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Description:	This document is the presentation given by staff on received proposals for high performance envelope measures in nonresidential buildings, given at the October 20, 2020 workshop.
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2022 Pre-Rulemaking for Building Energy Efficiency Standards

Payam Bozorgchami, P.E.

October 20, 2020

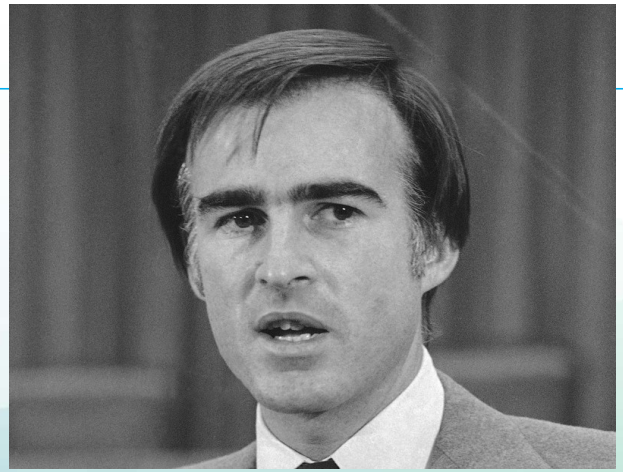
Start Time: 9:00 AM

What We Will Cover Today

- **Some Basic Background**
- **How Title 24, Part 6 is Developed**
- **Michael Shewmaker**
  - Steep-Sloped Cool Roof
  - Roof Alteration
  - Fenestration Requirements
  - Opaque Envelope
  - Simplification of Hotel/Motel Envelope Requirements

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

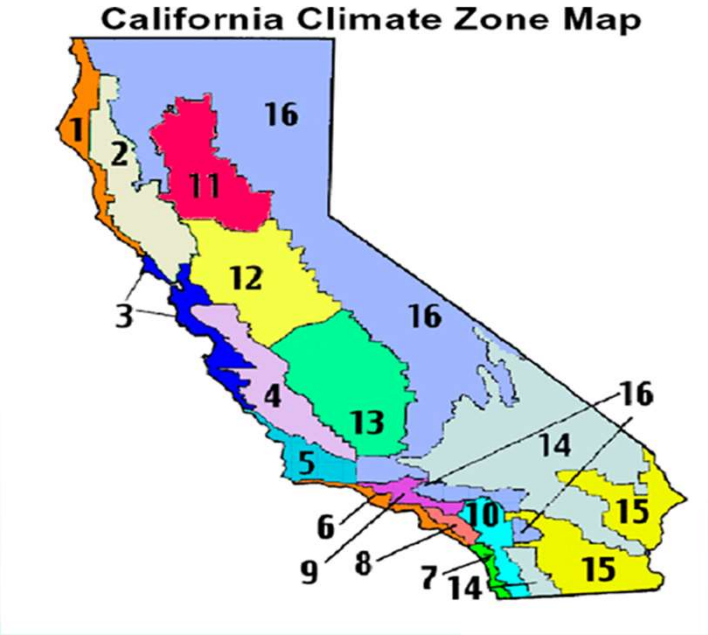
CEC staff, with input from utility partners and industry stakeholders, develop the triennial standards update

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 22**
  - 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 30**
  - Indoor Air Quality Roundtable discussion with the outside world
- **October 6 and November 19**
  - Solar Photo Voltaic and Electrification
  - Multifamily All Electric
- **October 7**
  - Nonresidential Indoor Lighting
  - Air Distribution
  - Nonresidential HVAC Controls
- **October 13**
  - Multifamily Domestic Hot Water
  - Multifamily Restructuring
- **October 20**
  - Nonresidential High Performance Envelope
- **October 27**
  - Control Environmental Horticulture
  - New Construction Steam Trap
- **November 3 ~~October 29~~ (Commissioner roundtable discussion on September 30 on IAQ)**
  - Indoor Air Quality Roundtable discussion with the outside world
  - Nonresidential Reduced Infiltration

Key Web-Links

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 November 3, 2020

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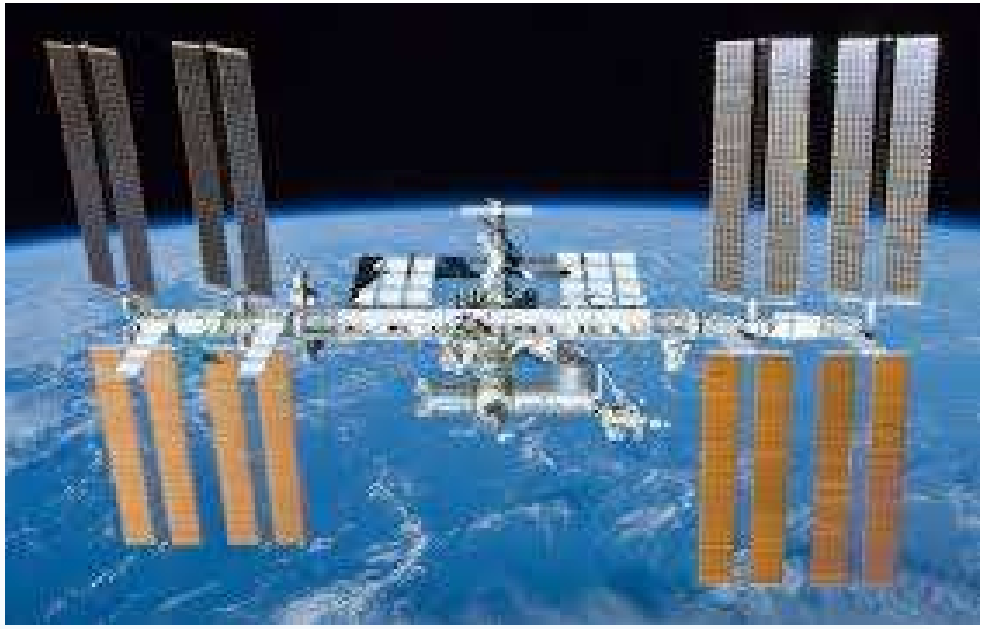
Comments For Todays Workshop

Due Date: November 3, 2020 By 5:00 PM

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

Questions ?



Thank You!

Nonresidential High Performance Envelope Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenters: Michael Shewmaker, Energy Commission Specialist

Date: October 20, 2020

Acknowledgements

- Special thanks to Alamelu Brooks, Benny Zank, Kirk Coakley, and Simon Silverberg, Energy Solutions
  - As well as, Eric Shadd (Determinant) and Christine Diosdado (Simpson Gumpertz & Heger)

List of Measures

1. Cool Roof
   a. Steep-sloped roofs
2. Roof Alterations
   a. Roof replacements
   b. Roof recovers
3. Fenestration
   a. Fixed & Curtainwall/storefront Windows (U-factor & SHGC)
   b. Updated RSHGC Equation
4. Opaque Envelope
   a. Walls
5. Simplification of Hotel/Motel Envelope Requirements

Cool Roof

Existing 2019 Code Requirements

Building Type	Sloped	Climate Zones	Aged Solar Reflectance	Thermal Emittance	SRI
Nonresidential Buildings Except High-rise Residential and Guestrooms of Hotel/Motel	Low	All	0.63	0.75	75
Nonresidential Buildings Except High-rise Residential and Guestrooms of Hotel/Motel	**Steep**	**All**	**0.20**	**0.75**	**16**
High-rise Residential and Guestrooms of Hotel/Motel	Low	9–11 & 13–15	0.55	0.75	64
High-rise Residential and Guestrooms of Hotel/Motel	Low	1–8, 12, 16	NR	NR	NR
High-rise Residential and Guestrooms of Hotel/Motel	Steep	2–15	0.20	0.75	16

What is Being Proposed for 2022?

- After numerous discussions with stakeholders and the CASE team, tit was decided to table the low-sloped cool roof proposal for inclusion in Part 6 for the 2022 code cycle and instead will revisit it again in 2025.
  - Possible inclusion in 2022, Part 11

- This proposed code change would impact new construction, additions, and alterations.
  - Alterations to healthcare facilities are exempt.

What is Being Proposed for 2022?

- Steep-sloped roofs: CZs 2 & 4-16
  - Aged solar reflectance/thermal emittance **0.25/0.80**
  - Solar Reflectance Index (SRI) **23**
    - This measure would apply to all nonresidential building types including relocatable public school buildings and healthcare facilities.

Sections Affected by Proposal

Part 6 sections

- §140.3(a)1B – the purposed of this change is to update the cool roof requirements for newly constructed buildings
- §141.0(b)2B – the purpose of this code change is to update to cool roof requirements for roof alterations

Reference Appendix sections

- No proposed changes to the Reference Appendices

Exceptions for Steep-Sloped Roofs

1. Roof area covered by building integrated solar photo voltaic panels or building integrated solar thermal panels.

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

- The insulation tradeoff tables for new construction (Table 140.3) and alterations (Table 141.0-B) will be updated to align with the new TDV values as well as the revised insulation levels proposed for alterations.

