



TITLE 24, PART 6 | **2025 CODE CYCLE**



Buried Ducts

Codes and Standards Enhancement (CASE) Proposal
Single Family | Residential Buried Ducts



Simon Pallin
February 14, 2023



Agenda

Background *2 min*

Market Overview and Analysis *2 min*

Technical Feasibility *2 min*

Cost and Energy Methodology *2 min*

Compliance and Enforcement *2 min*

Proposed Code Changes *2 min*

Discussion & Next Steps *3 min*





Background

- Code Change Proposal
- 2022 Code Requirements
- Context and History

Proposed Code Change

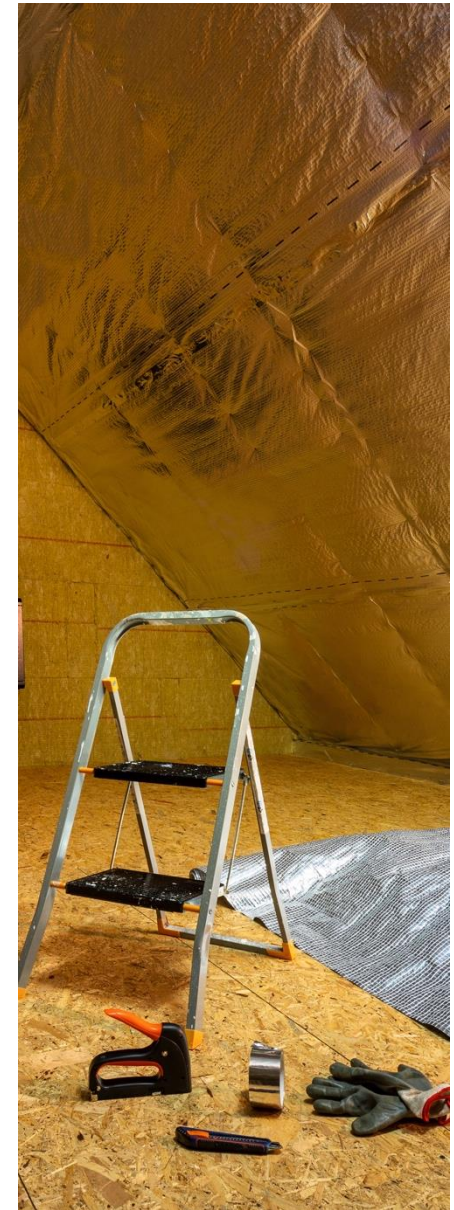
- **Applicability:** New single-family homes
 - Prescriptive alternative package in Climate Zones 4 & 8-16 to Option B (Table 150.1-A & Section 150.1(c)9)
 - Exception to mandatory roof deck insulation requirement
 - Prescriptive requirement with increased stringency in Climate Zones 1-3 & 5-7
- **Type of change:**
 - Remove Option B requirements for Climate Zones 1-3 & 5-7
 - Modification to compliance software (performance pathway) used for new home compliance, and for existing homes where all ducts are being replaced
- **Description of pathway:**
 - Ducts installed over ceiling and/or trusses and fully covered by R-49 or R-60 ceiling insulation
 - Some climate zones will have additional requirements
 - Simplified performance modeling and verification

Current Prescriptive Code Requirements

Title 24, Part 6 Requirements (Subchapter 8, Section 150.1(c) and Table 150.1-A):

- **Option B requires:**
 - R-19 insulation below the roof deck in Climate Zones 4 and 8 through 16
 - R-38 ceiling insulation in all zones except 3 and 5 through 7 (otherwise R-30)
- **Option C requires:**
 - Ducts in conditioned space
 - R-38 insulation in Zones 1 and 11 through 16
 - Radiant barrier in all zones except 1 and 16

Compliance credit is currently available for buried ducts and is modeled using R-values in Single-Family Residential ACM Reference Manual, Tables 15-20



Context and History

Why are we proposing this measure?

