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Docket Number:	19-BSTD-03
Project Title:	2022 Energy Code Pre-Rulemaking
TN #:	234602
Document Title:	September 1, 2022 Pre-Rulemaking Workshop Presentation
Description:	September 1, 2022 Pre-Rulemaking for Building Energy Efficiency Standards workshop presentation for Residential Energy Savings and Process Improvements for Alterations and Additions
Filer:	Haile Bucaneg
Organization:	California Energy Commission
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2022 Pre-Rulemaking for Building Energy Efficiency Standards

Payam Bozorgchami, P.E.

September 1, 2020

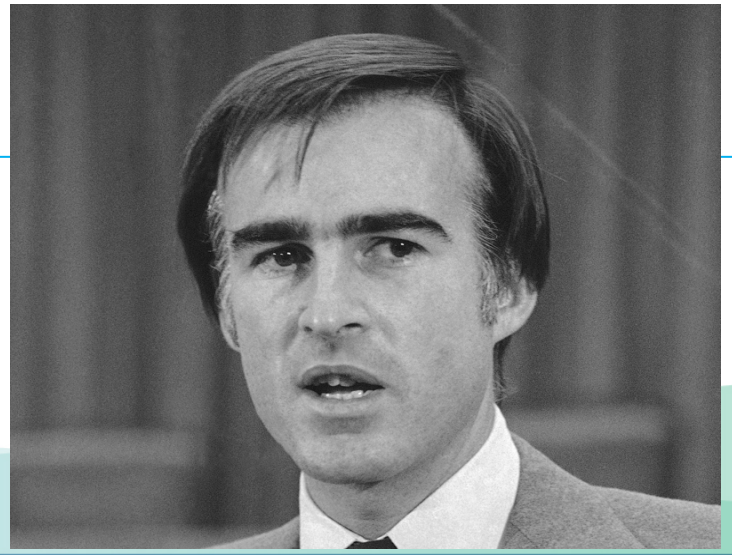
Start Time: 9:00 AM

What We Will Cover Today

- Some Basic, Background
- How Title 24, Part 6 is Developed
- **Michael Shewmaker**
  - Roof Replacements & Recover
  - Attic Insulation
- **Cheng Moua, P.E.**
  - Electric Space Heating Replacements
  - Duct Sealing Leakage
  - Duct Insulation
  - Duct Sealing and Insulation Trigger
- **Danny Tam**
  - Prescriptive Alteration to Electric Water Heater

Authority & Process

- **Public Resources Code (PRC 25402):** Reduction of wasteful, uneconomic, inefficient, or unnecessary consumption of energy
  - (a)(1) Prescribe, by regulation, lighting, insulation, climate control system, and other building design and construction standards that increase the efficiency in the use of energy and water…
  - Warren Alquist Act Signed into law in 1974 by Governor Ronald Reagan and launched by Governor Jerry Brown in 1975 which mandates updates Building Efficiency Standards and requires the building departments to enforce them through the permit process.

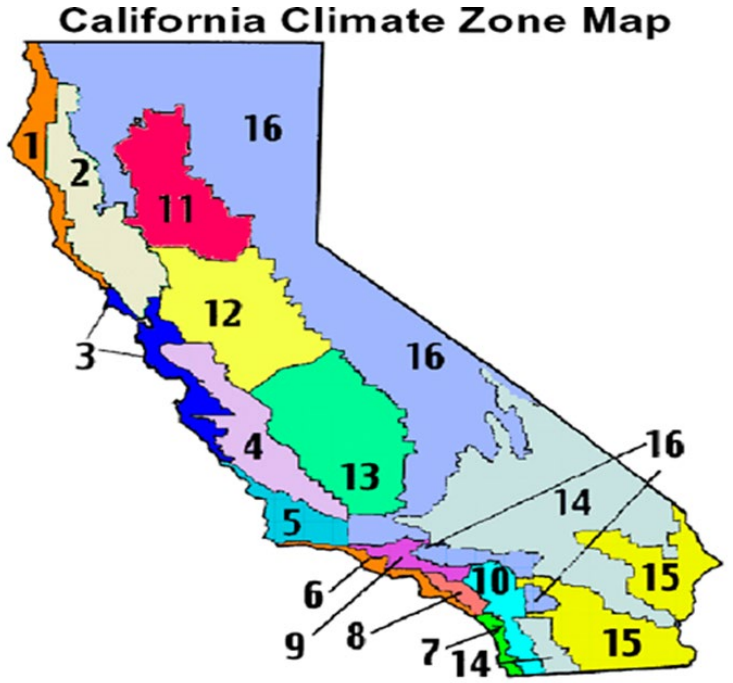


Goals of the California Energy Code

1. Increase building energy efficiency cost-effectively
2. Contribute to the state's GHG reduction goals
3. Enable pathways for all-electric buildings
4. Reduce residential building impacts on the electricity grid
5. Promote demand flexibility and self-utilization of PV generation
6. Provide tools for local government reach codes

Process Used to Updated Energy Codes

CEC staff, with input from utility partners and industry stakeholders, develop the triennial standards update



Opportunities for participation

- Utility-Sponsored Stakeholder Meetings
- CEC-Sponsored Workshops

Standards must be cost-effective

- Life-Cycle Costing Methodology
- Time Dependent Valuation (TDV)

2022 Standards Process

2022 STANDARDS UPDATE SCHEDULE	
DATE	**MILESTONES**
November 2018 - November 2019	Updated Weather Files
November 2018-December 2019	Metric Development
November 2018-July 2019	Measures Identified and approval
August 2019 to October 2020	Stakeholder meeting/workshop & final staff workshop
August 2020-October 2020	CASE Reports submitted to the CEC
February 2021	45-day Language Hearings
July 2021	Adoption of 2022 Standards at a Business Meeting
July 2021 to November 2021	Staff work on Software, Compliance Manuals, Electronic Documents Available to Industry
December of 2021	Approval of the Manuals
January 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January 1, 2023	Effective Date

Tentative Pre-Rulemaking Schedule

- **September 1**
  - Energy Savings and Process Improvements for Alterations and Additions
    - Roof deck insulation for low-slope roofs
    - Prescriptive attic insulation for alterations
    - Prescriptive duct sealing
    - Electric resistance water heating
    - Electric resistance space heating
    - 40-ft trigger for prescriptive duct requirements
    - Cool roof for steep-slope roofs
    - Cool roof for low-slope roof
- **September 9**
  - Nonresidential Grid Integration
  - Controlled Receptacle, CEA Proposal
- **September 10**
  - Verification Testing
- **September ~~17~~ moved to 21**
  - Indoor Air Quality Roundtable discussion with the outside world
- **September 22**
  - Nonresidential Indoor Lighting
  - Outdoor lighting
  - Daylighting
- **September 23**
  - Computer Room Efficiencies
  - Pipe Sizing and Leak Testing for Compressed Air Systems
  - Refrigeration System Operation

Tentative Pre-Rulemaking Schedule (Cont)

- **September 29**
  - Air Distribution
  - Nonresidential HVAC Controls
- **September 30 (TBD for Verification Testing)**
  - Controlled Environmental Horticulture
- **October 1**
  - Multifamily Domestic Hot Water
  - Multifamily Restructuring
- **October 6 and November 17**
  - Solar Photo Voltaic and Electrification
  - Multifamily All Electric
- **October 13**
  - Nonresidential High Performance Envelope
- **October 15 Place holder (May get pushed backed based on the Roundtable results from the September ~~17~~ 21)**
  - Indoor Air Quality Roundtable discussion with the outside world

Key Web-Link

2022 Title 24 Utility-Sponsored Stakeholder
http://title24stakeholders.com/

Building Energy Efficiency Program
http://www.energy.ca.gov/title24/

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

NOTE: For this workshop comments To Be Submitted By September 16, 2020

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Comments For Todays Workshop

Due Date September 16, 2020 By 5:00 PM

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

Questions?

2022 Pre-Rulemaking Workshop

Residential Additions and Alterations – Envelope Measures

Presenter: Michael Shewmaker

September 1, 2020

Acknowledgements

- Special thanks to Alea German and Bill Dakin, Frontier Energy.
  - As well as, Joshua Pereira, Ben White (Frontier Energy), Vrushali Mendon (Resource Refocus); and Elizabeth McCollum (TRC)

List of Envelope Measures

1. Roof Replacements & Recover
   i. Cool Roofs at Roof Replacement & Recover
   ii. Roof Insulation at Low-Sloped Roof Replacement & Recover

2. Attic Insulation
   i. Attic Insulation for Alterations
   ii. Attic Insulation for Additions

Roof Replacements & Recover

Cool Roofs & Insulation

Cool Roofs at Roof Replacement & Recover

Existing 2019 Code Requirements

- Section 150.2(b)1Ii
  - Low-rise residential buildings with steep-sloped roofs, in Climate Zones 10 through 15 shall have a minimum aged solar reflectance of **0.20** and a minimum thermal emittance of **0.75**, or a minimum SRI of **16**.