Product Availability

- 86% of products that currently meet the steep-sloped standards would meet the proposed standards.

- The proposed code change does not prohibit the use of any roofing product.
  - Prescriptive low-sloped cool roof/insulation trade off
  - Performance compliance approach

Moisture Concerns

- Online articles and simulations show that appropriate amounts of above deck insulation can be added to ensure the roof deck stays above the dew point temperature; mitigating any potential moisture concerns.

Moisture Concerns

- Stakeholders have indicated that moisture buildup is not a concern in new construction as designers can design the roof assembly to account for the more reflective roof surface.

- For alterations, multiple stakeholders indicated that although the specific conditions of each building need to be considered, there is general agreement that adding R-10 above deck will keep the roof deck warm enough to mitigate moisture accumulation in a vast majority of existing buildings.

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with one exception:
    - Hotel/motel guest rooms – the entire room area complies with the nonresidential requirements in Table 140.3-B

Energy Savings Methodology

- Software used for evaluation: CBECC-Com 2022 RV & EnergyPlus
- Prototypes not used, or were modified, for evaluation:
  - Hotels, warehouses, large retail buildings, and grocery buildings are not included in the scope of the measure.
  - The Retail Mixed Use building prototype does not include a roof, so it was not evaluated.
  - Office Small & Restaurant – modified the prototypes to include examples with steep-sloped roofs.
  - Stand Alone Retail & Retail Strip Mall – modified the prototypes to include examples with steep-sloped roofs.

Building Prototypes

- Energy models are sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings (CBECC-Com) prototypical building models.
  - These models are modified to include the proposed changes to the energy standards.
- Grocery and Assembly building models are sourced from the California Public Utilities Commission (CPUC) Database of Energy Efficient Resources (DEER) because there are currently no prototype models developed in CBECC-Com for these building types.
- The Hospital building model is sourced from the DOE's Commercial Prototype Buildings ASHRAE 90.1-2016.

Per-Unit First Year Energy Impacts

- Energy savings per unit are presented in the following tables/slides.

Cool Roof TDV Energy Savings – Steep-Sloped Roofs – New Construction

Prototype / Climate Zone	2	4	5	6	7	8	9	10	11	12	13	14	15	16
OfficeSmall	1.1	1.3	0.9	1.8	1.8	2.3	1.5	1.6	1.3	1.3	1.4	1.2	2.1	0.7
RestaurantFastFood	0.3	0.5	(0.2)	1.0	(0.3)	1.6	0.9	1.0	0.8	0.7	0.9	0.7	1.5	(0.0)
RetailStandAlone	(2.2)	(1.5)	0.8	0.5	0.5	1.9	2.4	(1.6)	5.1	0.3	(0.2)	(2.0)	3.5	0.3
RetailStripMall	4.0	2.9	0.3	0.8	1.1	2.1	0.7	1.8	04	(0.2)	1.2	0.9	2.0	(0.4)

Cool Roof TDV Energy Savings – Steep-Sloped Roofs – Alterations

Prototype / Climate Zone	2	4	5	6	7	8	9	10	11	12	13	14	15	16
OfficeSmall	3.0	5.0	4.2	5.2	5.2	6.5	6.2	4.2	3.4	3.5	3.7	3.4	4.6	2.4
RestaurantFastFood	0.4	1.4	(0.1)	1.5	4.1	3.1	2.8	1.8	1.4	1.2	1.7	1.3	12.9	0.2
RetailStandAlone	(5.0)	0.1	(0.0)	2.1	0.6	4.3	(0.6)	(0.2)	1.8	(2.5)	2.6	0.3	3.1	(1.5)
RetailStripMall	(2.5)	5.2	3.6	4.2	4.8	6.0	3.0	1.4	2.4	1.5	5.1	2.7	4.2	1.7

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

30-Year TDV Energy Cost Savings – Office Small, Steep-Sloped Roofs

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	N/A	N/A	N/A
2	$0.24	($0.06)	$0.18
3	N/A	N/A	N/A
4	$0.23	($0.04)	$0.20
5	$0.19	($0.04)	$0.14
6	$0.30	($0.02)	$0.28
7	$0.29	($0.02)	$0.27
8	$0.37	($0.02)	$0.35
9	$0.26	($0.02)	$0.24
10	$0.27	($0.03)	$0.24
11	$0.25	($0.05)	$0.20
12	$0.24	($0.05)	$0.19
13	$0.26	($0.04)	$0.21
14	$0.25	($0.06)	$0.19
15	$0.34	($0.01)	$0.33
16	$0.22	($0.11)	$0.11

30-Year TDV Energy Cost Savings – Steep-Sloped Roofs by Prototype

Climate Zone Building Prototype	2	4	5	6	7	8	9	10	11	12	13	14	15	16
Office Small	$0.18	$0.20	$0.14	$0.28	$0.27	$0.35	$0.24	$0.24	$0.20	$0.19	$0.21	$0.19	$0.33	$0.11
Restaurant	$0.04	$0.08	($0.02)	$0.15	($0.05)	$0.24	$0.14	$0.15	$0.12	$0.10	$0.14	$0.10	$0.24	($0.00)
Retail Stand Alone	($0.34)	($0.23)	$0.13	$0.08	$0.08	$0.29	$0.37	($0.25)	$0.79	$0.05	($0.03)	($0.31)	$0.54	$0.05
Retail Strip Mall	$0.62	$0.44	$0.05	$0.12	$0.16	$0.33	$0.11	$0.28	$0.06	($0.03)	$0.18	$0.13	$0.30	($0.06)

30-Year TDV Energy Cost Savings – Steep-Sloped Roofs by Prototype

Climate Zone Building Prototype	2	4	5	6	7	8	9	10	11	12	13	14	15	16
Office Small	$0.47	$0.77	$0.64	$0.81	$0.80	$1.00	$0.95	$0.65	$0.52	$0.55	$0.57	$0.52	$0.71	$0.37
Restaurant	$0.06	$0.22	($0.02)	$0.24	$0.64	$0.47	$0.44	$0.28	$0.22	$0.18	$0.25	$0.20	$1.98	$0.02
Retail Stand Alone	($0.77)	$0.02	($0.00)	$0.32	$0.09	$0.66	($0.09)	($0.03)	$0.27	($0.39)	$0.40	$0.05	$0.48	($0.24)
Retail Strip Mall	($0.38)	$0.80	$0.55	$0.65	$0.74	$0.93	$0.47	$0.21	$0.38	$0.23	$0.78	$0.42	$0.64	$0.26

Incremental Cost

- The incremental first costs for both new construction and roof alterations for this cool roof proposal consist of the difference in material costs of roofing products that meet the current requirements to those that meet the proposed requirements.

- No incremental cost for product installation.
  - No added cost for above deck insulation for alterations.

- No incremental maintenance cost.

Incremental Cost – Steep-Sloped Roofs

Product Type	Tile	Asphalt Shingles	Metal
Contractor Markup	30%	40%	30%
Steep-sloped Market Share	33%	33%	33%
Average Cost at Baseline Level ($ per square foot)	1.18	1.57	4.55
Average Cost at Proposed Level ($ per square foot)	1.18	1.64	4.55
Incremental Cost ($ per square foot)	0.00	0.07	0.00
Source(s)	2016 TRC report / calls to distributors	Online searches/ calls to retailers	2008 CASE Report / calls with trade groups

Incremental Cost – Steep-Sloped Roofs

- Using the incremental cost information from the previous slide as well as the percentage of the market that these roofing products occupy, as noted in Section 2.2, a blended incremental cost per square foot was estimated.

- Year one incremental costs were assumed to be **$0.02** per square foot for steep-sloped roofs.

- Replace membrane at Year-15.

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 and replacement 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.

Cost-Effectiveness Summary – OfficeSmall – Steep-Sloped Cool Roof

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	N/A	N/A	N/A
2	0.18	0.036	4.82
3	N/A	N/A	N/A
4	0.20	0.036	5.39
5	0.14	0.036	3.95
6	0.28	0.036	7.67
7	0.27	0.036	7.53
8	0.35	0.036	9.53
9	0.24	0.036	6.52
10	0.24	0.036	6.57
11	0.20	0.036	5.46
12	0.19	0.036	5.33
13	0.21	0.036	5.91
14	0.19	0.036	5.27
15	0.33	0.036	9.06
16	0.11	0.036	3.06

Benefit-to-Cost Ratio – Steep-Sloped Roofs – New Construction

Prototype / Climate Zone	2	4	5	6	7	8	9	10	11	12	13	14	15	16
OfficeSmall	4.8	5.4	4.0	7.7	7.5	9.5	6.5	6.6	5.5	5.3	5.9	5.3	9.1	3.1
RestaurantFastFood	1.1	2.4	(0.7)	4.4	(1.3)	7.0	4.1	4.4	3.5	2.9	4.1	3.0	6.8	(0.1)
RetailStandAlone	(11.2)	(7.5)	4.1	2.7	2.7	9.5	12.0	(8.1)	25.8	1.7	(1.0)	(10.2)	17.6	1.7
RetailStripMall	19.9	14.3	1.7	3.9	5.3	10.5	3.4	9.0	1.8	(1.1)	5.8	4.2	9.8	(1.8)
Construction-weighted Benefit-to-Cost Ratio	**3.4**	**4.0**	**2.6**	**6.1**	**5.3**	**8.6**	**5.8**	**5.2**	**5.7**	**4.5**	**5.2**	**3.7**	**8.8**	**1.9**

