Energy Efficiency Standards Update.* Accessed 2020. https://www.energy.ca.gov/title24/participation.html.

California Energy Commission. 2022. "Energy Code Data for Measure Proposals." *energy.ca.gov.* https://www.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2019. "Housing and Commercial Construction Data - Excel." https://ww2.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2018. "Impact Analysis: 2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings." *energy.ca.gov.* June 29. https://www.energy.ca.gov/title24/2019standards/post_adoption/documents/2019_Impact_Analysis_Final_Report_2018-06-29.pdf.

California Public Utilities Commission (CPUC). 2015b. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

California Public Utilities Commission. 2015a. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. . http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350.

CASE. 2017. *Quality Insulation Installation (QII) - Final Report.* Codes and Standards, California Utilities Statewide Codes and Standards Team. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_ResQII_Final_September-2017.pdf.

CMFNH. n.d. Accessed January 2020. https://cmfnh.com/.

CoStar. n.d. *CoStar.* Accessed June 2019. www.costar.com.

Dakin and German. 2017. "http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_ResQII_Final_September-2017.pdf." *Title 24 Stakeholders.* July. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_ResQII_Final_September-2017.pdf.

Energy + Environmental Economics. 2016. "Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs." Prepared for the California Energy Commission. July. http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf.

Energy Star. 2020. *Multifamily New Construction Certification Process.* march 23. Accessed March 23, 2020. https://www.energystar.gov/partner_resources/residential_new/program_reqs/mfnc_cert_process.

Ettenson, Lara , and Christa Heavey. 2015. *California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals.* Natural Resources Defense Council & Environmental Entrepreneurs (E2).

Federal Reserve Economic Data. n.d. https://fred.stlouisfed.org .

Goldman, Charles, Merrian C. Fuller, Elizabeth Stuart, Jane S Peters, Marjorie McRay, Nathaniel Albers, Susan Lutzenhiser, and Mersiha Spahic. 2010. *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth.* Lawrence Berkeley National Laboratory.

ICC. 2020. *2018 International Energy Conservation Code .* March 23. Accessed March 23, 2020. https://codes.iccsafe.org/content/iecc2018/chapter-4-%5bre%5d-residential-energy-efficiency#IECC2018_RE_Ch04_SecR402.4.

Institute, Instulation. 2020. *Grade I Installation.* March 23. Accessed 2020. https://insulationinstitute.org/im-a-building-or-facility-professional/residential/installation-guidance-2/grade-1-installation/.

Kenney, Michael, Heather Bird, and Heriberto Rosales. 2019. *2019 California Energy Efficiency Action Plan.* Publication Number: CEC-400-2019-010-CMF, California Energy Commission.

Means, RS. 2020. https://login.gordian.com/GordianLogin?signin=97a76138d2962c180559f0f07e91a35f&clientID=RsMeansOnline.

National Energy Assistance Directors' Association. 2011. *2011 National Energy Assistance Survey Final Report.* http://www.appriseinc.org/reports/Final%20NEADA%202011%20Report.pdf.

NFRC. n.d. Accessed January 2020. http://search.nfrc.org/search/cpd/cpd_search_default.aspx?SearchOption=O.

NYSERDA. 2020. *Multifamily Performance for Existing Buildings.* March 23. Accessed March 23, 2020. https://www.nyserda.ny.gov/All-Programs/Programs/MPP-Existing-Buildings.

RESNET. 2020. *Residential Energy Services Network.* March 23. Accessed 23 March, 2020. https://www.resnet.us/.

State of California, Employment Development Department. n.d. https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry .

Stone, Nehemiah, Jerry Nickelsburg, and William Yu. 2015. *Codes and Standards White Paper: Report - New Home Cost v. Price Study.* Pacific Gas and Electric Company. Accessed February 2, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/Migration-12-22-2015/Non-Regulatory/15-BSTD-01/TN%2075594%20April%202015%20Codes%20and%20Standards%20White%20Paper%20-%20Report%20-%20New%20Home%20Cost%20v%20Price%20Study.pdf.