- Section 150.2(b)1Iii
  - Low-sloped roofs in Climate Zones 13 and 15 shall have a 3-year aged solar reflectance equal or greater than **0.63** and a thermal emittance equal or greater than **0.75**, or a minimum SRI of **75**.

Existing 2019 Code Requirements

		Climate Zones															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Low-Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
	Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
Steep-Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	NR
	Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	0.75	0.75	0.75	0.75	0.75	NR

What is Being Proposed for Single Family?

We are not proposing new values, but rather expanding the current requirements to more climate zones where cost-effective.

- Steep-sloped roofs: New CZs 4, 8 & 9
  - Aged solar reflectance/thermal emittance **0.20/0.75**; or
  - Solar Reflectance Index (SRI) **16**
- Low-sloped roofs: New CZs 4, 6-12 & 14
  - Aged solar reflectance/thermal emittance **0.63/0.75**; or
  - Solar Reflectance Index (SRI) **75**

What is Being Proposed for Single Family?

		Climate Zones														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Low-Sloped	Aged Solar Reflectance	NR	NR	NR	0.63	NR	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	NR
	Thermal Emittance	NR	NR	NR	0.75	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Steep-Sloped	Aged Solar Reflectance	NR	NR	NR	0.20	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
	Thermal Emittance	NR	NR	NR	0.75	NR	NR	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR

What is Being Proposed for Multifamily?

We are not proposing new values, but rather expanding the current requirements to more climate zones where cost-effective.

- Steep-sloped roofs: New CZs 2, 4, 8 & 9
  - Aged solar reflectance/thermal emittance **0.20/0.75**; or
  - Solar Reflectance Index (SRI) **16**
- Low-sloped roofs: New CZs 2, 4, 6-12 & 14
  - Aged solar reflectance/thermal emittance **0.63/0.75**; or
  - Solar Reflectance Index (SRI) **75**

What is Being Proposed for Multifamily?

		Climate Zones															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Low-Sloped	Aged Solar Reflectance	NR	0.63	NR	0.63	NR	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	NR
	Thermal Emittance	NR	0.75	NR	0.75	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Steep-Sloped	Aged Solar Reflectance	NR	0.20	NR	0.20	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
	Thermal Emittance	NR	0.75	NR	0.75	NR	NR	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR

Summary of Exceptions for Steep-Sloped Roofs

1. The following shall be considered equivalent to subsection i:
   a. Buildings with ceilings assemblies with a U-factor lower than or equal to 0.025 or that are insulated with at least R-38 ceiling insulation in an attic; or
   b. Buildings with a radiant barrier in the attic, where the radiant barrier is not installed directly above spaced sheathing, meeting the requirements of Section 150.1(c)2; or
   c. Buildings that have no ducts in the attic **in Climate Zones 2, 4, 9, 10, 12 & 14**; or
   d. Buildings with R-2 or greater continuous insulation above or below the roof deck.

Summary of Exceptions for Steep-Sloped Roofs

2. **Roof area covered by building integrated photovoltaic panels or building integrated solar thermal panels are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.**

Exceptions for Steep-Sloped Roofs Being Modified and/or Removed

1. Air-space of 1.0 inch (25 mm) is provided between the top of the roof deck to the bottom of the roofing product.
   - **Reason for Removal:** Create consistency in the requirements applying equally to all roofs regardless of product type.
2. The installed roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product.
   - **Reason for Removal**: Create consistency in the requirements applying equally to all roofs regardless of product type.

Exceptions for Steep-Sloped Roofs Being Modified and/or Removed

3. Existing ducts in the attic are insulated and sealed according to Section 150.1(c)9
   - **Reason for Removal:** This exception is no longer valid. Section 150.1(c)9 does not reference duct sealing requirements, only duct insulation requirements. Duct sealing requirements have been moved from Section 150.1 to Section 150.0 and are now mandatory for new homes in addition to the prescriptive requirements for cool roof.
4. Buildings that have no ducts in the attic in Climate Zones 2, 4, 9, 10, 12 & 14
   - **Reason for Modification:** Based on simulations and cost-effective analysis, cool roofs are still cost-effective when ducts were in conditioned space in CZs 8, 11, 13 & 15

Summary of Exceptions of Low-Sloped Roofs

- **Exception 1 to Section 150.2(b)1liia**: The aged solar reflectance can be met by using insulation at the roof deck specified in Table 150.2-B

- **Exception 2 to Section 150.2(b)1liia: Roof area covered by building integrated photovoltaic panels or building integrated solar thermal panels are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.**

Exceptions for Low-Sloped Roofs Being Modified and/or Removed

1. Removed: Buildings with no ducts in the attic.
   - **Reason for Removal:** This exception is eliminated since most buildings with low-sloped roofs do not have an attic space and the cost-effectiveness calculations conducted for the 2022 CASE report are based on a building with ducts in conditioned space.

Exceptions for Low-Sloped Roofs Being Modified and/or Removed

2. Modified: Exception 2 – The aged solar reflectance can be met by using insulation at the roof deck specified in Table 150.2-B.
   - **Reason for Modification:** Exception 2 allows for trade-offs between the aged solar reflectance and above roof deck insulation. Table 6 is revised to reflect the new roof insulation requirements.

Proposed Values for Table 150.2-B

Minimum Aged Solar Reflectance	Roof Deck Continuous Insulation R-value (Climate Zones 6-7)	Roof Deck Continuous Insulation R-value (Climate Zones 2, 4, 8-15)
0.60	R-2	R-16
0.55	R-4	R-18
0.50	R-6	R-20
0.45	R-8	R-22
No requirement	R-10	R-24

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with two exceptions for alterations:
    1. For single family, the existing condition building infiltration assigned to the existing home (10 ACH50) is not reflected in the CBECC-Res Standard Design calculation per the ACM rules.

    2. For multifamily, the Standard design applied in this analysis differs from that calculated from the CBECC-Res software in one respect. Ductwork was located within the vented attic, while the CBECC-Res Standard Design for multifamily buildings assumes that ductwork is located within conditioned space.

Energy Savings Methodology

- Software used for evaluation: 2022 CBECC-Res RV
- Prototypes used for evaluation:
  - Single Family, 1,665 ft^2 (single story; 8-ft ceilings)
    1. Steep-sloped; and
    2. Low-sloped (cathedral ceiling)
  - Multifamily, 6,960 ft^2 (two-story; 8-unit apartment building with individual HVAC & DHW systems)
    1. Steep-sloped; and
    2. Low-sloped (cathedral ceiling)

Per-Unit Energy Impacts Results – First Year

- Energy savings and peak demand reductions per unit are presented in the following tables/slides.

Steep-Sloped Cool Roof First-Year Energy Impacts Per Home – Single Family

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-4	0.000	-4.6	-1,532
2	28	0.017	-1.1	1,615
3	3	0.008	-1.5	499
4	55	0.051	-0.9	2,747
5	2	0.000	-1.5	-283
6	43	0.034	-0.5	1,632
7	38	0.029	-0.4	1,315
8	68	0.027	-0.1	3,596
9	63	0.044	-0.2	3,546
10	-	-	-	-
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-

Steep-Sloped Cool Roof First-Year Energy Impacts Per Dwelling Unit – Multifamily

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	0	0.000	-0.6	-200
2	15	0.005	-0.1	948
3	4	0.003	-0.2	261
4	22	0.013	-0.1	1,488
5	3	0.001	-0.2	78
6	18	0.010	-0.1	618
7	18	0.005	0.0	505
8	28	0.003	0.0	1,618
9	27	0.020	0.0	1,114
10	-	-	-	-
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-

Low-Sloped Cool Roof First-Year Energy Impacts Per Home – Single Family

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-66	-0.001	-81.2	-27,989
2	228	0.164	-42.1	3,413
3	18	0.043	-31.8	-2,631
4	470	0.378	-25.8	12,920
5	-2	0.002	-37.8	-11,622
6	365	0.255	-14.0	10,023
7	330	0.270	-11.6	8,558
8	636	0.315	-17.4	22,378
9	563	0.383	-21.8	14,868
10	701	0.275	-22.6	16,966
11	706	0.340	-28.7	17,882
12	529	0.368	-31.0	13,203
13	-	-	-	-
14	644	0.350	-41.9	13,886
15	-	-	-	-