Benefit-to-Cost Ratio – Steep-Sloped Roofs – Alterations

Prototype / Climate Zone	2	4	5	6	7	8	9	10	11	12	13	14	15	16
OfficeSmall	12.8	21.1	17.6	22.2	21.9	27.6	26.2	17.9	14.2	15.0	15.6	14.3	19.6	10.1
RestaurantFastFood	1.7	6.4	(0.6)	6.9	18.4	13.6	12.6	8.2	6.3	5.2	7.3	5.7	57.3	0.7
RetailStandAlone	(25.1)	0.5	(0.1)	10.6	2.9	21.5	(2.8)	(0.9)	8.9	(12.8)	13.1	1.5	15.7	(7.7)
RetailStripMall	(12.3)	25.6	17.7	20.9	23.7	29.9	15.0	6.9	12.1	7.5	25.0	13.5	20.7	8.5
Construction-weighted Benefit-to-Cost Ratio	**7.7**	**16.1**	**12.0**	**20.5**	**22.1**	**19.2**	**13.3**	**12.3**	**11.6**	**11.6**	**13.9**	**10.4**	**28.9**	**6.4**

Questions

Roof Alterations

Existing 2019 Code Requirements

- Roofing insulation requirements for alterations were first introduced in 2008 and have remained unchanged since.
  - R-8 continuous insulation in Climate Zones 1 & 3-9
  - R-14 continuous insulation in Climate Zones 2 & 10-16

- Roof recovers are exempt from any insulation requirements.

What is Being Proposed for 2022?

- Roof replacements
  - Depending on climate zone, roofs would be required to have either R-17 or R-23.
    - CZs 1-5 & 9-16: R-23
    - CZs 6-8: R-17

- Roof recovers
  - Minimum of R-10 insulation be added during roof recovers or meet the insulation requirements for roof replacements, whichever is less.

Sections Affected by Proposal

Part 6 sections

- §141.0(b)2Biii – the purpose of this change is to update the insulation requirements for roof replacements and to add an insulation requirements for roof recovers and provide terminology consistency for all of Section 141.0(b)2B

Reference Appendix sections

- JA4, Table 4.2.2 – the purpose of this change is to update the table to include U-factors for R-17, R-20, and R-23.

Summary of Exceptions

a. If mechanical equipment is located on the roof and will not be disconnected and lifted as part of the roof **replacement in Climate Zones 2-7 and 9-15 or roof recover in Climate Zones 2-5, 9, 10, 12, 14, 15**, insulation added may be limited to the maximum insulation thickness that will allow a height **in accordance with Chapter 15 of the CBC**.

b. Tapered insulation may be used which has a thermal resistance less than that prescribed in Table 141.0-C, provided that the average thermal resistance equals or exceeds the value that is specified in Table 141.0-C.

Summary of Exceptions Being Modified and/or Removed

- Remove the exception that states that if existing roofs have R-7 insulation, insulation does not need to be added or replaced.

- Remove the exception that states that insulation is not required to be added if doing so would reduce the base flashing height to less than 8-inches at penthouse and parapet walls.

- Modify the exception for limited base flashing height of mechanical equipment
  - Roof replacements in Climate Zones 2-7 & 9-15
  - Roof recovers in Climate Zones 2-5, 9, 10, 12, 14 & 15

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with one exception:
    - Hotel/motel guest rooms – the entire roof area complies with the nonresidential requirements in Table 140.3-B

Energy Savings Methodology

- Software used for evaluation: CBECC-Com 2022 RV

- Prototypes not used for evaluation:
  - Hospitals – exempt from all alterations and additions requirements
  - Retail Mixed Use – does not have a roof
  - Public Assembly – continuing to evaluate the prototype

Building Prototypes

- Energy models are sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings (CBECC-Com) prototypical building models.
  - These models are modified to include the proposed changes to the energy standards.

- Grocery and Assembly building models are sourced from the California Public Utilities Commission (CPUC) Database of Energy Efficient Resources (DEER) because there are currently no prototype models developed in CBECC-Com for these building types.

Per-Unit First Year Energy Impacts

- Energy savings per unit are presented in the following tables/slides.

Roof Replacements TDV Energy Savings

Prototype / Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	38.7	14.0	29.8	34.2	30.8	19.2	16.9	22.9	31.5	13.1	15.6	14.7	15.2	16.1	14.3	19.1
OfficeLarge	1.7	0.6	1.1	1.3	1.2	0.6	1.0	0.5	1.0	0.2	0.6	0.7	0.6	0.8	0.7	0.9
OfficeMedium	6.5	2.5	4.5	5.5	4.7	2.7	2.1	4.0	5.0	2.0	2.8	2.7	2.6	2.8	2.6	3.2
OfficeSmall	18.7	5.9	8.6	11.6	8.0	3.7	2.3	8.1	10.9	4.2	8.3	6.2	8.1	7.2	9.9	8.8
RestaurantFast Food	25.7	13.2	20.2	20.2	19.1	8.7	8.4	13.1	18.9	8.5	10.6	10.3	10.0	10.1	17.6	11.2
RetailLarge	32.0	6.6	16.2	17.0	15.6	6.3	5.7	8.3	15.0	9.4	9.3	6.7	7.9	4.3	4.8	14.1
RetailStandAlone	30.3	9.8	11.2	10.1	16.3	7.4	6.2	10.2	12.1	2.7	14.3	11.8	6.9	12.6	(0.6)	13.0
RetailStripMall	24.9	4.9	15.6	9.1	9.9	0.9	1.1	8.0	12.3	6.5	4.4	9.7	11.5	9.1	8.5	12.4
SchoolPrimary	26.6	9.9	15.0	19.7	16.6	8.3	5.1	15.4	19.1	7.5	10.8	9.6	10.4	10.3	8.1	12.4
SchoolSecondary	21.3	7.1	14.4	16.5	14.9	7.9	6.7	11.7	16.6	5.5	7.1	6.8	6.9	8.0	6.2	11.3
Warehouse	20.4	5.0	11.1	9.8	10.3	4.3	4.2	4.8	7.0	2.7	4.8	4.7	3.7	4.3	1.5	8.3

Roof Recovers TDV Energy Savings

Prototype / Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	61.8	20.7	43.0	48.7	44.6	35.1	31.5	41.5	44.6	16.4	23.4	21.3	22.3	24.6	21.6	16.8
OfficeLarge	2.1	1.0	1.6	1.8	1.7	1.1	1.4	1.7	1.7	0.6	1.0	0.9	0.9	1.1	0.7	1.3
OfficeMedium	8.2	3.7	6.0	7.3	6.4	5.0	4.0	7.4	7.3	3.0	4.0	4.0	4.0	3.8	3.9	4.8
OfficeSmall	24.9	9.2	12.3	18.5	13.4	8.5	4.7	17.9	19.0	7.2	12.6	10.3	12.2	11.3	12.4	13.2
RestaurantFast Food	31.6	14.4	24.0	31.0	23.5	17.3	13.9	23.4	24.7	7.3	15.3	14.8	14.4	14.7	2.5	15.6
RetailLarge	46.1	10.6	24.7	26.8	24.2	13.0	9.7	18.2	25.5	9.3	13.7	9.7	13.6	10.1	10.0	20.8
RetailStandAlone	47.2	14.3	24.4	21.9	23.4	13.0	10.9	17.6	23.3	4.4	18.5	14.3	13.0	17.5	4.4	19.5
RetailStripMall	38.1	9.0	20.9	21.0	23.4	13.0	10.9	17.6	23.3	4.4	18.5	14.3	13.0	17.5	4.4	19.5
SchoolPrimary	38.1	15.6	27.2	34.5	26.5	22.2	15.9	33.0	35.3	11.6	17.0	15.8	15.1	16.0	14.9	18.1
SchoolSecondary	31.8	11.0	23.4	28.0	24.4	17.2	14.5	25.6	27.0	8.9	11.5	10.9	10.8	12.9	9.2	17.0
Warehouse	26.7	7.3	14.9	13.0	13.8	7.6	7.1	8.2	9.4	4.0	7.1	6.9	5.4	6.4	2.1	12.1

Energy Cost Savings Results – 30 Year

- Per-unit energy cost savings for 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