Team, Statewide Case. 2020. *Title 24 Stakeholders.* https://title24stakeholders.com/wp-content/uploads/2020/01/2022-T24-Utility-Sponsored-Stakeholder-Meeting-Notes_MF-HVAC-and-Envelope.pdf.

Team, Statewide CASE. 2019. *Notes from 2022 Title 24, Part 6 Code Cycle Utility-Sponsored Stakeholder Meeting for: Multfamily HVAC Envelope Utility Sponsored Stakeholder Meeting.* https://title24stakeholders.com/wp-

content/uploads/2019/07/T24-2022-MF-HVAC-Envelope-Meeting-Notes_Final.pdf.

—. n.d. "Notes from 2022 Title 24, Part 6 Code Cycle Utility-Sponsored Stakeholder Meeting for: Multifamily HVAC and Envelope ." https://title24stakeholders.com/wp-content/uploads/2020/01/2022-T24-Utility-Sponsored-Stakeholder-Meeting-Notes_MF-HVAC-and-Envelope.pdf.

Thornberg, Christopher, Hoyu Chong, and Adam Fowler. 2016. *California Green Innovation Index - 8th Edition.* Next 10.

TRC. 2018. "Multifamily Market Analysis." http://title24stakeholders.com/wp-content/uploads/2018/09/PGE_MultifamilyMarketAnalysis_TRC_FinalReport_2018-05-18.pdf.

TRC. 2018. "Multifamily Mid-Rise and Mixed-Use Modeling Rule Analysis."

TRC. 2019. "Multifmaily Prototypes."

U.S. Census Bureau, Population Division. 2014. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

U.S. EPA (United States Environmental Protection Agency). 2011. "Emission Factors for Greenhouse Gas Inventories." Accessed December 2, 2013. http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

United States Environmental Protection Agency. 1995. "AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources." https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors#5thed.

United States Environmental Protection Agency. 2018. "Emissions & Generation Resource Integrated Database (eGRID) 2016." https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

Zabin, Carol, and Karen Chapple. 2011. *California Workforce Education & Training Needs Assessment: For Energy Efficiency, Distributed Generation, and Demand Reponse.* University of California, Berkeley Donald Vial Center on Employment in the Green Economomy. Accessed February 3, 2017. http://laborcenter.berkeley.edu/pdf/2011/WET_Appendices_ALL.pdf.

Appendix A: Statewide Savings Methodology

The Statewide CASE Team estimated statewide first-year impacts by multiplying per-unit savings estimates by statewide construction forecasts that the Energy Commission provided (California Energy Commission 2019). 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 29 presents the number of new construction dwelling units that the Statewide CASE Team assumed would be impacted by the proposed code change during the first year the 2022 code is in effect. The Statewide CASE Team assumed that no (zero percent) existing dwelling units in any climate zone would be impacted by the proposed code change.

The Statewide CASE Team considered three data sources to determine the statewide distribution of new construction dwelling units impacted the proposed QII measure: CoStar project data set, the CMFNH program, and energy consultant project data sets. The Statewide CASE Team considered three data sources to determine the statewide distribution of new construction dwelling units impacted the proposed QII measure: CoStar project data set, the CMFNH program, and energy consultant project data sets.

The CMFNH data set contains 128 projects representing 646 buildings built or scheduled to be built during the 2016 or 2019 code cycles. The projects all voluntarily took part in PG&E's above-code, multifamily new construction program and are therefore all above-code projects. The data points from these projects are highly reliable—they were screened for accuracy and program eligibility, and TRC reviewed the plans as part of our role as program implementors.

The consultant project data set contains 39 projects representing 58 buildings. The project-available project data categories and details do not easily align with or provide complete details to categorize relative to CASE prototypes.