Low-Sloped Cool Roof First-Year Energy Impacts Per Dwelling Unit – Multifamily

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-7	0.001	-15.3	-5,229
2	107	0.052	-8.0	2,175
3	28	0.022	-5.5	244
4	135	0.088	-4.7	3,097
5	27	0.020	-6.5	-1,027
6	126	0.063	-2.2	3,228
7	121	0.070	-1.5	3,228
8	194	0.073	-3.2	5,916
9	174	0.089	-4.0	4,550
10	204	0.058	-4.6	4,750
11	185	0.066	-5.9	4,594
12	157	0.092	-6.3	4,159
13	-	-	-	-
14	174	0.045	-8.8	3,950
15	-	-	-	-

Energy Cost Savings Results – 30 Year

- Per-unit energy cost savings for newly constructed buildings and alterations that are realized over the 30-year period of analysis are presented in 2023 dollars in the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Steep-Sloped Cool Roof 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Home – Single Family

Climate Zone	30-Year TDV Electricity Cost Savings (2023 $)	30-Year TDV Natural Gas Cost Savings (2023 $)	Total 30-Year TDV Energy Cost Savings (2023 $)
1	-$17	-$248	-$265
2	$343	-$63	$279
3	$176	-$89	$86
4	$527	-$52	$475
5	$35	-$84	-$49
6	$314	-$32	$282
7	$251	-$23	$228
8	$631	-$9	$622
9	$625	-$12	$614
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-

Steep-Sloped Cool Roof 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Multifamily

Climate Zone	30-Year TDV Electricity Cost Savings (2023 $)	30-Year TDV Natural Gas Cost Savings (2023 $)	Total 30-Year TDV Energy Cost Savings (2023 $)
1	-$2	-$33	-$35
2	$169	-$5	$164
3	$57	-$12	$45
4	$262	-$5	$257
5	$24	-$11	$14
6	$111	-$5	$107
7	$90	-$3	$87
8	$280	$0	$280
9	$193	$0	$193
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-

Low-Sloped Cool Roof 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Home – Single Family

Climate Zone	30-Year TDV Electricity Cost Savings (2023 $)	30-Year TDV Natural Gas Cost Savings (2023 $)	Total 30-Year TDV Energy Cost Savings (2023 $)
1	-$317	-$4,525	-$4,842
2	$3,065	-$2,474	$590
3	$1,420	-$1,875	-$455
4	$3,773	-$1,538	$2,235
5	$199	-$2,209	-$2,011
6	$2,587	-$853	$1,734
7	$2,195	-$714	$1,481
8	$4,928	-$1,057	$3,871
9	$3,889	-$1,316	$2,572
10	$4,309	-$1,374	$2,935
11	$4,790	-$1,697	$3,094
12	$4,116	-$1,832	$2,284
13	-	-	-
14	$4,923	-$2,520	$2,402
15	-	-	-

Low-Sloped Cool Roof 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Multifamily

Climate Zone	30-Year TDV Electricity Cost Savings (2023 $)	30-Year TDV Natural Gas Cost Savings (2023 $)	Total 30-Year TDV Energy Cost Savings (2023 $)
1	-$48	-$856	-$905
2	$850	-$474	$376
3	$370	-$328	$42
4	$819	-$283	$536
5	$203	-$381	-$178
6	$694	-$135	$558
7	$653	-$95	$558
8	$1,218	-$194	$1,023
9	$1,028	-$241	$787
10	$1,103	-$281	$822
11	$1,145	-$351	$795
12	$1,096	-$376	$719
13	-	-	-
14	$1,215	-$531	$683
15	-	-	-

Incremental Cost – Steep-Sloped Roofs

Incremental costs for this measure reflect the difference between replacing a standard roof that does not meet the prescriptive minimum aged solar reflectance and thermal emissivity values with one that does.

- Material cost: $0-$0.55/ft^2
  - Relative to non-cool roof products
- Replacement/maintenance cost: $0.105/ft^2
  - Assumes an average lifetime of 20-years
- No incremental labor cost for this measure

Total Incremental Cost - Steep-Sloped Roofs

Steep-sloped roofs: (asphalt shingle cool roof)

- Incremental Cost: $0.189/ft^2
- Useful Life: 20-years
- Present Value of Replacement Cost at Year 20: $0.105/ft^2
- Present Value of Remaining Useful Life at Year 30: -$0.039/ft^2
- Total Incremental Cost: **$0.255/ft^2**

Incremental Cost – Low-Sloped Roofs

Incremental costs for this measure reflect the difference between replacing a standard roof that does not meet the prescriptive minimum aged solar reflectance and thermal emissivity values with one that does.

- Material cost: $0.17-$0.84/ft^2
  - Relative to non-cool roof products
- Replacement/maintenance cost: $0.337/ft^2
  - Assumes an average lifetime of 15-years
- No incremental labor cost for this measure

Total Incremental Cost – Low-Sloped Roofs

Low-sloped roofs: (modified bitumen cool roof)

- Incremental Cost: $0.525/ft^2
- Useful Life: 15-years
- Present Value of Replacement Cost at Year 15: $0.337/ft^2
- Total Incremental Cost: **$0.862/ft^2**

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 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.
  - Note: Design costs were not included nor were the incremental costs of code compliance verification.

Steep-Sloped Cool Roof Cost-Effectiveness Summary Per Home – Single Family

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	-$265	$460	0.58
2	$279	$460	0.61
3	$86	$460	0.19
4	$475	$460	1.03
5	-$49	$460	0.11
6	$282	$460	0.61
7	$228	$460	0.49
8	$622	$460	1.35
9	$614	$460	1.33
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	$37	$460	0.08

Steep-Slope Cool Roof Cost-Effectiveness Summary Per Dwelling Unit – Multifamily

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	-$35	$133	-0.26
2	$164	$133	1.23
3	$45	$133	0.34
4	$257	$133	1.93
5	$14	$133	0.10
6	$107	$133	0.80
7	$87	$133	0.66
8	$280	$133	2.10
9	$193	$133	1.45
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	$36	$133	0.27

Low-Slope Cool Roof Cost-Effectiveness Summary Per Home – Single Family

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	- $4,842	$1,435	-3.37
2	$590	$1,435	0.41
3	-$455	$1,435	-0.32
4	$2,235	$1,435	1.56
5	-$2,011	$1,435	-1.40
6	$1,734	$1,435	1.21
7	$1,481	$1,435	1.03
8	$3,871	$1,435	2.70
9	$2,572	$1,435	1.79
10	$2,935	$1,435	2.05
11	$3,094	$1,435	2.16
12	$2,284	$1,435	1.59
13	-	-	-
14	$2,402	$1,435	1.67
15	-	-	-
16	-$2,578	$1,435	-1.80

Low-Slope Cool Roof Cost-Effectiveness Summary Per Dwelling Unit – Multifamily

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	-$905	$375	-2.40
2	$376	$375	1.00
3	$42	$375	0.11
4	$536	$375	1.43
5	-$178	$375	-0.47
6	$558	$375	1.49
7	$558	$375	1.49
8	$1,023	$375	2.73
9	$787	$375	2.10
10	$822	$375	2.19
11	$795	$375	2.12
12	$719	$375	1.92
13	-	-	-
14	$683	$375	1.82
15	-	-	-
16	-$322	$375	-0.86

Questions

Roof Insulation at Low-Sloped Roof Replacement & Recover

What is Being Proposed for 2022?

New measure. Would be triggered by the replacement of the exterior surface of an existing roof, including adding a new surface layer on top of an existing surface, where more than 50 percent of the roof is being replaced.

- Would build on existing prescriptive requirement **Section 150.2(b)1Iii**

- Low-sloped roofs: CZs 1, 2, 4 & 8-16 = **R-14 continuous insulation above the roof deck**
  - Roof Assembly U-factor = 0.058

Summary of Proposed Exceptions

1. Existing roofs with a minimum continuous insulation R-value of at least R-10 above or below the roof deck are not required to meet the R-value requirements.
2. Existing roofs with an assembly U-factor lower than or equal to 0.056 or that are insulated with at least R-19 insulation in the roof:
   - Single Family: Climate Zones 1, 2, 4 & 8-10
   - Multifamily: Climate Zones 1, 2, 4, 8-10 & 16

Summary of Proposed Exceptions

3. Continuous insulation over the entire roof deck may be reduced to R-4 where:
   a. Mechanical equipment is located on the roof and adding insulation would reduce the base flashing height to less than that set forth in manufacturer's installation instructions per the California Residential Code Section R900; or
   b. The roof has sidewall or parapet walls and adding insulation would reduce the base flashing height to less than that set forth in the manufacturer's installation instructions as per the California Residential Code Section R900.
      - Note: Certain conditions do apply.

Summary of Proposed Exceptions

4. Where adding insulation would result in the necessity to move existing exterior windows or doors, increased thickness may be reduced over the entire roof.

5. Allowance to use tapered insulation provided that the average thermal resistance equals or exceeds the required value.