- Duct burial is a demonstrated means of improving distribution efficiency
- Readily available products, industry expertise, and software modeling components
- Simplification of modeling, installation, and verification can substantially reduce compliance and verification challenges
 - Entry of duct designs into compliance software not required
 - Inspections reduced to visual verification that duct layout is consistent with plans and maximum supply duct diameter not exceeded (prior to insulation installation)



Context and History

- Researched under the U.S. DOE Building America program
- Introduced as a compliance option in the 2016 Title 24, Part 6 Standards
- Included in 2018 & 2021 IECC (R403.3.3) - Assigns R-25 to ducts surrounded by min. R-30 insulation and covered with ≥ 3.5 inches
- Tables in the Alternative Calculation Method (ACM) Reference Manual underestimate effective R-values
- Very low apparent utilization by California builders



Credit: Home Innovation Research Labs



Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

Current Market

- Attics are the most common locations for ducts and air handlers/furnaces

Market Trends

- Ducts are not always designed to ACCA standards, but new tools are available to simplify designs and may increase compliance with sizing requirements
- Insulating the roof deck is an additional expense and subject to CalOSHA safety requirements
- Uptake of the buried duct compliance option is low due to complexity of model inputs and verification requirements

**Do you agree with
this description?
What else should be
known?**

**Stakeholder
input needed:**

How common is it to install buried ducts? What can be done to increase use?

Will proposed simplification of compliance and enforcement make buried ducts more attractive than High-Performance Attic (Option B)?

Are there differences in costs between traditional trunk/branch vs. radial duct design?



Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Attic insulation level, type, and duct insulation will determine “allowable” duct diameters (Example: R-49 attic insulation and R-8 duct insulation will require ≤ 10 inches in fiberglass insulation. R-60 attic and R-6 duct insulation allow for up to 16 inches)
- Will require duct design to allow for fully buried ducts within the attic insulation (ACCA Manual D or equivalent can help to optimize duct diameters for full burial)
- Larger duct diameters can be utilized with increased attic insulation allowing for full burial.
- R-49 or R-60 blown-in insulation will also improve envelope performance
- Cannot be used in cathedral (vaulted) ceilings

**Do you agree with this description?
What else should we know?**

Stakeholder input needed:

Installation/design issues with maximum duct diameter requirements, or any practical challenges or benefits resulting from proper duct design?

Will installation of buried ducts require higher trade skills?

Any cost or verification challenges?

Energy and Cost Impacts Per Unit

Methodology and Assumptions

- Energy Savings
- Cost Impacts
 - Incremental costs
 - Energy cost savings



Methodology for Energy Impacts Analysis

- **Various simulation tools used:**

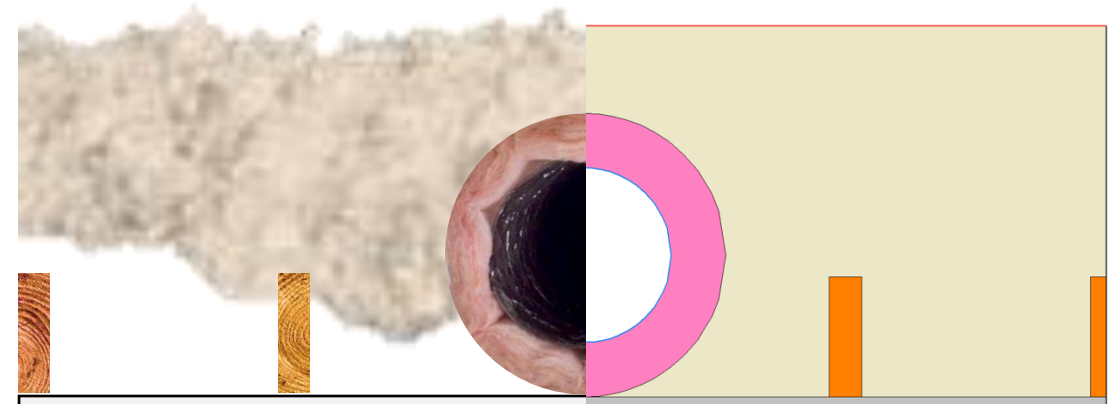
- Kwik Model: Used for ACCA Manuals J, D, and S sizing and duct design
- THERM: Used for effective R-values for buried ducts
- CBECC-Res: Used for whole-house energy analysis

- **Prototypes used:**

- Single-family 1-story, 2,100 ft²
- Single-family 2-story, 2,700 ft²

- **Climate zones:**

- R-49 or R-60 attic insulation in all zones
- Radiant barriers in all zones except 1 & 16



- Additional requirements evaluated such as duct air leakage, HRV and roof solar reflectance.