30-Year TDV Energy Cost Savings – Roof Replacements

Prototype / Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	$5.96	$2.16	$4.59	$5.27	$4.75	$2.95	$2.60	$3.52	$4.85	$2.02	$2.41	$2.26	$2.34	$2.48	$2.20	$2.94
OfficeLarge	$0.27	$0.10	$0.17	$0.19	$0.19	$0.09	$0.15	$0.08	$0.15	$0.03	$0.09	$0.10	$0.10	$0.12	$0.11	$0.14
OfficeMedium	$1.00	$0.38	$0.69	$0.85	$0.72	$0.41	$0.32	$0.62	$0.77	$0.30	$0.43	$0.42	$0.39	$0.43	$0.41	$0.50
OfficeSmall	$2.88	$0.91	$1.33	$1.79	$1.23	$0.56	$0.35	$1.25	$1.68	$0.64	$1.28	$0.96	$1.25	$1.11	$1.52	$1.36
RestaurantFast Food	$3.96	$2.03	$3.12	$3.11	$2.94	$1.34	$1.29	$2.02	$2.92	$1.31	$1.63	$1.59	$1.54	$1.56	$2.72	$1.73
RetailLarge	$4.92	$1.01	$2.49	$2.61	$2.40	$0.96	$0.87	$1.28	$2.31	$1.45	$1.43	$1.03	$1.22	$0.66	$0.74	$2.17
RetailStand Alone	$4.67	$1.51	$1.72	$1.56	$2.50	$1.13	$0.95	$1.56	$1.86	$0.42	$2.21	$1.81	$1.06	$1.95	($0.09)	$1.99
RetailStripMall	$3.84	$0.76	$2.41	$1.41	$1.52	$0.14	$0.17	$1.23	$1.90	$0.99	$0.68	$1.49	$1.77	$1.40	$1.30	$1.91
SchoolPrimary	$4.10	$1.53	$2.31	$3.04	$2.56	$1.28	$0.78	$2.37	$2.95	$1.15	$1.66	$1.47	$1.60	$1.59	$1.24	$1.90
School Secondary	$3.28	$1.09	$2.21	$2.55	$2.29	$1.22	$1.03	$1.81	$2.55	$0.85	$1.09	$1.05	$1.06	$1.23	$0.95	$1.74
Warehouse	$3.14	$0.77	$1.71	$1.52	$1.58	$0.66	$0.64	$0.74	$1.07	$0.42	$0.74	$0.72	$0.56	$0.66	$0.22	$1.28

30-Year TDV Energy Cost Savings – Roof Recovers

Prototype / Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	$9.51	$3.19	$6.62	$7.50	$6.86	$5.41	$4.85	$6.39	$6.86	$2.52	$3.61	$3.29	$3.44	$3.79	$3.33	$2.58
OfficeLarge	$0.33	$0.15	$0.24	$0.28	$0.26	$0.18	$0.22	$0.27	$0.27	$0.10	$0.15	$0.13	$0.13	$0.17	$0.11	$0.19
OfficeMedium	$1.26	$0.57	$0.92	$1.12	$0.98	$0.77	$0.62	$1.14	$1.12	$0.47	$0.62	$0.61	$0.62	$0.58	$0.60	$0.73
OfficeSmall	$3.83	$1.41	$1.89	$2.85	$2.06	$1.31	$0.73	$2.76	$2.93	$1.11	$1.95	$1.58	$1.87	$1.75	$1.90	$2.04
RestaurantFast Food	$4.86	$2.22	$3.70	$4.77	$3.62	$2.66	$2.15	$3.61	$3.81	$1.13	$2.36	$2.28	$2.22	$2.27	$0.38	$2.40
RetailLarge	$7.10	$1.63	$3.80	$4.13	$3.73	$1.99	$1.49	$2.80	$3.93	$1.44	$2.11	$1.49	$2.09	$1.55	$1.55	$3.20
RetailStandAlone	$7.27	$2.21	$3.76	$3.38	$3.61	$2.00	$1.68	$2.71	$3.59	$0.67	$2.84	$2.19	$2.01	$2.70	$0.67	$3.00
RetailStripMall	$5.87	$1.39	$3.21	$3.24	$2.57	$1.23	$0.90	$4.76	$5.03	$1.48	$1.65	$1.62	$1.12	$1.61	$2.11	$2.71
SchoolPrimary	$5.87	$2.40	$4.19	$5.32	$4.08	$3.42	$2.44	$5.09	$5.44	$1.79	$2.62	$2.44	$2.33	$2.46	$2.30	$2.78
SchoolSecondary	$4.90	$1.69	$3.61	$4.31	$3.76	$2.65	$2.23	$3.94	$4.15	$1.37	$1.77	$1.67	$1.66	$1.99	$1.42	$2.62
Warehouse	$4.12	$1.13	$2.30	$2.00	$2.12	$1.17	$1.10	$1.26	$1.45	$0.61	$1.10	$1.07	$0.83	$0.98	$0.32	$1.86

Incremental Cost

- The incremental first cost estimate includes the material cost of insulation, the labor to install it, and the cost of lifting mechanical equipment to maintain the necessary base flashing height.

- Replace membrane at Year-15.

Incremental Maintenance and Replacement Costs

- No incremental replacement or maintenance cost is expected for roof replacements.

- For roof recovers, we assumed a replacement cost of
  - $0.55/ft^2 in Climate Zones 1 & 3-9
  - $0.51/ft^2 in Climate Zones 2 & 10-16

Incremental Cost

Where Applicable	Standard Design Insulation	Proposed Design Insulation	Incremental Material Cost	Incremental Labor Cost	~~Verification Cost ($)~~	Total Incremental First Cost
Recover, CZ 1, 3-9	R-5	R-15	$0.73	$0.13	~~$0.03~~	**$0.86** ~~$0.89~~
Recover, CZ 2, 10-16	R-11	R-21	$0.73	$0.08	~~$0.03~~	**$0.80** ~~$0.83~~
Replacement, CZ 1, 3-5, 9	R-8	R-23	$1.09	$0.12	~~$0.03~~	**$1.21** ~~$1.24~~
Replacement, CZ 2, 10-16	R-14	R-23	$0.66	$0.06	~~$0.03~~	**$0.71** ~~$0.74~~
Replacement, CZ 6-8	R-8	R-17	$0.66	$0.09	~~$0.03~~	**$0.74** ~~$0.77~~

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.

Benefit-to-Cost Ratio – Roof Replacements

Climate Zone / Prototype	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	4.8	2.9	3.7	4.3	3.8	3.8	3.4	4.6	3.9	2.7	3.3	3.1	3.2	3.4	3.0	4.0
OfficeLarge	2.6	1.6	1.7	1.9	1.8	1.3	2.3	1.3	1.5	0.6	1.5	1.7	1.5	1.9	1.8	2.2
OfficeMedium	2.4	1.6	1.7	2.1	1.7	1.6	1.2	2.4	1.9	1.2	1.8	1.7	1.6	1.8	1.7	2.0
OfficeSmall	2.0	1.0	0.9	1.2	0.8	0.6	0.4	1.4	1.2	0.7	1.5	1.1	1.4	1.3	1.8	1.6
RestaurantFast Food	2.9	2.5	2.3	2.3	2.1	1.6	1.5	2.4	2.1	1.6	2.0	1.9	1.9	1.9	3.3	2.1
RetailLarge	4.0	1.4	2.0	2.1	2.0	1.3	1.1	1.7	1.9	2.0	2.0	1.4	1.7	0.9	1.0	3.0
RetailStandAlone	3.8	2.1	1.4	1.3	2.1	1.5	1.3	2.1	1.5	0.6	3.0	2.5	1.5	2.7	(0.1)	2.7
RetailStripMall	3.1	1.0	1.9	1.1	1.2	0.2	0.2	1.6	1.5	1.3	0.9	2.0	2.4	1.9	1.8	2.6
SchoolPrimary	3.3	2.1	1.9	2.4	2.1	1.7	1.0	3.1	2.4	1.6	2.2	2.0	2.2	2.1	1.7	2.6
SchoolSecondary	4.4	2.5	3.0	3.4	3.1	2.6	2.2	3.9	3.4	1.9	2.5	2.4	2.4	2.8	2.1	3.9
Warehouse	2.8	1.2	1.5	1.4	1.4	0.9	0.9	1.1	1.0	0.6	1.1	1.1	0.8	1.0	0.3	1.9
Construction-weighted Benefit-to-Cost Ratio	**3.3**	**1.7**	**1.9**	**2.1**	**2.0**	**1.5**	**1.5**	**2.0**	**1.8**	**1.3**	**1.9**	**1.7**	**1.7**	**1.6**	**1.2**	**2.6**