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with two exceptions for alterations:
    1. For single family, the existing condition building infiltration assigned to the existing home (10 ACH50) is not reflected in the CBECC-Res Standard Design calculation per the ACM rules.

    2. For multifamily, the Standard design applied in this analysis differs from that calculated from the CBECC-Res software in one respect. Ductwork was located within the vented attic, while the CBECC-Res Standard Design for multifamily buildings assumes that ductwork is located within conditioned space.

Energy Savings Methodology

- Software used for evaluation: 2022 CBECC-Res RV
- Prototypes used for evaluation:
  - Single Family, 1,665 ft^2 (single story; 8-ft ceilings)
    1. Low-sloped (cathedral ceiling)
  - Multifamily, 6,960 ft^2 (two-story; 8-unit apartment building with individual HVAC & DHW systems)
    1. Low-sloped (cathedral ceiling)

Per-unit Energy Impacts Results – First Year

- Energy savings and peak demand reductions per unit are presented in the following tables/slides.

Low-Sloped Roof Insulation First-Year Energy Impacts Per Home – Single Family

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	88	0.002	99.0	36,697
2	451	0.177	64.9	48,635
3	112	0.059	50.4	28,888
4	626	0.295	45.9	44,272
5	91	0.012	48.8	20,929
6	446	0.133	20.6	22,661
7	408	0.117	16.1	16,983
8	805	0.132	22.5	47,519
9	746	0.357	28.5	42,591
10	969	0.136	34.0	47,286
11	1,106	0.288	67.0	68,898
12	823	0.359	61.8	58,791
13	1,389	0.462	45.7	72,261
14	1,006	0.321	68.2	68,864
15	2,078	0.233	14.6	75,524

Low-Sloped Roof Insulation First-Year Energy Impacts Per Dwelling Unit – Multifamily

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	18	0.001	26.4	9,527
2	143	0.040	16.4	12,119
3	41	0.018	12.2	6,490
4	155	0.044	11.3	10,118
5	42	0.015	12.0	5,429
6	124	0.009	4.6	5,107
7	110	0.010	3.1	3,358
8	216	0.009	5.4	11,458
9	198	0.079	7.0	10,022
10	258	0.004	8.5	11,736
11	273	0.053	17.1	16,721
12	216	0.079	15.8	14,538
13	352	0.073	11.8	17,618
14	254	0.020	17.5	16,922
15	510	0.045	3.6	17,826

Energy Cost Savings Results – 30 Year

- Per-unit energy cost savings for newly constructed buildings and additions that are realized over the 30-year period of analysis are presented in 2023 dollars in the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Low-Sloped Roof Insulation 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Home – Single Family

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	$495	$5,853	$6,349
2	$4,491	$3,923	$8,414
3	$1,953	$3,045	$4,998
4	$4,871	$2,788	$7,659
5	$677	$2,944	$3,621
6	$2,659	$1,262	$3,920
7	$1,947	$991	$2,938
8	$6,844	$1,377	$8,221
9	$5,628	$1,740	$7,368
10	$6,104	$2,077	$8,180
11	$7,849	$4,070	$11,919
12	$6,421	$3,750	$10,171
13	$9,713	$2,788	$12,501
14	$7,763	$4,151	$11,914
15	$12,173	$893	$13,066

Low-Sloped Roof Insulation 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Multifamily

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	$95	$1,553	$1,648
2	$1,105	$992	$2,097
3	$382	$741	$1,123
4	$1,066	$685	$1,750
5	$218	$721	$939
6	$604	$280	$883
7	$391	$190	$581
8	$1,651	$331	$1,982
9	$1,308	$426	$1,734
10	$1,508	$522	$2,030
11	$1,851	$1,042	$2,893
12	$1,558	$957	$2,515
13	$2,328	$719	$3,048
14	$1,862	$1,066	$2,927
15	$2,863	$221	$3,084

Incremental Cost

Incremental costs for this measure reflect the difference between installing a new roof on an existing low-sloped roof with and without above roof deck insulation.

- Material cost: $2.12/ft^2
  - Based on cost data found online
- Labor cost: $1.29/ft^2
  - Extrapolated based on costs provided by roofing contractors for installation of above deck insulation on steep-sloped roofs.
- No replacement/maintenance cost for this measure

Total Incremental Cost

- Material Cost: $2.12/ft^2
- Labor Cost: $1.29/ft^2
- Total Incremental Cost: **$3.41/ft^2**

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 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.
  - Note: Design costs were not included nor were the incremental costs of code compliance verification.

Low-Sloped Roof Insulation Cost-Effectiveness Summary Per Home – Single Family

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$6,349	$5,671	1.12
2	$8,414	$5,671	1.48
3	$4,998	$5,671	0.88
4	$7,659	$5,671	1.35
5	$3,621	$5,671	0.64
6	$3,920	$5,671	0.69
7	$2,938	$5,671	0.52
8	$8,221	$5,671	1.45
9	$7,368	$5,671	1.30
10	$8,180	$5,671	1.44
11	$11,919	$5,671	2.10
12	$10,171	$5,671	1.79
13	$12,501	$5,671	2.20
14	$11,914	$5,671	2.10
15	$13,066	$5,671	2.30
16	$9,742	$5,671	1.72

Low-Sloped Roof Insulation Cost-Effectiveness Summary Per Dwelling Unit – Multifamily

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$1,648	$1,481	1.11
2	$2,097	$1,481	1.42
3	$1,123	$1,481	0.76
4	$1,750	$1,481	1.18
5	$939	$1,481	0.63
6	$883	$1,481	0.60
7	$581	$1,481	0.39
8	$1,982	$1,481	1.34
9	$1,734	$1,481	1.17
10	$2,030	$1,481	1.37
11	$2,893	$1,481	1.95
12	$2,515	$1,481	1.70
13	$3,048	$1,481	2.06
14	$2,927	$1,481	1.98
15	$3,084	$1,481	2.08
16	$2,423	$1,481	1.64

Questions

Attic Insulation

For Alterations & Additions

Attic Insulation for Alterations

What is Being Proposed for 2022?

New measure. Would be triggered when an entirely new or complete replacement duct system is installed in a vented attic.

1. Buildings with < R-19 existing insulation
    a. Attic Sealing
    b. Ceiling Insulation
    c. Recessed Cans
2. Buildings with ≥ R-19 existing insulation
    a. Ceiling Insulation
    b. Recessed Cans

What is Being Proposed for 2022?

- Ceiling Insulation
  - R-49 or R-19 depending on climate zone
- Air Sealing
  - All accessible areas of the ceiling plane between the attic and the conditioned space shall be sealed in accordance with Section 110.7 of the standards.
- Recessed downlight luminaires in the ceiling must be covered with insulation to the same depth as the rest of the attic.
  - This requires that fixtures that are not rated for Insulation Contact (IC) be retrofit or a fire rated cover be installed over the attic side of the fixture.

What is Being Proposed for Single Family?

Climate Zones	Existing	Proposed Building with < R-19 existing attic insulation	Proposed Building with ≥ R-19 existing attic insulation
Single Family			
5, 7	R-19	R-19	R-19
6	R-19	R-49	R-19
1, 3	R-19	R-49 & recessed cans	R-19
2, 4, 8-10	R-19	R-49 & recessed cans & air sealing	R-49
11-16	R-19	R-49 & recessed cans & air sealing	R-49 & recessed cans

What is Being Proposed for Multifamily?

Climate Zones	Existing	Proposed Building with < R-19 existing attic insulation	Proposed Building with ≥ R-19 existing attic insulation
Multifamily			
5, 7	R-19	R-19	R-19
1, 3, 4	R-19	R-49 & recessed cans	R-19
9	R-19	R-49 & recessed cans	R-19
8, 10	R-19	R-49 & recessed cans	R-49
2	R-19	R-49 & recessed cans & air sealing	R-49
11-16	R-19	R-49 & recessed cans & air sealing	R-49 & recessed cans

Summary of Proposed Exceptions

1. Dwelling units with at least R-38 existing attic insulation;

2. Dwelling units where the alteration would directly cause the disturbance of asbestos;

3. Dwelling units with knob and tube wiring located in the vented attic;

Summary of Proposed Exceptions

4. Attics with limited vertical height that do not allow the installation of the required insulation R-value may install a lower R-value that maximizes the depth while still meeting code requirements, including required air gaps;

5. Where the attic space above the altered dwelling unit is shared with other dwelling units that are not being altered.

Summary of Proposed Exceptions to Ceiling Insulation Requirements

1. Buildings with at least R-19 existing insulation installed at the ceiling level with third party verification of existing conditions
   - Single Family: CZs 1, 3, & 6
   - Multifamily: CZs 1, 3, 4 & 9

Summary of Proposed Exceptions to Air Sealing Requirements

1. Dwelling units with at least R-19 existing insulation installed at the ceiling level with third party verification of existing conditions;

2. Dwelling units with atmospherically vented space heating or water heating combustion appliances located inside the pressure boundary of the dwelling unit.