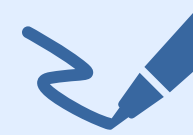
Assumptions for Standard and Proposed Designs

Climate Zones 4, 8-16: Equivalency



Standard Design

- Complies with 2022 Prescriptive Option B
 - R-38 attic ceiling insulation
 - R-19 below-roof deck insulation
- Suspended duct design with default supply duct surface areas



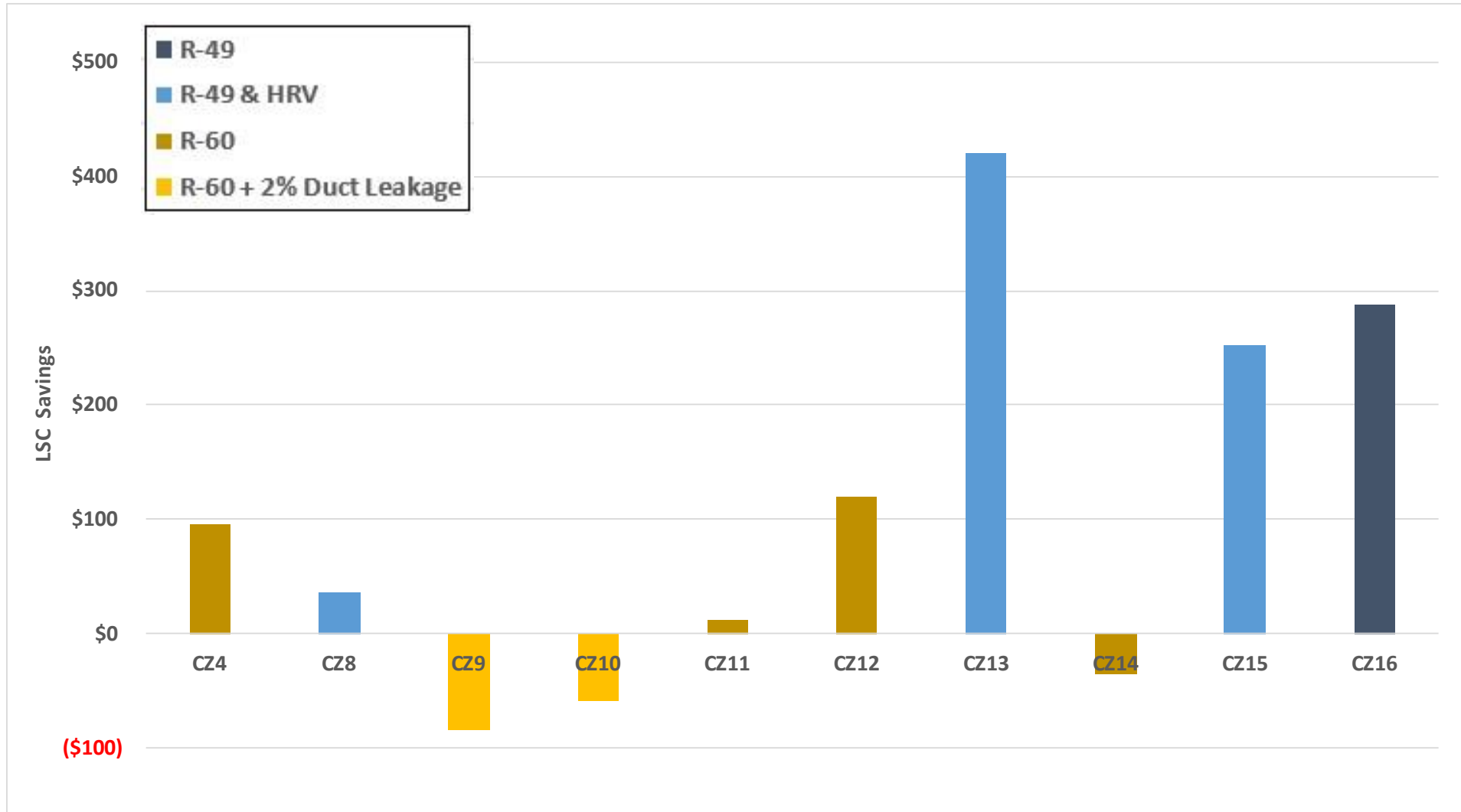
Proposed Design

- No roof deck insulation (no mandatory requirement)
- Radiant barrier (except CZ16)
- R-6 ducts fully buried
- Supply ducts resting on the ceiling or bottom truss cords