Benefit-to-Cost Ratio – Roof Recovers

Prototype / Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grocery	6.5	2.3	4.5	5.1	4.7	3.7	3.3	4.4	4.7	1.8	2.6	2.4	2.5	2.8	2.4	1.9
OfficeLarge	2.7	1.3	2.0	2.3	2.1	1.4	1.8	2.2	2.2	0.8	1.3	1.2	1.2	1.5	1.0	1.7
OfficeMedium	2.6	1.2	1.9	2.3	2.0	1.6	1.3	2.4	2.3	1.0	1.4	1.3	1.4	1.3	1.3	1.6
OfficeSmall	2.2	0.9	1.1	1.7	1.2	0.8	0.4	1.6	1.7	0.7	1.2	1.0	1.2	1.1	1.2	1.3
RestaurantFast Food	3.0	1.5	2.3	2.9	2.2	1.6	1.3	2.2	2.3	0.7	1.6	1.5	1.5	1.5	0.2	1.6
RetailLarge	4.9	1.2	2.6	2.9	2.6	1.4	1.0	1.9	2.7	1.1	1.6	1.1	1.6	1.2	1.2	2.4
RetailStandAlone	5.1	1.6	2.6	2.3	2.5	1.4	1.2	1.9	2.5	0.5	2.1	1.6	1.5	2.0	0.5	2.2
RetailStripMall	4.0	1.0	2.2	2.2	1.8	0.8	0.6	3.3	3.4	1.1	1.2	1.2	0.8	1.2	1.6	2.0
SchoolPrimary	4.0	1.8	2.9	3.6	2.8	2.3	1.7	3.5	3.7	1.3	1.9	1.8	1.7	1.8	1.7	2.0
SchoolSecondary	5.6	2.1	4.1	4.9	4.3	3.0	2.5	4.5	4.7	1.7	2.2	2.0	2.0	2.4	1.7	3.2
Warehouse	3.1	0.9	1.7	1.5	1.6	0.9	0.8	1.0	1.1	0.5	0.9	0.9	0.7	0.8	0.3	1.5
Construction-weighted Benefit-to-Cost Ratio	**3.9**	**1.4**	**2.4**	**2.7**	**2.5**	**1.6**	**1.5**	**2.3**	**2.5**	**0.95**	**1.5**	**1.3**	**1.4**	**1.4**	**1.0**	**2.0**

Construction Weighted Benefit-to-Cost Ratio by Climate Zone

Climate Zone	Benefit-to-Cost Ratio Replacements	Benefit-to-Cost Ratio Recovers
1	3.27	3.86
2	1.67	1.38
3	1.93	2.41
4	2.12	2.69
5	1.98	2.47
6	1.53	1.62
7	1.51	1.48
8	2.02	2.25
9	1.83	2.47
10	1.31	0.95
11	1.85	1.51
12	1.66	1.32
13	1.73	1.44
14	1.59	1.37
15	1.16	1.00
16	2.58	1.95

Cost Effectiveness for Adding a Cover Board and Insulation for Recovers

Climate Zone	Benefit-to-Cost Ratio
1	2.66
2	0.93
3	1.66
4	1.85
5	1.70
6	1.12
7	1.02
8	1.55
9	1.71
10	0.64
11	1.02
12	0.89
13	0.97
14	0.92
15	0.67
16	1.32

Questions

Fenestration

U-factor & SHGC

Existing 2019 Code Requirements

		All Climate Zones				
			Fixed Window	Operable Window	**Curtainwall or Storefront**	Glazed Doors
Vertical	Area-Weighted Performance Rating	Max U-factor	**0.36**	0.46	**0.41**	0.45
		Max RSHGC	**0.25**	0.22	**0.26**	0.23
	Area-Weighted Performance Rating	Min VT	**0.42**	0.32	**0.46**	0.17
	Maximum WWR (%)	40%				

What is Being Proposed for 2022?

- This measure applies to new construction only.
- The proposed update would reflect more stringent U-factor and SHGC values while VT would remain the same.
- This measure would update the reference table to include values that vary across climate zones to account for climate-specific needs for fixed windows.

What is Being Proposed for 2022?

		Climate Zone															
	Area-Weighted Performance Rating	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vertical		Fixed Window															
	Max U-factor	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	**0.34**	0.36	**0.34**	**0.34**	**0.34**	**0.34**	**0.34**	0.36
	Max RSHGC	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	**0.22**	0.25	**0.22**	**0.22**	**0.22**	**0.22**	**0.22**	0.25
	Min VT	0.42															
		Curtainwall or Storefront															
	Max U-factor	**0.38**	0.41	0.41	0.41	0.41	0.41	**0.38**	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	Max RSHGC	**0.25**	0.26	0.26	0.26	0.26	0.26	**0.25**	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	Min VT	0.46															
	Maximum WWR (%)	40%															

Sections Affected by Proposal

Part 6 sections

- §100.1(b) – add/revise definitions
- §110.6 – remove exception for site-built fenestration
- §130.1 – provide consistency within the code
- §140.3 – accommodate new RSHGC equation and supporting equations, and update U-factor and SHGC requirements

Reference Appendix sections

- NA7.4.5 – the purpose of this change is to rename section to “NA7.4.5 Interior and Exterior Horizontal Slats” to better reflect the language

Summary of Exceptions Being Modified and/or Removed

- Remove the exception that exempts up to 200 ft^2 of site-built fenestration from the fenestration certification requirements.
  - Reason: To increase the rate of compliance with NFRC certification and reduce/eliminate the amount of uncertified fenestration products being installed in CA.

Technical Feasibility

- No new materials or processes would be needed to comply with the proposed standards.
  - Many technologies are currently available that would allow designers to meet the proposed requirements. These include argon and krypton gas fill, low-emissivity (low-e) coatings, thermally broken frames, warm edge spaces, and triple-pane glazing.

- Achieving the proposed overall U-factors may require several of these strategies to be employed together.
  - Including a fourth-surface low-e coating on the baseline technology is sufficient to meet the updated requirements.

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements
  - Fixed windows:
    - For building prototypes expected to contain curtainwall/storefront (CW/SF) products, it was assumed that 80% of the building fenestration was fixed and 20% CW/SF.

Energy Savings Methodology

- Software used for evaluation: CBECC-Com 2022 RV & EnergyPlus

- Prototypes used for evaluation:
  - All prototypes were modeled/evaluated

Building Prototypes

- Energy models are sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings (CBECC-Com) prototypical building models.
  - These models are modified to include the proposed changes to the energy standards.
- Grocery and Assembly building models are sourced from the California Public Utilities Commission (CPUC) Database of Energy Efficient Resources (DEER) because there are currently no prototype models developed in CBECC-Com for these building types.
- The Hospital building model is sourced from the DOE's Commercial Prototype Buildings ASHRAE 90.1-2016.

Per-Unit First Year Energy Impacts

- Energy savings per unit are presented in the following tables/slides.

TDV Energy Savings – Fixed Windows

Prototype / Climate Zone	9	11	12	13	14	15
Grocery	0.15	0.23	0.20	0.31	0.19	0.40
Hospital	0.94	2.32	0.69	1.60	1.56	1.18
OfficeLarge	1.58	1.31	1.13	1.42	1.75	1.42
OfficeMedium	2.07	2.02	1.54	2.10	2.44	2.74
OfficeMediumLab	0.69	0.90	0.57	0.74	0.99	1.55
OfficeSmall	2.87	3.04	2.49	2.88	2.87	3.89
Restaurant FastFood	3.24	2.86	11.67	2.70	2.04	3.75
RetailLarge	0.28	(0.01)	0.23	0.48	(0.12)	0.62
RetailMixedUse	0.22	0.77	(0.39)	0.69	0.55	1.54
RetailStandAlone	0.15	0.08	1.02	2.89	0.99	1.52
RetailStripMall	(0.17)	0.03	0.53	(0.08)	0.81	0.48
SchoolPrimary	3.48	3.46	2.65	3.51	3.24	4.81
SchoolSecondary	0.61	1.10	0.40	1.08	0.75	0.94
Warehouse	0.06	0.02	(0.00)	(0.01)	0.04	0.02

TDV Energy Savings – Curtainwall/Storefront

Prototype Climate Zone	1	7
Grocery	0.34	0.11
Hospital	0.53	1.80
HotelSmall	0.87	0.22
OfficeLarge	1.04	0.09
OfficeMedium	0.65	0.00
OfficeSmall	0.65	0.00
Restaurant FastFood	1.51	(0.31)
RetailLarge	0.27	0.40
RetailMixedUse	0.22	0.68
RetailStandAlone	(0.12)	1.95
RetailStripMall	0.37	0.61

Energy Cost Savings Results – 30 Year

- 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 the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods

30-Year TDV Energy Cost Savings – Fixed Windows

Climate Zone / Prototype	9	11	12	13	14	15
Grocery	$0.02	$0.03	$0.03	$0.05	$0.03	$0.06
Hospital	$0.14	$0.36	$0.11	$0.25	$0.24	$0.18
OfficeLarge	$0.24	$0.20	$0.17	$0.22	$0.27	$0.22
OfficeMedium	$0.32	$0.31	$0.24	$0.32	$0.38	$0.42
OfficeMediumLab	$0.11	$0.14	$0.09	$0.11	$0.15	$0.24
OfficeSmall	$0.44	$0.47	$0.38	$0.44	$0.44	$0.60
Restaurant FastFood	$0.50	$0.44	$1.80	$0.42	$0.31	$0.58
RetailLarge	$0.04	($0.00)	$0.04	$0.07	($0.02)	$0.09
RetailMixedUse	$0.03	$0.12	($0.06)	$0.11	$0.09	$0.24
RetailStandAlone	$0.02	$0.01	$0.16	$0.44	$0.15	$0.23
RetailStripMall	($0.03)	$0.00	$0.08	($0.01)	$0.13	$0.07
SchoolPrimary	$0.54	$0.53	$0.41	$0.54	$0.50	$0.74
SchoolSecondary	$0.09	$0.17	$0.06	$0.17	$0.12	$0.14
Warehouse	$0.01	$0.00	($0.00)	($0.00)	$0.01	$0.00