Summary of Proposed Exceptions to Recessed Can Insulation Requirements

1. Dwelling units with at least R-19 existing insulation installed at the ceiling level with third party verification of existing conditions in Climate Zones 1-4 & 8-10.

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with two exceptions for alterations:
    1. For single family, the existing condition building infiltration assigned to the existing home (10 ACH50) is not reflected in the CBECC-Res Standard Design calculation per the ACM rules.

    2. For multifamily, the Standard design applied in this analysis differs from that calculated from the CBECC-Res software in one respect. Ductwork was located within the vented attic, while the CBECC-Res Standard Design for multifamily buildings assumes that ductwork is located within conditioned space.

Energy Savings Methodology

- Software used for evaluation: 2022 CBECC-Res RV
- Prototypes used for evaluation:
  - Single Family, 1,665 ft^2 (single story; 8-ft ceilings)
    1. Steep-sloped (roof above attic); and
    2. Low-sloped
  - Multifamily, 6,960 ft^2 (two-story; 8-unit apartment building with individual HVAC & DHW systems)
    1. Steep-sloped (roof above attic); and
    2. Low-sloped

Per-Unit Energy Impacts Results – First Year

- Energy savings and peak demand reductions per unit are presented in the following tables/slides.
  - The energy savings account for the thermal impact of increased insulation and reduced building infiltration. They do not account for any lighting savings from replacing existing incandescent or compact fluorescent recessed can fixtures with LED fixtures.

Attic Insulation for Alterations First-Year Energy Impacts Per Home – Single Family

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	52	0.001	58.6	21,795
2	285	0.134	42.8	33,800
3	68	0.056	32.3	21,845
4	420	0.287	32.0	29,853
5	53	0.001	29.2	13,869
6	283	0.182	13.6	15,984
7	259	0.179	10.1	12,904
8	565	0.231	14.2	31,002
9	516	0.312	18.3	29,937
10	638	0.173	22.8	32,085
11	721	0.260	48.9	45,754
12	559	0.297	42.0	41,009
13	919	0.430	31.4	45,338
14	635	0.146	48.1	44,539
15	1,318	0.281	10.4	47,852

Attic Insulation for Alterations First-Year Energy Impacts Per Dwelling Unit – Multifamily

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	12	0.000	16.9	6,125
2	90	0.028	11.2	7,965
3	24	0.018	8.6	4,646
4	94	0.049	7.6	6,569
5	22	0.013	8.1	3,645
6	75	0.027	3.3	3,419
7	73	0.018	2.2	2,593
8	145	0.026	3.4	6,917
9	132	0.064	4.4	6,012
10	156	0.023	5.3	6,786
11	152	0.014	12.5	10,270
12	133	0.047	10.8	9,549
13	201	0.034	7.9	10,614
14	136	-0.011	12.4	10,077
15	271	-0.001	2.7	10,877

Energy Cost Savings Results – 30 Year

- Per-unit energy cost savings for newly constructed buildings and alterations that are realized over the 30-year period of analysis are presented in 2023 dollars in the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Attic Insulation for Alterations 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Home – Single Family

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	$274	$3,497	$3,771
2	$3,252	$2,595	$5,847
3	$1,820	$1,959	$3,779
4	$3,223	$1,941	$5,165
5	$631	$1,769	$2,399
6	$1,936	$830	$2,765
7	$1,607	$625	$2,232
8	$4,491	$873	$5,363
9	$4,059	$1,120	$5,179
10	$4,156	$1,394	$5,551
11	$4,937	$2,978	$7,915
12	$4,537	$2,558	$7,095
13	$5,922	$1,921	$7,843
14	$4,770	$2,935	$7,705
15	$7,642	$637	$8,278

Attic Insulation for Alterations 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Multifamily

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	$60	$999	$1,060
2	$727	$651	$1,378
3	$283	$521	$804
4	$677	$459	$1,136
5	$143	$488	$631
6	$387	$205	$592
7	$315	$134	$449
8	$987	$209	$1,197
9	$772	$268	$1,040
10	$849	$325	$1,174
11	$1,056	$721	$1,777
12	$1,025	$627	$1,652
13	$1,375	$461	$1,836
14	$1,026	$718	$1,743
15	$1,718	$164	$1,882

Incremental Cost

The incremental cost for this measure reflects the full cost of adding R-49 attic insulation, conducting air sealing of the ceiling floor, retrofitting existing recessed can fixtures that are not rated for insulation contact, and HERS verification of air sealing.

- Material/Labor Cost:
  - Attic insulation: $1.71/ft^2
  - Air Sealing: $0.89/ft^2
  - Replaced Recessed Cans: $69/recessed can
- No replacement/maintenance cost for this measure

Total Incremental Cost

- R-49 Attic Insulation: $1.71/ft^2
- Air Sealing: $0.89/ft^2
  - Includes removing or shifting around any existing insulation in order to access the ceiling plane.
- Replaced Recessed Cans: $0.29/ft^2
  - It was estimated that the home has seven recessed can fixtures that need to be retrofitted to be airtight and allow for insulation contact.
- HERS Rater: $0.09/ft^2
- Total Incremental Cost: **$2.98/ft^2**

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 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.
  - Note: Design costs were not included nor were the incremental costs of code compliance verification.

Attic Insulation for Alterations Cost-Effectiveness Summary Per Home – Single Family

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$3,771	$3,041	1.24
2	$5,847	$4,964	1.18
3	$3,779	$3,041	1.24
4	$5,165	$4,964	1.04
5	$2,399	$2,560	0.94
6	$2,765	$2,560	1.08
7	$2,232	$2,560	0.87
8	$5,363	$4,964	1.08
9	$5,179	$4,964	1.04
10	$5,551	$4,964	1.12
11	$7,915	$4,964	1.59
12	$7,095	$4,964	1.43
13	$7,843	$4,964	1.58
14	$7,705	$4,964	1.55
15	$8,278	$4,964	1.67
16	$6,887	$4,964	1.39

Attic Insulation for Alterations Cost-Effectiveness Summary Per Dwelling Unit – Multifamily

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$1,060	$794	1.33
2	$1,378	$1,297	1.06
3	$804	$794	1.01
4	$1,136	$794	1.43
5	$631	$669	0.94
6	$592	$669	0.88
7	$449	$669	0.67
8	$1,197	$794	1.51
9	$1,040	$794	1.31
10	$1,174	$794	1.48
11	$1,777	$1,297	1.37
12	$1,652	$1,297	1.27
13	$1,836	$1,297	1.42
14	$1,743	$1,297	1.34
15	$1,882	$1,297	1.45
16	$1,642	$1,297	1.27

Questions

Attic Insulation for Additions

Existing 2019 Code Requirements

- Section 150.2(a)1Bi
  - Roof and Ceiling insulation in an attic shall be insulated to R-38 in climate zones 1, 11-16 or R-30 in climate zones 2-10

Existing 2019 Code Requirements

	Climate Zone															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ceiling Insulation	R-38	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38	R-38	R-38	R-38	R-38

What is Being Proposed for 2022?

We are not proposing new values, but rather expanding the current R-38 requirement to more climate zones where cost-effective.

- This measure would apply to additions ≤ 700 ft^2
- Ceiling Insulation
  - CZs 2, 4 & 8-10 = **R-38**

What is Being Proposed for 2022?

	Climate Zone															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ceiling Insulation	R-38	R-38	R-30	R-38	R-30	R-30	R-30	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with one exception for alterations:
    1. For single family, the existing condition building infiltration assigned to the existing home (10 ACH50) is not reflected in the CBECC-Res Standard Design calculation per the ACM rules.

    2. ~~For multifamily, the Standard design applied in this analysis differs from that calculated from the CBECC-Res software in one respect. Ductwork was located within the vented attic, while the CBECC-Res Standard Design for multifamily buildings assumes that ductwork is located within conditioned space.~~

Energy Savings Methodology

- Software used for evaluation: 2022 CBECC-Res RV
- Prototypes used for evaluation:
  - Single Family, 1,665 ft^2 (single story; 8-ft ceilings)
    1. Steep-sloped (roof above attic); and
    2. Low-sloped
  - ~~Multifamily, 6,960 ft^2 (two-story; 8-unit apartment building with individual HVAC & DHW systems)~~
    1. ~~Steep-sloped (roof above attic); and~~
    2. ~~Low-sloped~~

Per-Unit Energy Impacts Results – First Year

- Energy savings and peak demand reductions per unit are presented in the following tables/slides.