Cases evaluated:

- R-49/R-60 attic insulation
- 2% tested duct leakage
- Heat recovery ventilator (HRV) with 0.7 W/cfm and 67% sensible recovery efficiency
- Increased roof solar reflectance

Climate Zones 4, 8-16 Modeling Results



- Equivalent package varies by CZ
- Alternative to HRV is higher roof solar reflectance (0.35 – 0.40)

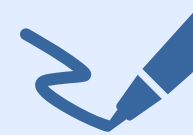
Assumptions for Standard and Proposed Designs

Climate Zones 1-3, 5-7: Increased Stringency



Standard Design

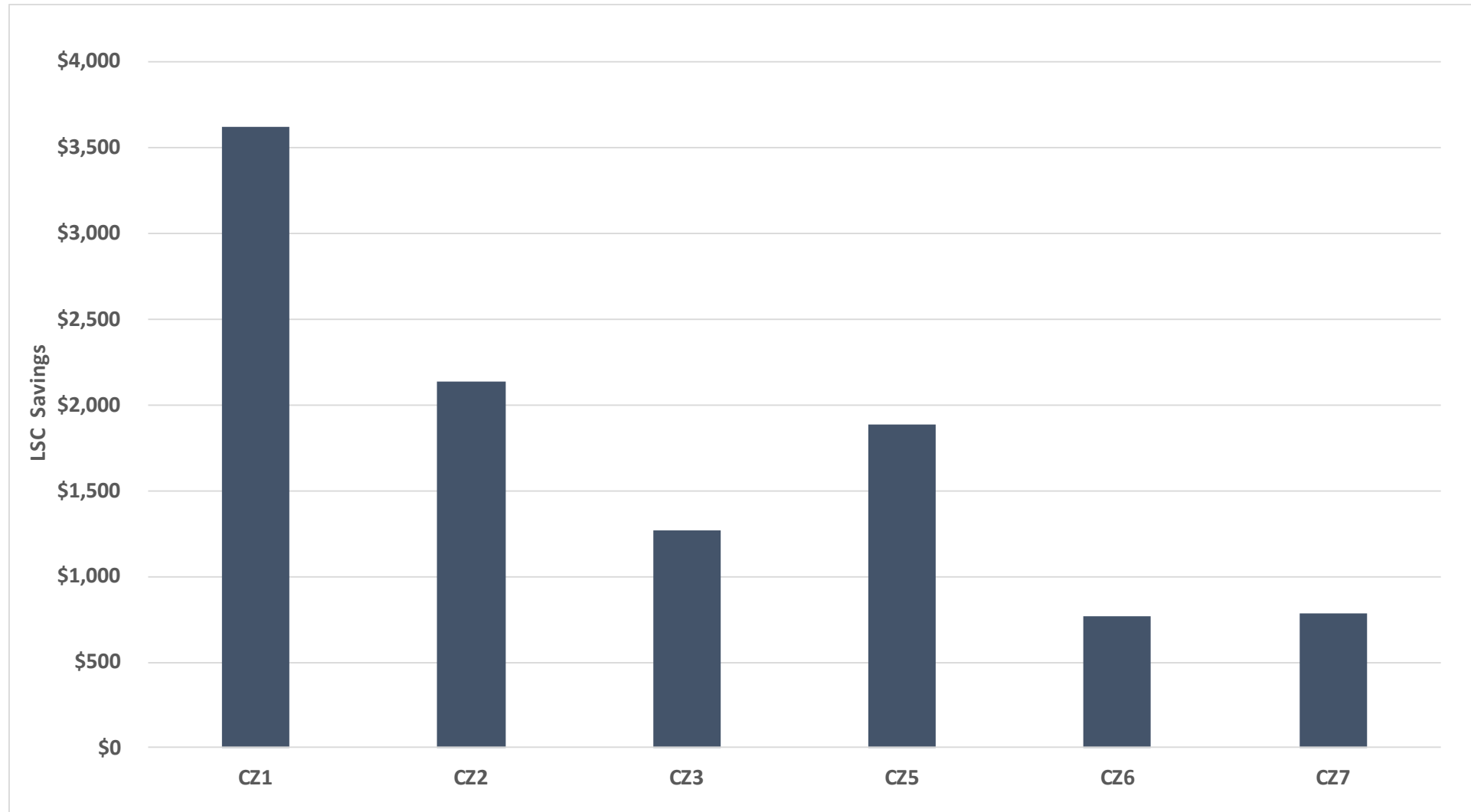
- Complies with 2022 Prescriptive Option B
 - R-30 or R-38 attic ceiling insulation
 - No roof deck insulation
- Suspended duct design with default supply duct surface areas