30-Year TDV Energy Cost Savings – Curtainwall/Storefront

Climate Zone / Prototype	1	7
Grocery	$0.05	$0.02
HotelSmall	$0.09	($0.00)
OfficeMedium	$0.16	$0.01
OfficeSmall	$0.10	($0.00)
Restaurant FastFood	$0.23	($0.05)
RetailLarge	$0.04	$0.06
RetailMixedUse	$0.03	$0.11
RetailStandAlone	($0.02)	$0.30
RetailStripMall	$0.06	$0.09

Incremental Cost

- Incremental costs are relative to a window that is minimally compliant with 2019 Title 24, Part 6
- Includes labor and materials costs
- No incremental maintenance or replacement costs

Incremental Cost – Fixed Window Scenario 1

Building Prototype	Net Window Area (ft^2)	Window-to-Wall Ratio	Percent of Window Included in Scenario	Incremental Cost per Sq. Foot of Window	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/ft^2$)
Grocery	1,587	7%	80%	$1.75	$2,777.30	50,002	$0.06
Hospital	4,280	0%	80%	$1.75	$7,490.61	249,985	$0.03
HotelSmall	1,983	11%	80%	$1.75	$3,470.44	42,554	$0.08
OfficeLarge	48,134	52%	80%	$1.75	$84,234.19	498,589	$0.17
OfficeMedium	7,027	33%	80%	$1.75	$12,297.62	53,628	$0.23
OfficeMediumLab	7,027	33%	100%	$1.75	$12,297.62	53,628	$0.23
OfficeSmall	642	21%	80%	$1.75	$1,124.36	5,502	$0.20
RestaurantFastFood	280	14%	80%	$1.75	$490.25	2,501	$0.20
RetailLarge	5,881	12%	80%	$1.75	$10,291.03	240,000	$0.04
RetailMixedUse	558	10%	80%	$1.75	$976.31	9,375	$0.10
RetailStandAlone	904	7%	80%	$1.75	$1,581.25	24,563	$0.06
RetailStripMall	558	8%	80%	$1.75	$976.31	9,375	$0.10
SchoolPrimary	4,964	36%	100%	$1.75	$8,686.77	24,413	$0.36
SchoolSecondary	22,162	34%	100%	$1.75	$38,783.34	210,866	$0.18
Warehouse	190	1%	80%	$1.75	$332.73	49,495	$0.01

Incremental Cost – CW/SF Window Scenario 3

Building Prototype	Net Window Area (ft^2)	Window-to-Wall Ratio	Percent of Window Included in Scenario	Incremental Cost per Sq. Foot of Window	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/ft^2$)
Grocery	1,587	7%	20%	$1.00	$1,587.03	50,002	$0.03
OfficeLarge	48,134	52%	20%	$1.00	$48,133.82	498,589	$0.10
OfficeMedium	7,027	33%	20%	$1.00	$7,027.21	53,628	$0.13
OfficeSmall	642	21%	20%	$1.00	$642.49	5,502	$0.12
RestaurantFastFood	280	14%	20%	$1.00	$280.14	2,501	$0.11
RetailLarge	5,881	12%	20%	$1.00	$5,880.59	240,000	$0.02
RetailMixedUse	558	10%	20%	$1.00	$557.89	9,375	$0.06
RetailStandAlone	904	7%	20%	$1.00	$903.57	24,563	$0.04
RetailStripMall	558	8%	20%	$1.00	$557.89	9,375	$0.06

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.

Cost-Effectiveness Summary – New Construction, OfficeLarge, Fixed Windows

Climate Zone	Benefits: 2023 PV$ Energy Cost Savings + Other PV Savings per ft^2	Costs: Total Incremental PV Costs	Benefit-to-Cost Ratio
9	$0.24	$0.18	1.33
11	$0.20	$0.18	1.10
12	$0.17	$0.18	0.95
13	$0.22	$0.18	1.20
14	$0.27	$0.18	1.47
15	$0.22	$0.18	1.19

Cost-Effectiveness Summary – New Construction, OfficeLarge, CW/SF Windows

Climate Zone	Benefits: 2023 PV$ Energy Cost Savings + Other PV Savings per ft^2	Costs: Total Incremental PV Costs	Benefit-to-Cost Ratio
1	$0.04	$0.02	1.68
7	$0.06	$0.02	2.54

Benefit-to-Cost Ratio – Fixed Windows

Climate Zone / Prototype	9	11	12	13	14	15
Grocery	0.41	0.63	0.56	0.86	0.53	1.10
Hospital	2.19	5.43	1.61	3.73	3.64	2.76
OfficeLarge	1.33	1.10	0.95	1.20	1.47	1.19
OfficeMedium	1.39	1.36	1.04	1.41	1.64	1.84
OfficeMediumLab	0.46	0.60	0.38	0.49	0.66	1.04
OfficeSmall	2.16	2.29	1.87	2.17	2.16	2.93
RestaurantFastFood	2.55	2.25	9.17	2.12	1.60	2.95
RetailLarge	1.01	(0.05)	0.83	1.72	(0.44)	2.21
RetailMixedUse	0.32	1.13	(0.57)	1.02	0.82	2.28
RetailStandAlone	0.37	0.20	2.44	6.90	2.37	3.64
RetailStripMall	(0.25)	0.04	0.79	(0.12)	1.20	0.71
SchoolPrimary	1.51	1.50	1.15	1.52	1.40	2.08
SchoolSecondary	0.51	0.92	0.33	0.90	0.63	0.78
Warehouse	1.33	0.47	(0.08)	(0.21)	0.88	0.52
Construction-weighted Benefit-to-Cost Ratio	**1.32**	**1.29**	**1.00**	**1.42**	**1.12**	**1.58**

Benefit-to-Cost Ratio – Curtainwall/Storefront Windows

Climate Zone / Prototype	1	7
Grocery	1.64	0.54
HotelSmall	1.90	(0.02)
OfficeMedium	1.22	0.11
OfficeSmall	0.85	0.00
Restaurant FastFood	2.08	(0.43)
RetailLarge	1.68	2.54
RetailMixedUse	0.56	1.77
RetailStandAlone	(0.50)	8.17
RetailStripMall	0.95	1.58
Construction-weighted Benefit-to-Cost Ratio	**1.10**	**1.11**