Attic Insulation for Additions First-Year Energy Impacts Per Home – Single Family

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-	-	-	-
2	3	0.003	0.4	299
3	-	-	-	-
4	3	0.002	0.2	315
5	-	-	-	-
6	-	-	-	-
7	-	-	-	-
8	5	0.002	0.0	234
9	5	0.002	0.1	430
10	5	0.002	0.1	272
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-

Energy Cost Savings Results – 30 Year

- Per-unit energy cost savings for newly constructed buildings and additions that are realized over the 30-year period of analysis are presented in 2023 dollars in the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Attic Insulation for Additions 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Home – Single Family

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	-	-	-
2	$26	$26	$52
3	-	-	-
4	$40	$14	$54
5	-	-	-
6	-	-	-
7	-	-	-
8	$40	$1	$40
9	$71	$3	$74
10	$39	$8	$47
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-

Total Incremental Cost

Incremental costs for this measure reflects the incremental cost of increasing attic insulation to R-38 instead of R-30.

- Material Cost: $0.17/ft^2
- Total Incremental Cost: **$0.17/ft^2**

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 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.
  - Note: Design costs were not included nor were the incremental costs of code compliance verification.

Attic Insulation for Additions Cost-Effectiveness Summary Per Home – Single Family

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	-	-	-
2	$52	$38	1.36
3	-	-	-
4	$54	$38	1.43
5	-	-	-
6	-	-	-
7	-	-	-
8	$40	$38	1.06
9	$74	$38	1.96
10	$47	$38	1.24
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	-	-	-

Attic Insulation for Additions Cost Effectiveness Summary Per Dwelling Unit –Multifamily

- Not evaluated since additions are not common in multifamily buildings. While it is proposed that this code change proposal apply to multifamily buildings in the case of an addition, the Statewide CASE Team considers that this can be justified without direct modeling.

- It is suspected that the cost effectiveness results would be similar for low-rise multifamily as for single family.

Questions

Closing

- Where to find a copy of the CASE report:
  - https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03
- Where to submit comments:
  - https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=19-BSTD-03

Written comments must be submitted to the Docket Unit by

5:00 p.m. on September 16, 2020.

How to Participate

- How to submit comments:
  1. Electronic commenting system
  2. By email: docket@energy.ca.gov
     - Include docket number **19-BSTD-03** and **2022 Building Energy Efficiency Standards** in the subject line.
  3. By mail:

     California Energy Commission
     Docket Unit, MS-4
     Docket No. 19-BSTD-03
     1516 Ninth Street
     Sacramento, CA 95814-5512

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Final
Comments & Questions

Low-Rise Residential Additions and Alterations HVAC Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenters: Cheng Moua, PE, Mechanical Engineer

Date: September 1, 2020

Proposal Summary

Staff received proposals for four HVAC measures relating to low-rise residential additions and alterations. These are **revisions** to existing prescriptive requirements.

- Electric Space Heating Replacements
- Duct Sealing Leakage
- Duct Insulation
- Duct Sealing and Insulation Trigger

Sections Affected By These Four Measures

Energy Standards

- Section 150.2(a)
- Section 150.2(b)1C
- Section 150.2(b)1D
- Section 150.2(b)1E
- Section 150.2(b)1G

Reference Appendices

- RA3.1.4.2

Electric Space Heating Replacements

Electric Space Heating Replacements

Current Prescriptive Requirement, Section 150.2(b)1C and Section 150.2(b)1G

- Limits replacement equipment to only natural gas, liquefied petroleum gas, the existing fuel type, or a heat pump
- “Existing fuel type” allows for electric resistance when existing equipment is electric

Electric Space Heating Replacements

Proposed Prescriptive Requirement

- Intended move electric resistance to heat pump technology where cost effective
- Prohibits electric resistance when heating system is part of a new or replacement ducted cooling system
- Does not apply to non-ducted systems
- Does not apply if only the electric resistance heating equipment is being replaced
- Does not apply to single family in Climate Zone (CZ) 7 or 15 and multifamily in CZ 6, 7, 8, or 15

Electric Space Heating Replacements

Technical Feasibility

- Replacement from a central electric resistance furnace with AC to heat pump is straightforward
- Does not change compliance and enforcement process

Cost Effectiveness

- Cost effective in all climate zones except 7 and 15 for single family
- Cost effective in all climate zones except 6,7,8 and 15 for multifamily

Electric Space Heating Replacements

Market Overview of Electric Resistance in Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (homes/dwelling units)	Percent of Homes Impacted by Proposal	Statewide Homes Impacted by Proposal in 2023
Single Family	8,828,191	0.04%	3,461
Low-Rise Multifamily	3,620,491	0.11%	3,922
Total	**12,448,682**	**0.06%**	**7,383**

Source: 2009 Residential Appliance Saturation Study (California Energy Commission 2009)

Electric Space Heating Replacements

Incremental First Cost

- $408 based on 3-ton system for materials
- $0 labor since both base case and upgrade case include replacing outdoor unit
- Same HERS testing required for both

Electric Space Heating Replacements

Summary of Replacement Cost

	Electric Resistance Furnace & Air Conditioner	Split Heat Pump
First Cost	$5,000	$5,408
Useful Life	20	15
Present Value of Replacement Cost at Year 15	N/A	$3,471
Present Value of Replacement Cost at Year 20	$2,768	N/A
Present Value of Remaining Useful Life at Year 30	($1,030)	N/A
Total Cost	$6,738	$8,879
Total Incremental Cost	-	$2,141

Electric Space Heating Replacements

30-Year Cost-Effectiveness Summary per Home for Single Family

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	$33,114	$2,141	15.47
2	$15,226	$2,141	7.11
3	$12,245	$2,141	5.72
4	$9,382	$2,141	4.38
5	$9,019	$2,141	4.21
6	$2,855	$2,141	1.33
7	$1,633	$2,141	0.76
8	$3,871	$2,141	1.81
9	$5,674	$2,141	2.65
10	$7,316	$2,141	3.42
11	$18,305	$2,141	8.55
12	$17,179	$2,141	8.02
13	$12,694	$2,141	5.93
14	$15,986	$2,141	7.47
15	$1,795	$2,141	0.84
16	$37,936	$2,141	17.72

Electric Space Heating Replacements

30-Year Cost-Effectiveness Summary per Dwelling for Multifamily

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	$12,075	$2,141	5.64
2	$5,789	$2,141	2.70
3	$3,990	$2,141	1.86
4	$3,135	$2,141	1.46
5	$3,058	$2,141	1.43
6	$676	$2,141	0.32
7	$309	$2,141	0.14
8	$1,642	$2,141	0.77
9	$2,479	$2,141	1.16
10	$3,269	$2,141	1.53
11	$7,723	$2,141	3.61
12	$7,294	$2,141	3.41
13	$6,139	$2,141	2.87
14	$6,892	$2,141	3.22
15	$2,140	$2,141	0.9998
16	$15,138	$2,141	7.07

Electric Space Heating Replacements

Statewide Energy and Cost Impacts

Climate Zone	Statewide Existing Building Stock Impacted by Proposed Change in 2023 (single family & multifamily: 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	0	0.00	0.00	0.00	$0.00
2	0	0.00	0.00	0.00	$0.00
3	524	0.39	0.00	0.00	$2.09
4	1,970	1.26	0.00	0.00	$6.79
5	0	0.00	0.00	0.00	$0.00
6	254	0.13	0.00	0.00	$0.72
7	N/A	N/A	N/A	N/A	N/A
8	126	0.09	0.00	0.00	$0.49
9	2,023	1.68	0.04	0.00	$8.90
10	763	0.77	0.02	0.00	$4.05
11	723	2.69	0.00	0.00	$13.24
12	579	1.23	0.01	0.00	$6.38
13	310	0.66	0.01	0.00	$3.45
14	50	0.10	0.00	0.00	$0.49
15	N/A	N/A	N/A	N/A	N/A
16	269	1.30	0.00	0.00	$7.60
TOTAL	**7,589**	**10.31**	**0.08**	**0.00**	**$54.21**

Electric Space Heating Replacements

First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (million therms/y)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
Electric Space Heating Replacements	10.31	2,477	0.00	0	2,477

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.