The CoStar data include self-reported building data from all multifamily buildings constructed or scheduled to complete construction between 2014 and 2022. It contains data from 2,180 projects representing 6,771 buildings. It is the most comprehensive set of data available with the fewest inherent biases, and it was the primary source of information for statewide distribution of building type for this savings assessment. However, review of the data show clearly inaccurate data within some project records, and the available data categories do not cleanly align with or provide complete detail to categorize relative to CASE prototypes and the proposed snapshot-QII threshold of 40,000 ft^2 of conditioned space. Therefore, the Statewide CASE Team made multiple subjective decisions on how to filter, sort, interpret, and analyze the data to determine representation of multifamily building type in the California market for the statewide savings claim. The Statewide CASE Team relied on SME guidance and market

knowledge, plus insight from the other two data sources, to develop the final distribution estimations by prototype and building size.

Table 26 shows each prototype, the number of stories each prototype represents for the variety of real construction expectations, as well as the percentage of dwelling units represented in the data for each prototype both above and below the 40,000 ft^2 threshold. Two story buildings are represented either by the low-rise garden style prototype or the low-rise loaded corridor prototype, depending on other aspects of their construction methodology and building layout.

Table 26: Classification of Project Data into CASE Prototypes by Number of Stories

Prototype	Number of Stories	Percent of prototype's dwelling units in buildings <40,000 CFA	Percent of prototype's dwelling units in buildings ≥40,000 CFA	Percent of prototype's dwelling units in buildings using curtain wall construction assemblies
Low-Rise Garden Style	1-2	100%	0%	0%
Low-Rise Loaded Corridor	2-3	78%	22%	0%
Mid-Rise Mixed Use	4-6	13%	72%	15%
High-Rise Mixed Use	7+	0%	7%	93%

27 shows the impact of those ratios when applied to projected 2023 multifamily new construction rates by dwelling unit.

Table 27: Estimated New Construction for Multifamily Buildings by Prototype and QII Requirement

Building Type	Total Statewide New Construction Permitted in 2023 (dwelling units)	Percent of Statewide New Construction Impacted by Proposal		New Construction Permitted in 2023 (dwelling units)
Low-rise Garden	2,079	Full QII	100%	2,079
		Snapshot QII	0	0
		No QII	0	0
Loaded Corridor	17,149	Full QII	78%	13,376
		Snapshot QII	22%	3,773
		No QII	0%	0

Building Type	Total Statewide New Construction Permitted in 2023 (dwelling units)	Percent of Statewide New Construction Impacted by Proposal		New Construction Permitted in 2023 (dwelling units)
Mid-Rise Mixed Use	30,140	Full QII	13%	3,918
		Snapshot QII	72%	21,701
		No QII	15%	4,521
High-Rise Mixed Use	2,598	Full QII	0%	0
		Snapshot QII	7%	182
		No QII	93%	2,416

Table 26 through 27 present the number of dwelling units for each prototype type that the Statewide CASE Team determined would be impacted by the proposed code change during the first year the 2022 code is in effect.

Table 28: Breakdown of Estimated New Construction for Multifamily Buildings by Climate Zone