Questions

RSHGC Equation

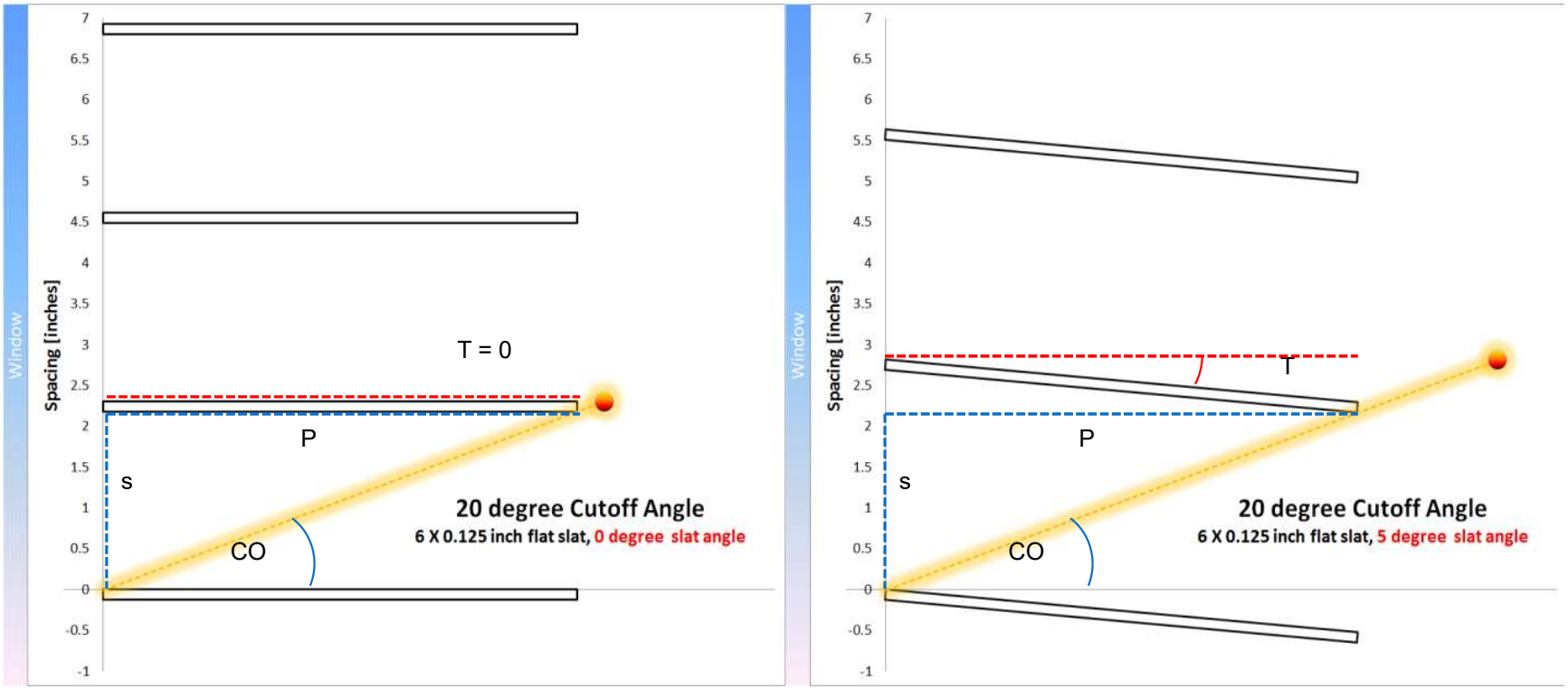
Energy Savings Methodology - RSHGC

- Key Assumptions:
  - Energy savings from exterior shading is only a function of the solar heat gain that passes through the shading and onto the window it shades.
    - It is only affected by the geometry and solar reflectance of the shading material.
    - It is not affected by the choice of prototype building.
  - The interior characteristics of the building do not affect the amount of solar radiation passing through the exterior shading device.
  - In addition, since the size of the exterior shade would be required to cover the entire window, the size of the window does not affect the relative energy savings.
  - For these reasons, **only the SmallOffice prototype was modeled**.

Methodology for RSHGC Calculation Update

- The prototype was modeled as a baseline with no horizontal slats, then as proposed models with exterior horizontal slats.
- Various cutoff angles, tilt angles, and reflectances were modeled in the proposed cases.
- All models were rotated to cover a range of orientations.

Figure 2: Cutoff angle, tilt angle, and projection factor



Methodology for RSHGC Calculation Update

- Calculating Shading Factor (SHF)
  - The shading factor is the factor multiplied by a window's SHGC to reduce the RSHGC when shading is present.
- The simulated SHFs were calculated per Equation 1 (below)

$$SHF_{proposed} = \sum_{CZ=1}^{16} \frac{NRC_{CZ}}{NRC_{CA}} \times \frac{\sum_{h=1}^{8760} WSG_{CZ,h,proposed} \times TDV_{CZ,h}}{\sum_{h=1}^{8760} WSG_{CZ,h,baseline} \times TDV_{CZ,h}}$$

Methodology for RSHGC Calculation Update – Overhangs

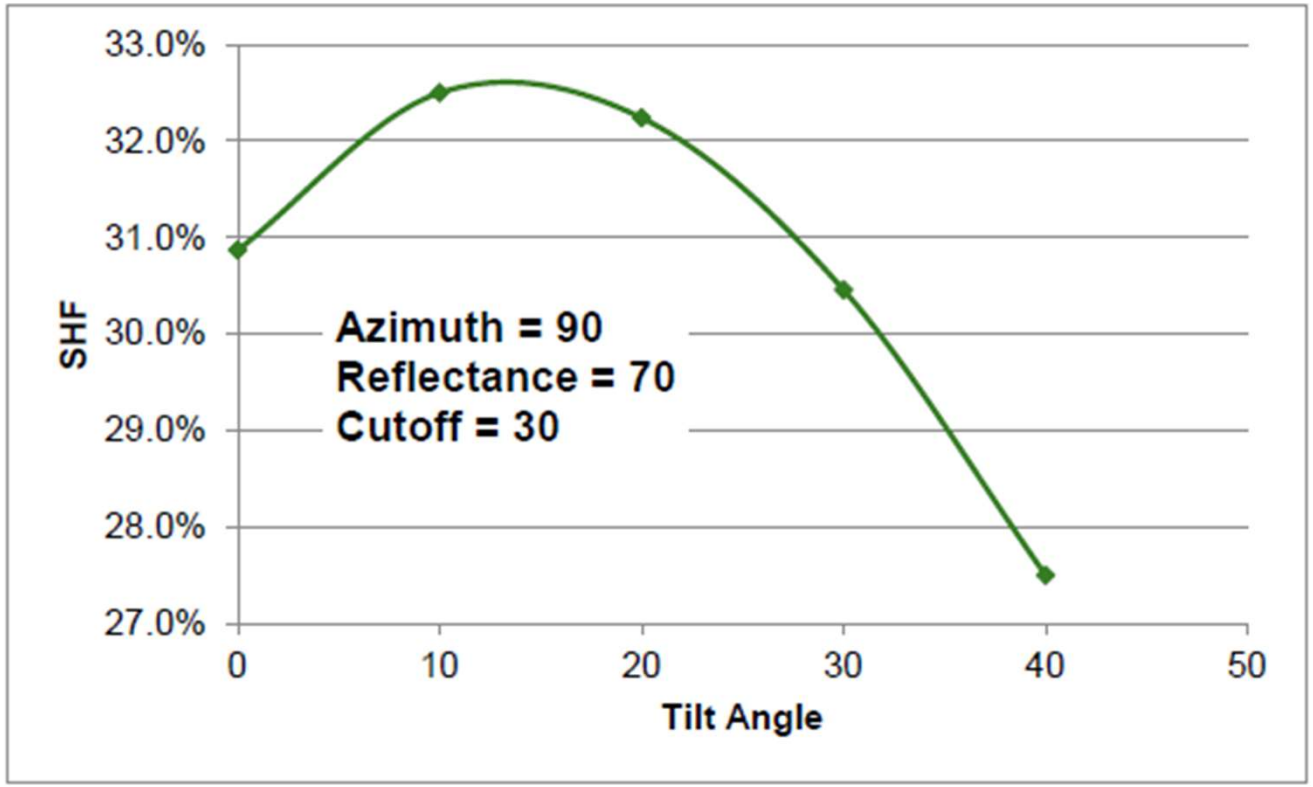
- The zero tilt, zero reflectance SHF results were used to determine the savings from an overhang.
  - Since overhangs do not have interreflection between slats, they don't transmit indirect solar gains. Their reflectance is considered virtually zero.

- Calculating overhang SHF in this way created consistency with the horizontal slat calculations so that a single formula for both overhangs and horizontal slats could be more readily developed.

Methodology for RSHGC Calculation Update – Horizontal Slats

- For horizontal slats, the physics is more complex due to the reflectance of light between the slats, resulting in more interior gains.
- For a given cutoff angle, there is a tilt angle of maximum solar gain.
  - At low tilt angles, the slats mostly interreflect between themselves and not into the interior space.
  - At high title angles, the slats mostly bounce sunlight back out to the exterior.
  - Somewhere in between these points there is a maximum solar gain point. To be conservative, this maximum point was used for determining the SHF formula.

Shading Factor as a Function of Tilt Angle for a Horizontal Slat



Proposed RSHGC Equation

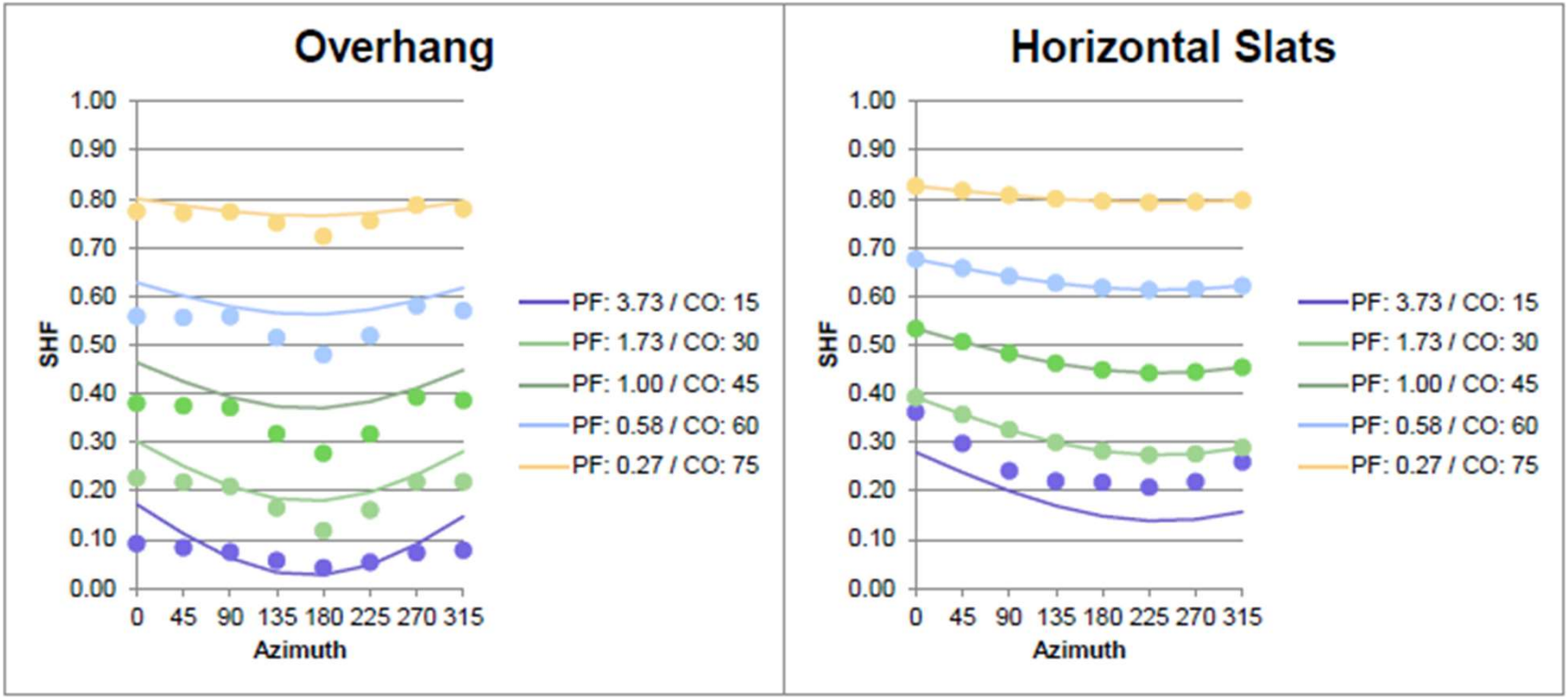
$$RSHGC = SHGC_{win}[1 + a(2.72^{-PF} - 1)(\sin(b \times Az) - c)]$$