DUCT SEALING LEAKAGE

Duct Sealing Leakage

Current Prescriptive Requirement, Section 150.2(b)1D for altered ducts and Section 150.2(b)1E for altered space conditioning systems

- Demonstrate measured duct leakage equal to or less than 15 percent of system air handler airflow or measured duct leakage to outside equal to less than 10 percent of system air handler airflow for both single family and multifamily
- System air handler airflow for establishing duct leakage rate compliance targets is calculated (RA 3.1.4.2) and allows either nominal or measured airflow
  - Nominal airflow is the greater of 400 CFM per ton of condensing unit cooling capacity or 21.7 CFM per kBtu/hr of rated heating output capacity (typically used)
  - Measured airflow is airflow measured according to procedures in RA3.3.3

Duct Sealing Leakage

Separate but related requirement…

- Section 150.2(b)1Fii requires system airflow to be measured for altered systems that replace a refrigerant-containing component in CZ 2 and 8-15 according to procedures in RA3.3.3
- System must demonstrate measured an airflow rate equal or greater than 300 CFM per ton

Duct Sealing Leakage

Proposed Prescriptive Requirement

- Demonstrate measure duct leakage equal to or less than 10 percent of system air handler airflow for single family
- Reduce duct leakage to outside option to less than or equal to 7 percent of system air handler airflow for single family
- Multifamily remains at 15 percent and 10 percent, respectively
- Requires that measured airflow be used for establishing duct leakage rate compliance targets in place of nominal airflow when measured airflow is available, as required by Section 150.2(b)1Fii

Duct Sealing Leakage

Technical Feasibility

- Revises targets for existing duct sealing requirements and does not introduce any new HERS protocols
- Does not change compliance and enforcement process

Cost Effectiveness

- Cost effective in all climate zones

Duct Sealing Leakage

Market Overview of Systems Impacted in Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (homes/dwelling units)	Percent of Homes Impacted by Proposal	Statewide Homes Impacted by Proposal in 2023
Single Family	8,828,191	0.36%	31,497
Low-Rise Multifamily	3,620,491	0.02%	562
Total	**12,448,682**	**0.26%**	**32,059**

- HERS Registry data used to estimate altered duct systems with 10-15 percent leakage

Duct Sealing Leakage

Based on CalCERTS data…

Duct Sealing

- 75 percent of single family HVAC alterations included duct testing.
- 40 percent of projects tested at or below 10 percent leakage.
- 39 percent of projects tested between 10 and 15 percent leakage.

Airflow Measurement

- 85 percent of single family HVAC alterations in CZ 2 and 8-15 included airflow measurement (per Section 150.2(b)Fii).
- 90 percent of projects measured at or greater than 300 CFM per ton requirement.
- 79 percent of projects measured between 300 and 400 CFM per ton.

Duct Sealing Leakage

Duct Leakage Test Results Data

Duct Leakage Results or Compliance Path		% of Altered Duct Systems	
		Single Family	Low-Rise Multifamily
Total Leakage	<=5%	7%	0%
	5.1-10%	33%	28%
	10.1-12%	13%	19%
	12.1-13%	7%	8%
	13.1-15%	19%	21%
Visual Inspection Exception		15%	16%
Asbestos Exception		6%	5%
Leakage to Outside		0%	2%

Source: CalCERTS

Duct Sealing Leakage

System Airflow Test Results Data

Measured System Airflow (cfm/ton)	% of Altered Duct Systems	
	Single Family	Low-Rise Multifamily
0 to 299	10%	4%
300 to 349	54%	49%
350 to 399	25%	30%
400 to 449	8%	10%
450 to 499	2%	4%
500 +	1%	3%

Source: CalCERTS

Duct Sealing Leakage

Incremental First Cost

- $20 for materials
- $240 for labor estimated at 2 hours additional labor
- Total of $260

No incremental maintenance or replacement costs

Duct Sealing Leakage

30-Year Cost-Effectiveness Summary per Home for Single Family

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	$1,584	$260	6.09
2	$1,676	$260	6.45
3	$755	$260	2.90
4	$1,613	$260	6.20
5	$579	$260	2.23
6	$631	$260	2.43
7	$400	$260	1.54
8	$1,593	$260	6.13
9	$1,544	$260	5.94
10	$1,838	$260	7.07
11	$3,503	$260	13.47
12	$2,163	$260	8.32
13	$3,010	$260	11.58
14	$3,606	$260	13.87
15	$4,522	$260	17.39
16	$2,685	$260	10.33

Duct Sealing Leakage

Statewide Energy and Cost Impacts

Climate Zone	Statewide Existing Building Stock Impacted by Proposed Change in 2023 (single family: 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	174	0.00	0.00	0.00	$0.28
2	1,032	0.04	0.02	0.01	$1.73
3	3,819	0.04	0.01	0.04	$2.88
4	1,939	0.16	0.13	0.01	$3.13
5	378	0.00	0.00	0.00	$0.22
6	2,336	0.10	0.08	0.01	$1.47
7	1,937	0.08	0.05	0.00	$0.78
8	3,622	0.36	0.15	0.01	$5.77
9	4,906	0.50	0.52	0.02	$7.57
10	4,137	0.61	0.26	0.03	$7.60
11	1,260	0.34	0.21	0.02	$4.41
12	5,055	0.56	0.38	0.07	$10.93
13	2,430	0.70	0.51	0.02	$7.31
14	938	0.23	0.10	0.02	$3.38
15	667	0.42	0.16	0.00	$3.02
16	365	0.03	0.01	0.01	$0.98
TOTAL	**34,997**	**4.18**	**2.58**	**0.29**	**$61.47**

Duct Sealing Leakage

First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (million therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
Duct Sealing	4.18	1,004	0.29	1,563	2,568

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.

Duct Insulation

Duct Insulation

Current Prescriptive Requirement

- Requires duct insulation per Table 150.2-A apply to new ducts in unconditioned space
- Requires R-6 in CZ 1-10, 12, and 13
- Requires R-8 in CZ 11, and 14-16

Duct Insulation

Proposed Prescriptive Requirement

- Aligns duct insulation (Table 150.2-A) with new construction Tables 150.1-A and 150.1-B, Option B
- Increase from R-6 to R-8 in CZ 1, 2, 4, 8-10, 12, and 13

Duct Insulation

Summary of Duct Insulation Proposal

Climate Zones	Existing	Proposed
3, 5-7	R-6	R-6
1-2, 4, 8-10, 12-13	R-6	R-8
11, 14-16	R-8	R-8

Duct Insulation

Technical Feasibility

- Existing market and industry because R-8 is already required in certain CZs
- Does not change compliance and enforcement process

Cost Effectiveness

- Cost effective in CZ 1, 2, 4, 8-10, 12, and 13

Duct Insulation

Percent of New Ducts in Alterations that used R-8 Insulation

Climate Zones	Current/Proposed Insulation Requirement	% of New Ducts with R-8 Insulation	
		Single Family	Low-Rise Multifamily
All	N/A	20%	20%
3, 5-7	R-6/R-6	5%	20%
1-2, 4, 8-10, 12-13	R-6/R-8	13%	3%
11, 14-16	R-8/R-8	100%	100%

Source: CalCERTS

Duct Insulation

Incremental First Cost

- $0.49 per square foot of duct surface area for materials
- Duct surface area equals 0.27 times floor area per the Residential ACM Manual
- Assumes entire duct system is replaced
- $0 for labor
- Total is **$220** for single family and **$115** for multifamily

Duct Insulation

Summary of First Cost

	Single Family	Multifamily (per unit)
Incremental cost per square foot of duct surface area	$0.489	$0.489
Square foot of duct surface area	450	235
Total Incremental First Cost	$220	$115

Summary of Replacement Cost

	R-8 vs R-6 Duct Insulation (per square foot of duct surface area)
Incremental First Cost	$0.49
Present Value of Replacement Cost at Year 20	$0.27
Present Value of Remaining Useful Life at Year 30	($0.10)
Total Present Value of Incremental Cost	$0.66

Duct Insulation

30-Year Cost-Effectiveness Summary per Home for Single Family

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	$349	$296	1.18
2	$369	$296	1.24
3	N/A	N/A	N/A
4	$441	$296	1.49
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	N/A	N/A	N/A
8	$377	$296	1.27
9	$403	$296	1.36
10	$455	$296	1.54
11	N/A	N/A	N/A
12	$639	$296	2.16
13	$824	$296	2.78
14	N/A	N/A	N/A
15	N/A	N/A	N/A
16	N/A	N/A	N/A

Duct Insulation

30-Year Cost-Effectiveness Summary per Dwelling for Multifamily

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	$181	$155	1.17
2	$257	$155	1.66
3	N/A	N/A	N/A
4	$242	$155	1.57
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	N/A	N/A	N/A
8	$199	$155	1.28
9	$209	$155	1.35
10	$259	$155	1.67
11	N/A	N/A	N/A
12	$313	$155	2.02
13	$412	$155	2.66
14	N/A	N/A	N/A
15	N/A	N/A	N/A
16	N/A	N/A	N/A

Duct Insulation

Statewide Energy and Cost Impacts

Climate Zone	Statewide Existing Building Stock Impacted by Proposed Change in 2023 (single family and multifamily: 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	50	0.00	0.00	0.00	$0.02
2	296	0.00	0.00	0.00	$0.11
3	N/A	N/A	N/A	N/A	N/A
4	560	0.01	0.01	0.00	$0.24
5	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A
8	1,045	0.03	0.02	0.00	$0.39
9	1,431	0.04	0.04	0.00	$0.57
10	1,185	0.04	0.03	0.00	$0.54
11	N/A	N/A	N/A	N/A	N/A
12	1,451	0.04	0.02	0.00	$0.92
13	695	0.05	0.03	0.00	$0.57
14	N/A	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A	N/A
TOTAL	**6,714**	**0.21**	**0.15**	**0.01**	**$3.36**

Duct Insulation

First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (million therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
Duct Insulation	0.21	52	0.01	69	121

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.