Building Climate Zone	Total Dwelling Units Completed in 2023 [A]		Percent of New Dwelling Units Impacted by Proposal [B]			Dwelling Units Impacted by Proposal in 2023 C = A x B					
	MRMU	HRMU	LRLC	MRMU - Snapshot	MRMU - full	HRMU - Snapshot	LRLC - Snapshot	MRMU - Snapshot	MRMU - full	HRMU - Snapshot	LRLC - Snapshot
1	154	13	87	72%	13%	7%	22%	111	20	1	19
2	912	79	519	72%	13%	7%	22%	657	119	6	114
3	4,425	381	2,518	72%	13%	7%	22%	3,186	575	27	554
4	2,305	199	1,312	72%	13%	7%	22%	1,660	300	14	289
5	409	35	233	72%	13%	7%	22%	295	53	2	51
6	1,955	168	1,112	72%	13%	7%	22%	1,407	254	12	245
7	2,101	181	1,196	72%	13%	7%	22%	1,513	273	13	263
8	2,748	237	1,564	72%	13%	7%	22%	1,979	357	17	344
9	6,452	556	3,671	72%	13%	7%	22%	4,645	839	39	808
10	2,279	196	1,297	72%	13%	7%	22%	1,641	296	14	285
11	651	56	370	72%	13%	7%	22%	469	85	4	81
12	3,674	317	2,091	72%	13%	7%	22%	2,645	478	22	460
13	1,072	92	610	72%	13%	7%	22%	772	139	6	134
14	487	42	277	72%	13%	7%	22%	351	63	3	61
15	317	27	181	72%	13%	7%	22%	228	41	2	40
16	197	17	112	72%	13%	7%	22%	142	26	1	25

Building Climate Zone	Total Dwelling Units Completed in 2023 [A]		Percent of New Dwelling Units Impacted by Proposal [B]			Dwelling Units Impacted by Proposal in 2023 C = A x B					
	MRMU	HRMU	LRLC	MRMU - Snapshot	MRMU - full	HRMU - Snapshot	LRLC - Snapshot	MRMU - Snapshot	MRMU - full	HRMU - Snapshot	LRLC - Snapshot
TOTAL	**30,140**	**2,598**	**17,149**					**21,701**	**3,918**	**183**	**3,773**

Table 29: Estimated New Construction for Multifamily Buildings by Climate Zone

Building Climate Zone	New Construction in 2023 (dwelling units)			Existing Building Stock in 2023 (dwelling units)		
	Total Dwelling Units Completed in 2023 [A]	Percent of New Dwelling Units Impacted by Proposal [B]	Dwelling Units Impacted by Proposal in 2023 C = A x B	Total Existing Dwelling Units in 2023 [D]	Percent of New Dwelling Units Impacted by Proposal [E]	Dwelling Units Impacted by Proposal in 2023 F = D x E
1	265	57 percent	151	17,126	0 percent	0
2	1,573	57 percent	895	101,721	0 percent	0
3	7,630	57 percent	4,342	530,089	0 percent	0
4	3,975	57 percent	2,262	278,535	0 percent	0
5	706	57 percent	402	44,816	0 percent	0
6	3,370	57 percent	1,918	315,784	0 percent	0
7	3,623	57 percent	2,062	291,804	0 percent	0
8	4,738	57 percent	2,697	489,337	0 percent	0
9	11,124	57 percent	6,331	1,086,699	0 percent	0
10	3,930	57 percent	2,237	316,384	0 percent	0
11	1,122	57 percent	639	81,820	0 percent	0
12	6,335	57 percent	3,605	455,265	0 percent	0
13	1,849	57 percent	1,052	154,048	0 percent	0
14	840	57 percent	478	79,142	0 percent	0
15	547	57 percent	311	40,033	0 percent	0
16	339	57 percent	193	27,505	0 percent	0
TOTAL	**51,966**		**29,575**	4,310,108		**0**