Proposed Design

- Ducts fully buried, R-6 or R-8
- Supply ducts resting on the ceiling or bottom truss cords
- R-49 attic ceiling insulation

Climate Zones 1-3, 5-7 Modeling Results



Incremental Costs (Climate Zones 1-3, 5-7) Over 30 Year Period of Analysis

Incremental First Cost	
R-49 vs R-30 insulation	\$0.44/sqft ceiling
R-49 vs R-38 insulation	\$0.28/sqft ceiling
Duct Design	
Burying Ducts	\$0
Verification	\$300 per home

Total incremental cost (labor + material) over 30-year period of analysis:

\$934 – \$1,219 for R-30 base

\$699 – \$878 for R-38 base

Cost data came from previous CASE analysis.

Looking for cost feedback on:

- Attic insulation
- Duct design
- HERS rating



Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process



1. Design Phase

- Designer ensures that duct design will result in full burial in ceiling insulation
- Complete compliance model calculations using simplified buried duct specification



2. Permit Application Phase

Submit permit application package with CF1R (including worksheet with ACCA Manual J, S, and D calculations if applicable) and new buried duct form to the enforcement agency.



3. Construction Phase

- Install ducts over ceiling (encouraged) and over joists
- Confirm duct diameter & R-value and conduct testing to verify duct leakage
- Blow in attic insulation and complete QII
- Submission of CF2R



4. Inspection Phase

Building inspector verifies that required CF3Rs are completed

Compliance and Verification

Changes to buried duct compliance process:

- Detailed duct designs not required to be entered in compliance software (average R-value is assumed)
- Only blown fiberglass insulation with a rating of R-49 or R-60 is permitted

HERS verifications:

- Before attic insulation: Verify R-6 or R-8 ducts and maximum duct diameter, leakage testing
- After attic insulation: QII to verify R-49/R-60 & complete coverage of ducts by insulation

Are the proposed compliance and verification approaches sufficiently simplified to reduce barriers to the use of buried ducts?



Software Updates

Current buried duct compliance method:

- The diameter, length, and R-value of each duct segment is entered in compliance software
- The software calculates distribution efficiency and duct loss/gain based on the surface area, and the effective R-value of each duct segment using ACM Manual Tables 15 – 20

Proposed:

- The software will utilize an average R-value – detailed entry of duct designs will not be required
- Current standard assumptions for duct surface area, and averaging R-values will be used to calculate distribution efficiency and duct loss/gain
- Updated ACM Tables for effective R-values

Details to be provided in Appendix C of the CASE Report.

Review of Code Language Markup

- Draft Code Change Language



Draft Code Change Language

Title 24, Part 6, Subchapter 7, Section 150.0(a)1:

- Add 3rd exception that treats fully buried ducts the same as ducts in conditioned space

SUBCHAPTER 7 – SINGLE-FAMILY RESIDENTIAL BUILDINGS – MANDATORY FEATURES AND DEVICES

— SECTION 150.0 – Mandatory Features and Devices

(a) **Roof deck, ceiling and rafter roof insulation.** The opaque portions of roof decks separating attic spaces from ambient air, and ceilings or rafter roofs separating conditioned spaces from unconditioned spaces or ambient air, shall meet the requirements of Items 1 through 4 below:

1. In Climate Zones 4 and 8 through 16, roof decks in newly constructed attic systems shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.184.