Duct Sealing and Insulation Trigger

Duct Sealing and Insulation Trigger

Current Prescriptive Requirement

- Duct sealing and duct insulation requirements are triggered when more than 40 ft of new or replacement ducts are installed under additions and alterations.

Duct Sealing and Insulation Trigger

Proposed Prescriptive Requirement

- Under additions, duct sealing and duct insulation requirements are triggered regardless of length of extended ducts
- Under alterations, duct sealing and duct insulation requirements are triggered when more than 25 ft of new or replacement ducts are installed

Duct Sealing and Insulation Trigger

- 2005 CASE Report for duct sealing requirements did not include 40 foot threshold exception
- Presumably, added in 45-day language to provide relief for small alteration projects to support transition to sealing requirements
- Large addition projects can use the 40 foot threshold exception to bypass duct sealing requirements where these are prime opportunity to seal existing ducts

Duct Sealing and Insulation Trigger

- Proposal for new threshold of 25 feet based on the length of flexible ductwork in a typical package
- Keeping exception at 25 feet or less still allows relief for projects that replace a small portion of the ducts (less than a single package) to not trigger prescriptive duct sealing and insulation requirements
- Expecting this would impact a very small number of alteration projects statewide
- Less than 2 percent of registered performance projects with CalCERTS involving an addition took the exception for 40 foot (765 projects under 2013 and 2016 code cycles)

Duct Sealing and Insulation Trigger

Technical Feasibility

- 25 feet based on the length of flexible ductwork in a typical package
- Revision would impact a small number of projects

Cost Effectiveness

- Does not change energy savings and cost effectiveness conclusions from 2005
- Cost effectiveness was not determined by the 40 feet trigger

Duct Sealing and Insulation Trigger

- Energy Savings and Cost-Effective analysis were not provided for this submeasure because those provided in the 2005 CASE Report are applicable
- Prescriptive duct requirements were cost effective regardless of length of ductwork replaced or added

Closing

- Copy of the CASE Report found here:

  https://efiling.energy.ca.gov/GetDocument.aspx?tn=234503&DocumentContentId=67328

- How to submit comments:

  1. Submit E-Comment here:
  https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

  2. By Email: docket@energy.ca.gov
  - Include docket number **19-BSTD-03** and **2022 Building Energy Efficiency Standards** in the subject line.

  3. By mail:
  - California Energy Commission
    Docket Unit, MS-4
    Docket No. 19-BSTD-03
    1516 Ninth Street
    Sacramento, CA 95814-5512

Comments are due September 16, 2020 by 5:00 PM

Questions

Thank You!

Electric Water Heater Alteration Proposals

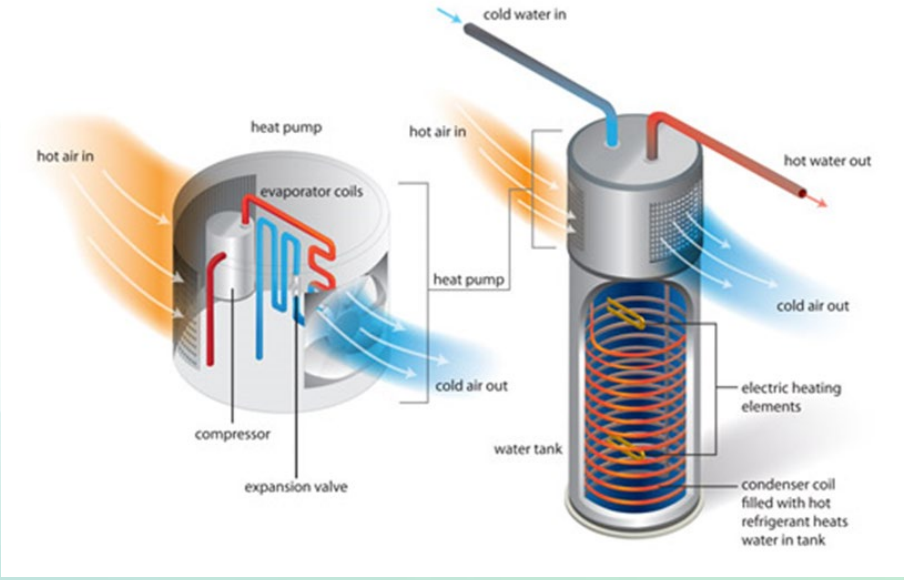
Staff Pre-Rulemaking Workshop

Presenters: Danny Tam, Mechanical Engineer

Date: September 1, 2020

Proposal Summary

- Staff received proposal for change in prescriptive alteration requirement for water heating.
- Applies to replacement of existing electric water heater with no natural gas connection to the existing location.
- Proposed measure requires the replacement to be a heat pump water heater (HPWH) with some exceptions.



Sections Affected

- Section 150.2(b)1H

Detailed Description

- Measure applies to alteration when no natural gas is connected to the existing water heater location.
- Current T24 requirement is consumer electric water heater.
- Proposed measure will require HPWH
  - HPWH typically 3-4 times more efficient than electric resistance water heater.

Detailed Description (cont)

- Electric resistance water heater is allowed under the following:
  - Water heater is located within condition space, or
  - Proposed location is not large enough for installation of HPWH, or
  - A solar water-heating system is installed with SSF of at least 60 percent, or
  - Multifamily building in CZ16.

Estimated Impacts

- Benefits of implementing the measure
  - Average first year electricity savings of 50.71 GWh.
  - Average first year peak electrical demand reduction of 5.44 MW.
  - Annual GHG emission reductions of 12,189 Metric Tons CO2e.
  - Allow more water heaters to be grid-enabled resources.

Estimated Impacts

	Electric Resistance Water Heater	Heat Pump Water Heater
First Cost	$1,000	$3,000
Useful Life	13	13
Present Value of Replacement Cost at Year 13	$680	$2,043
Present Value of Replacement Cost at Year 26	$464	$1,391
Present Value of Remaining Useful Life at Year 30	($285)	($856)
Total Cost	***$1,859***	***$5,578***
Incremental Cost	***-***	***$3,719***

Preliminary Findings

Technical Feasibility

- All major water heater manufacturer offers HPWHs.
- Plumbers may need additional training.

Cost Effectiveness

- Cost effective in all CZ for single family alteration.
- Cost effective in CZ1-15 for low-rise garden multifamily.

Preliminary Findings

Electric Water Heating Replacements 30-Year Cost-Effectiveness Summary Per Home – Single Family Alteration

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	$7,472	$3,719	2.01
2	$6,677	$3,719	1.80
3	$7,481	$3,719	2.01
4	$6,328	$3,719	1.70
5	$6,478	$3,719	1.74
6	$6,369	$3,719	1.71
7	$6,271	$3,719	1.69
8	$5,674	$3,719	1.53
9	$5,542	$3,719	1.49
10	$5,660	$3,719	1.52
11	$5,554	$3,719	1.49
12	$5,960	$3,719	1.60
13	$5,775	$3,719	1.55
14	$5,516	$3,719	1.48
15	$4,721	$3,719	1.27
16	$7,809	$3,719	2.10

Preliminary Findings

Electric Water Heating Replacements 30-Year Cost-Effectiveness Summary Per Home – Low-Rise Garden Alteration

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	$4,139	$3,719	1.11
2	$4,446	$3,719	1.20
3	$5,119	$3,719	1.38
4	$5,024	$3,719	1.35
5	$4,961	$3,719	1.33
6	$5,036	$3,719	1.35
7	$5,021	$3,719	1.35
8	$4,845	$3,719	1.30
9	$4,851	$3,719	1.30
10	$4,425	$3,719	1.19
11	$4,147	$3,719	1.12
12	$4,643	$3,719	1.25
13	$4,157	$3,719	1.12
14	$3,784	$3,719	1.02
15	$3,734	$3,719	1.00
16	$2,697	$3,719	0.7376

Staff Questions

Staff is highly interested in input on the following questions:

- Q1: Do the exception language adequately address situations where space is not large enough for HPWH?
- Q2: Any issues for plumbers to get additional training?
- Q3: Is the incremental first cost too high a barrier for homeowners?

Comments for Todays Workshop

Due Date September 16, 2020 By 5:00 PM

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

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Thank You!