Appendix B: Embedded Electricity in Water Methodology

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

Appendix C: Environmental Impacts Methodology

Greenhouse Gas (GHG) Emissions Factors

As directed by Energy Commission staff, GHG emissions were calculated making use of the average emissions factors specified in the United States Environmental Protection Agency (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion (United States Environmental Protection Agency 2018). This ensures consistency between state and federal estimations of potential environmental impacts. The electricity emissions factor calculated from the eGRID data is 240.4 metric tonnes CO2e per GWh. The Summary Table from eGrid 2016 reports an average emission rate of 529.9 pounds CO2e/MWh for the WECC CAMX subregion. This value was converted to metric tonnes/GWh.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in Chapter 1.4 of the U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42) (United States Environmental Protection Agency 1995). The U.S. EPA's estimates of GHG pollutants that are emitted during combustion of one million standard cubic feet of natural gas are: 120,000 pounds of CO_2 (Carbon Dioxide), 0.64 pounds of N_2O (Nitrous Oxide) and 2.3 pounds of CH_4 (Methane). The emission value for N_2O assumed that low NOx burners are used in accordance with California air pollution control requirements. The carbon equivalent values of N_2O and CH_4 were calculated by multiplying by the global warming potentials (GWP) that the California Air Resources Board used for the 2000-2016 GHG emission inventory, which are consistent with the 100-year GWPs that the Intergovernmental Panel on Climate Change used in the fourth assessment report (AR4). The GWP for N_2O and CH_4 are 298 and 25, respectively. Using a nominal value of 1,000 Btu per standard cubic foot of natural gas, the carbon equivalent emission factor for natural gas consumption is 5,454.4 metric tonnes per million therms.

GHG Emissions Monetization Methodology

The 2022 TDV energy cost factors used in the lifecycle cost-effectiveness analysis include the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs). 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. The authors used the same monetary values that are used in the TDV factors – \$40/MTCO_2e.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

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

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for commercial/residential buildings (CBECC- Com/Res) along with the supporting documentation that the Energy Commission staff and the technical support contractors would need to approve and implement the software revisions.

Snapshot QII requires a minor update to the compliance software. The Statewide CASE Team populates select sections with high level descriptions and anticipates to add detailed software update needs on user input/output, compliance report and verification, and testing later on in coordination with the software development team.

Technical Basis for Software Change

The compliance software needs to be updated to incorporate modeling rule changes for buildings that are eligible for and select the Snapshot QII feature. The software currently has only the full QII modeling rulesets in place.

Description of Software Change

Background Information for Software Change

The proposed Snapshot QII code change would be a compliance option for multifamily buildings with larger than 40,000 CFA. The change concerns with treatment of cavity insulation of walls, floors, attic roof, and cathedral ceiling spaces. Aligned with the existing full QII feature, the Snapshot QII feature is applicable to all climate zones except for climate zone 7. Software change needs are for both the Standard Design (base model) and the Proposed Design (user defined).

Existing CBECC- Com/Res Modeling Capabilities

Both CBECC-Res and CBECC-Com currently have a QII checkbox with the options of “no” and “verified”. With the new prescriptive requirement that allow a Snapshot QII approach for larger multifamily buildings, the current software needs to incorporate the function and mechanisms to display and allow users to select appropriate QII features and perform the insulation R-value derate modifications accordingly.

Summary of Proposed Revisions to CBECC Com/Res

Modeling features to be added to the software tools include:

- Display of acceptable QII options based on building CFA info

- Algorithm changes to reflect the modeling rules for the selected option
    - For both Standard Design and Proposed Design
    - For three components
        - Walls, floors, attic roofs, cathedral ceilings cavity insulation R-value derates
        - Ceilings below attic (rarely applicable to multifamily buildings) blown in batt insulation R-value derate
        - Ceilings below attic added heat flow from conditioned zone to attic
    - Accounting for requirement difference based on climate zone

User Inputs to CBECC-Com/Res

Simulation Engine Inputs

Simulation Engine Output Variables

Compliance Report

Compliance Verification

Testing and Confirming CBECC-Com/Res Modeling

Description of Changes to ACM Reference Manual

Description of changes to the ACM Reference Manual are in Section 7.4 and reproduced in full below.

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, Snapshot QII" or "Unverified"~~yes or no~~. The 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, Snapshot QII" introduced a 15% derate 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" for QII.