Exception to Section 150.0(a)1:

- i. The space-conditioning system air handler and ducts are located entirely in conditioned space below the ceiling separating the occupiable space from the attic; or
- ii. The space-conditioning system air handler is located in unconditioned space and has 12 linear feet or less of supply duct, including the length of the air handler and the plenum, located in unconditioned space, with all other portions of the supply ducts located in conditioned space below the ceiling separating the occupiable space from the attic.

- iii. **Buried ducts...**

Draft code language available for review in Handouts and downloadable.

Draft Code Change Language

Title 24, Part 6, Subchapter Section 150.1(c) under 1.B. and 9:

- Add 3rd prescriptive compliance option for fully buried ducts

SUBCHAPTER 8 – SINGLE-FAMILY RESIDENTIAL BUILDINGS - PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

— SECTION 150.1(c) – Prescriptive standards/component packages

1. Insulation.

- B. Roof and ceiling insulation shall be installed in a ventilated attic with an R-value equal to or greater than that shown in Table 150.1-A meeting options ii or iii below.
 - i. Option A: **RESERVED**.
 - ii. Option B: A minimum R-value of insulation installed between the roof rafters in contact with the roof deck and an additional layer of ceiling insulation located between the attic and the conditioned space when meeting Section 150.1(c)9A; or
 - iii. Option C: A minimum R-value of ceiling insulation located between the attic and the conditioned space when meeting Section 150.1(c)9B.
 - iv. **Option D: TBD**

9. **Space conditioning distribution systems.** All space conditioning systems shall meet all applicable requirements of A or B below:

- A. High performance attics. Air handlers or ducts are allowed to be in ventilated attic spaces when the roof and ceiling insulation level meet Option B in Table 150.1-A. Duct insulation levels shall meet the requirements in Table 150.1-A.
- B. Duct and air handlers located in conditioned space. Duct systems and air handlers of HVAC systems shall be located in conditioned space, and confirmed by field verification and diagnostic testing to meet the criterion of Reference Residential Appendix Section RA3.1.4.3.8. Duct insulation levels shall meet the requirements in Table 150.1-A.
- C. **Buried ducts...**

Draft code language available for review in Handouts and downloadable.



Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at <https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency>

Comments on this measure are due by February 28. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Simon Pallin, PhD

Buried Ducts / Envelopes CASE Lead

(530)316-1503

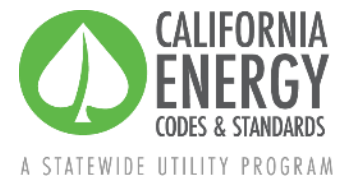
spallin@frontierenergy.com

David Springer

Principal Consultant

(530)322-9143

dspringer@frontierenergy.com





TITLE 24, PART 6

2025 CODE CYCLE

Prescriptive Code Requirements for Cathedral Ceilings and High-Performance Attics

Codes and Standards Enhancement (CASE) Proposal
Single-Family | High-Performance Envelope



Simon Pallin
January 1st, 2023



Background

- Code Change Proposal
- 2022 Code Requirements
- Context and History

Proposed Code Change

New prescriptive option: **minimum-R ceiling/roof deck insulation.**

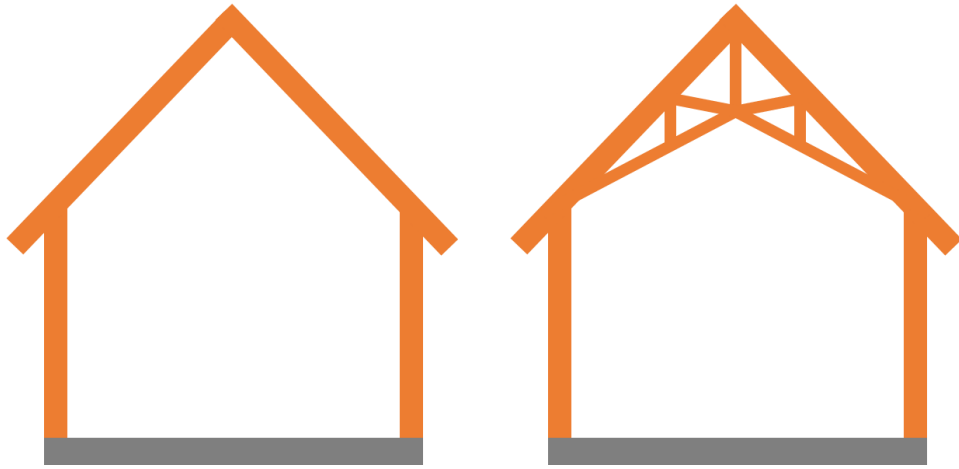
- R-38 in Climate Zone 1 through 4, and 8 through 16
- R-50 in Climate Zone 5 through 7



Title 24, Part 6, Subchapter 8, Section 150.0(a) - Table 150.1-A

Context and History

Cathedral ceilings lack attic space and a flat horizontal surface that easily accommodate insulation



Why are we proposing this measure?

- Cathedral ceilings are common in small homes and Additional Dwelling Units (ADUs), but are penalized under Performance approach and have no prescriptive alternative
- Cathedral ceilings can offer net energy benefits if designed properly

More evaluation of ventilation requirements needed.



Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

Current Market

- Well established market including materials and design practices

Market Trends

- Increasingly common as a feature in ADUs

Market Barriers

- No barriers identified

**Do you agree with
this description?
What else should be
known?**



Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

Technical Considerations

- QII may be more difficult with deck (vs. attic) insulation
- For batt insulation, roof rafter dimensions must allow for R-30/38
- R-values requirements higher than R-38 will call for spray foam, rigid insulation, blown-in, or in combination with batt insulation.
- No significant changes to standard design practices
- Insulation material must directly face the roof deck (no ventilation requirements between insulation and roof deck but must comply with R806.5 Unvented Attic and Unvented Enclosed Rafter Assemblies)

Technical Barriers and Potential Solutions

- No known technical barriers

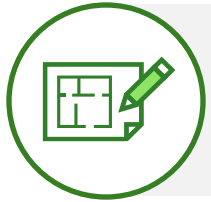
**Climate Zones 5–7
will require R-50
insulation. Do you
foresee design or
practical challenges?**



Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process



1. Design Phase

Specify assembly components meeting new insulation requirements



2. Permit Application Phase

Not significant change identified



3. Construction Phase

Not significant change identified



4. Inspection Phase

Inspection equivalent to that of HPA below-deck insulation

Compliance and Verification

- Proposed measure does not eliminate design options nor aggravate the compliance process.
- Verification not affected—below roof deck insulation already common practice and present in code for Option B roof insulation prescriptive requirements.



Market Actors

Market actors involved in implementing this measure include:

- Designers
- Energy Consultants
- Builders
- Installers
- Plans Examiners
- Building Inspectors
- HERS Raters
- Manufacturers



Software Updates

- Standard Design currently has a cathedral ceiling option—proposed insulation requirements to be added.
- Update to reflect ACM section changes:
 - 2.5.6.2 Non-Attic (Cathedral) Ceiling and Roof
 - 2.6.1. Attic Components (Solar Reflectance and Thermal Emittance sections)



Review of Code Language Markup

- Draft Code Change Language



Draft Code Change Language

PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR SINGLE-FAMILY RESIDENTIAL BUILDINGS

(c) **Prescriptive standards/component packages.** Buildings that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 150.1-A. In Table 150.1-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

1. Insulation.
- i. Roof and ceiling insulation shall be installed in a ventilated attic with an R-value equal to or greater than that shown in Table 150.1-A meeting options ii or iii below.
1. Option A: **RESERVED.**
 2. Option B: A minimum R-value of insulation installed between the roof rafters in contact with the roof deck and an additional layer of ceiling insulation located between the attic and the conditioned space when meeting Section 150.1(c)9A; or
 3. Option C: A minimum R-value of ceiling insulation located between the attic and the conditioned space when meeting Section 150.1(c)9B.
 4. Option D: Buried Ducts...
 5. Option E: A minimum R-value of cavity insulation installed between the roof rafters and/or continuous roof deck insulation when meeting Section 150.1(c)9B.



Discussion and Next Steps

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