STANDARD DESIGN
The standard design is modeled with "yes" for verified QII for newly constructed single-family low-rise houses and additions greater than 700 ft^2 in all climate zones except climate zone 7~~,~~

The standard design is "Verified, full QII" ~~f~~for newly constructed multifamily ~~low-rise residential~~ buildings smaller than 40,000 ft^2 CFA and additions greater than 700 ft2 in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no requirement ~~for multifamily buildings~~.) The standard design is "Verified, Snapshot QII" for newly constructed multifamily buildings with 40,000 ft^2 CFA or larger 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 "no" for new construction and additions.
~~fFor multifamily low-rise residential buildings and additions equal to greater than 700 ft^2 in Climate Zones 1-6 and 8-16. (Climate Zone 7 has no QII for multifamily buildings.)~~

VERIFICATION AND REPORTING
The presence of QII is reported in the HERS required verification listings on the CF1R. Both "Verified, full QII" and "Verified, Snapshot QII" are ~~is~~ certified by the installer and field verified to comply with RA3.5. Credit for "Verified, full QII" and "Verified, Snapshot 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, Snapshot 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.

Appendix E: Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. Table 30 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing workflow, and ways to mitigate negative impacts. The information contained in Table 30 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.

Coordination between the trades is needed to facilitate successful field verifications. The construction industry has built up familiarity and understanding of the scope, coverage, and process in current code where QII is a performance credit. Since existing requirements are for low-rise multifamily buildings only, contractors working on high-rise multifamily projects would not possess the experience and knowledge base unless they participated in LEED for Homes/Green Point Rated and similar voluntary programs. As a result, trades would have a moderate learning curve for conducting Snapshot QII verification for larger multifamily buildings. Part of the proposed measure's effectiveness in the field hinges on having compliance enhancement trainings for HERS Raters/ATTs in the near term.

The Statewide CASE Team considered the challenge of installers arbitrarily picking and choosing portion of the installation for visual inspections. The proposed change describes that HERS Raters/ATTs should cover all visually accessible wall areas at appropriate construction points to eliminate the potential loophole or gaming. This is as opposed to allowing for sampling between dwelling units employed by many other HERS measures.

Table 30: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Architect/ Design Team	• Determines building envelope design and confirms compliance • Coordinates design with other team members, including energy consultant • Completes compliance documents for permit application	• Streamlines coordination with team members • Demonstrates compliance with information provided on plans • Completes compliance documents	Would coordinate with team to decide on QII compliance approach (if Snapshot QII is an option, whether to select that versus going for full QII for additional compliance credit)	• Ensure compliance forms auto-populate available options clearly • Modeling software would queue application compliance forms for installation and verification activities
Energy Consultant	• Effectively communicates applicable QII compliance choices • Performs compliance modeling and coordinates with team members • Completes compliance documents for permit application	• Coordinates with team members • Completes compliance documents	Would work with architect/design team to determine QII compliance choice	• Ensure compliance forms clearly denote and auto-populate available options • Modeling software would queue application compliance forms for installation and verification • Fact sheet that summarizes code and modeling rule changes to help consultants stay informed

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Energy Commission	NA	NA	NA	• Incorporate and update HERS verification scope and procedure in compliance forms. • Determine and support HERS or ATT infrastructure needs for compliance data hosting and maintenance
Plans Examiner	• Identifies relevant requirements • Confirms plans/specifications match data on documents • Confirms data on documents are compliant • Provides correction comments if necessary	• Determines requirements based on project scope • Locates and checks plans against submitted documents • Provides comments that would resolve issues	NA	NA
General Contractor	• Manages overall construction activities and details • Coordinates all trades on site and communicates schedules and changes when needed	• Ensures successful project build on time and on budget • Ensures trades activities are coordinated and to spec	Would self-certify system installations meet design plans and code requirements	• Training to increase understanding and familiarity and enhance compliance performance • Marketing campaign to explain the new role and increase credibility of third-party verification

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Insulation Installers	• Performs insulation installation • Populates and signs the Certificate of Installation	• Quickly and effectively install installations per spec • Smooth completion and submission of compliance forms • Satisfactory compliance results	• Would communicate progress and schedule to enable scheduling of verification visits at appropriate construction stages/verification points • Would respond to and correct deficiencies quickly to continue QII verification	Training to increase understanding and familiarity and enhance compliance performance
HERS Rater/ATT	• Coordinates closely with general contractor and trades to ensure appropriate construction stages/ verification points and to schedule verification visits • Performs field verification • Populates and signs the Certificate of Verification	• Perform visual verification • Completion and submission of compliance forms	• Would familiarize with scope and coverage of Snapshot QII protocol • Would work with larger multifamily building market actors	HERS Rater/ATT training to increase understanding and familiarity with verification protocols

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 Energy Commission in this Draft 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
- 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 2022 code cycle. The goal of stakeholder meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asks for feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results for analyses
- Data to support assumptions
- Compliance and enforcement, and
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for multifamily high performance thermal envelope via webinar. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, slide presentations, proposal summaries with code language, and meeting notes are included in the bibliography section of this report.

Table 31: Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Multifamily HVAC and Envelope Utility-Sponsored Stakeholder Meeting	Thursday, August 22, 2019	https://title24stakeholders.com/event/multifamily-hvac-and-envelope-utility-sponsored-stakeholder-meeting/
Second Round of Multifamily HVAC and Envelope Utility-Sponsored Stakeholder Meeting	Wednesday, March 25, 2020	https://title24stakeholders.com/event/multifamily-hvac-and-envelope-utility-sponsored-stakeholder-meeting-2/

The first round of utility-sponsored stakeholder meetings occurred from August to November 2019 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 2022 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 from March to May 2020 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 1,900 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[7] (and cross-promoted on the Energy Commission 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 in to the listserv. Exported webinar meeting data captured attendance numbers and individual comments, and recorded live attendee polls outcomes to evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders shown in Table 32 when developing this report.

Table 32: Quality Insulation Installation Stakeholders

Organization	Person	Role
1 Earth, Inc.	Stanford Rollins	HERS Rater; Energy Consultant
Bright Green Strategies	Peter Kennedy Sharon Block	Energy Consultant
Brummit Engineering	Hans Marsman	Energy Consultant, Designer
CalCERTS	Charlie Bachand Roy Eads, Russ King	HERS Provider
Chit Wood Energy	Rick Chitwood	Consultant
Cool Machines Inc.	Dave Krendl	Insulation Device Manufacturer
Environmental Protection Agency (EPA)	Dean Gamble, Rebecca Hudson	Government Agency; Above Code Program
Frontier Energy	Alea German Bill Dakin	CASE Team Researcher
Gabel Energy	Gina Rodda	Energy Consultant
Knauf Insulation	David W. Ware	Manufacturer
North America Insulation Manufacturers Association (NAIMA)	Rich Curt	Industry Association

[7] Title 24 Stakeholders' LinkedIn page can be found here: https://www.linkedin.com/showcase/title-24-stakeholders/.

Organization	Person	Role
New York Energy Research and Development Authority Multifamily Performance Program (NYSERDA MPP)	Gwen McLaughlin (TRC, as a program administration)	Above Code Program
OJ Insulation LP	Griff Jenkins	Installer
Red Car Analytics	Neil Bulger	Energy Consultant
Steven Winter Associates, Inc.	Gayathri Vijayakumar	Consultant; Above Code Program
Valley Duct Testing	John Flores	HERS Rater, Energy Consultant
VCA Green	Glen Folland Wayne Alldredge	Energy Consultant, Designer

Appendix G: Nominal Savings Tables

This appendix will be included for the Final CASE Report.

In Section 5, the energy cost savings of the proposed code changes over the 15- and 30-year period of analysis are presented in 2023 present value dollars.

This appendix presents energy cost savings in nominal dollars. Energy costs are escalating as in the TDV analysis but the time value of money is not included so the results are not discounted.