- RSHGC = Relative Solar Heat Gain Coefficient
- $SHGC_{win}$ = The NFRC SHGC of the window
- AZ = The azimuth (or orientation) of the window
- PF = the projection factor of the exterior shade
- a, b, c = Coefficients shown in Table 104: Best Fit RSHGC Formula Coefficient

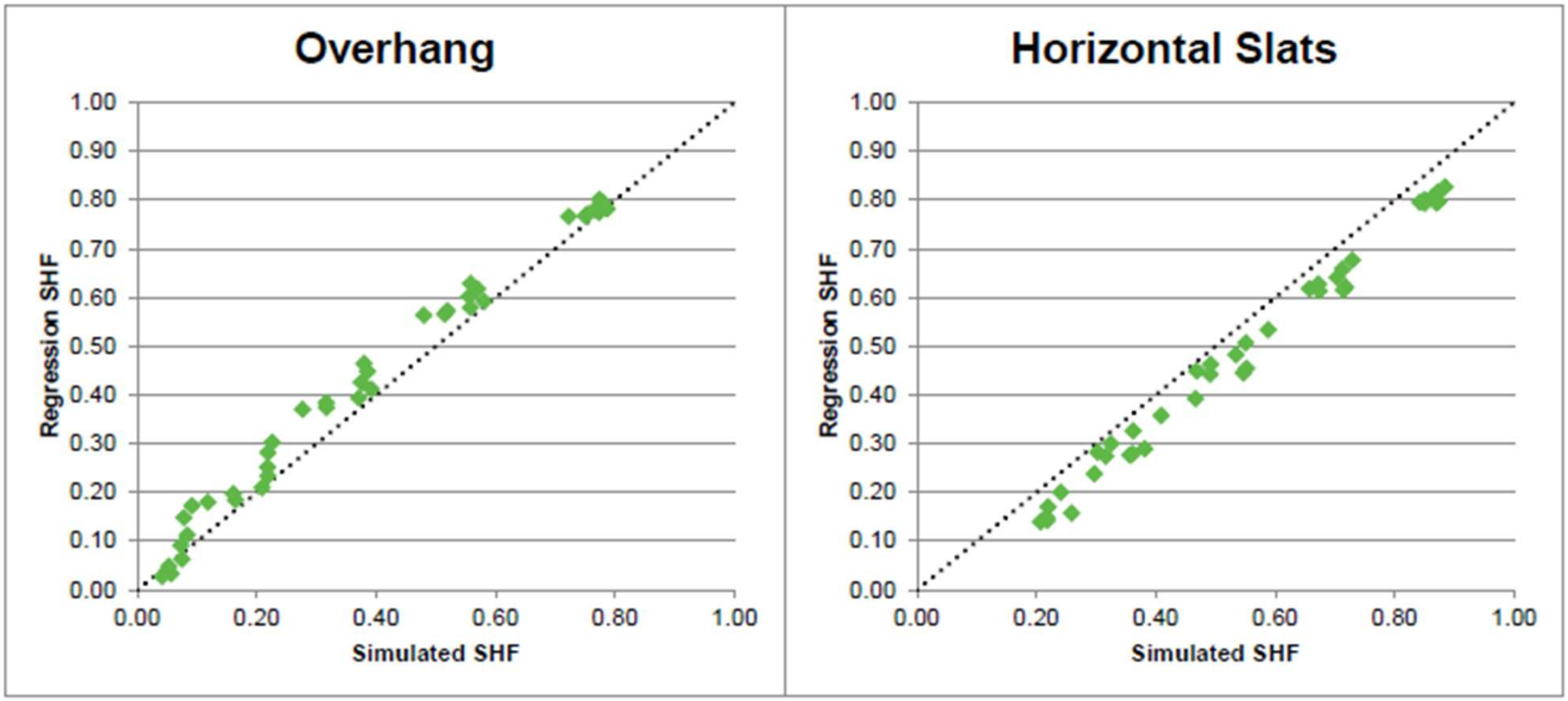
Table 104: Best Fit RSHGC Formula Coefficient

	a	b	c
Overhang	0.150	0.130	5.67
Horizontal Slat	0.144	0.133	5.13

Shading Factor Regression Curve with Simulated Values



Shading Factor Regression Curve vs. Simulated Values



Questions

Opaque Envelope

Existing 2019 Code Requirements

		Climate Zone															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
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	0.196	0.170	0.278	0.277	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	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	0.211	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	0.0.45	0.059	0.059	0.059	0.042	0.059

What is Being Proposed for 2022?

- This measure would apply to new constructed buildings, additions, and alterations

- Wall Insulation
  - Additional R-4 continuous insulation

What is Being Proposed for 2022?

		Climate Zone															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
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	**0.060**	**0.055**	**0.071**	**0.055**	**0.055**	**0.060**	**0.060**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**
	Mass Light	0.196	0.170	0.278	0.277	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	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	0.211	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	0.0.45	0.059	0.059	0.059	0.042	0.059

Sections Affected by Proposal

Part 6 sections

- §140.3 – the purpose of this change is to update assembly U-factors for walls and roofs
  - Table 140.3-B – increase stringency of prescriptive envelope U-factor criteria
  - Table 140.3-C – remove the table to simplify code; specifically multifamily and hotel/motel envelope requirements

Reference Appendix sections

- No proposed changes to the Reference Appendices

Energy Savings Methodology

- Key Assumptions:
  - Standard Design is minimally compliant with the 2019 Title 24 requirements with one exception:
    - Hotel/motel guest rooms – the entire roof area complies with the nonresidential requirements in Table 140.3-B

Energy Savings Methodology

- Software used for evaluation: CBECC-Com 2022 RV & EnergyPlus

- Prototypes used for evaluation:
  - All prototypes were modeled/evaluated

Building Prototypes

Building Type ID from Statewide Construction Forecast	Building Prototype for Energy Modeling	Weighting Factors for Statewide Impacts Analysis
Small Office	OfficeSmall	100%
Large Office	OfficeMedium	50%
	OfficeLarge	50%
Restaurant	RestaurantFastFood	100%
Retail	RetailStandAlone	10%
	RetailLarge	75%
	RetailStripMall	5%
	RetailMixedUse	10%
Grocery Store	Grocery	100%
Non-Refrigerated Warehouse	Warehouse	100%
Refrigerated Warehouse	RefrigWarehouse	N/A
Schools	SchoolPrimary	60%
	SchoolSecondary	40%
Colleges	OfficeSmall	5%
	OfficeMedium	15%
	OfficeMediumLab	20%
	PublicAssembly	5%
	SchoolSecondary	30%
	ApartmentHighRise	25%
Hospitals	Hospital	100%
Hotel/Motels	HotelSmall	100%

Per-Unit First Year Energy Impacts

- Energy savings per unit are presented in the following tables/slides.

TDV Energy Savings – Walls

Climate Zone / Prototype	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ApartmentHighRise	0.48	0.27	0.29	0.18	0.18	0.08	0.06	0.10	0.12	0.15	0.29	0.24	0.23	0.28	0.13	0.50
Assembly	0.08	0.03	(0.02)	0.01	(0.03)	(0.02)	(0.02)	(0.02)	0.00	(0.03)	0.03	0.01	(0.01)	(0.01)	(0.01)	0.20
Grocery	0.55	0.31	0.40	0.26	0.24	0.16	0.18	0.16	0.21	0.23	0.38	0.32	0.34	0.38	0.27	0.51
Hospital	(0.03)	0.04	0.04	0.18	0.01	(0.47)	0.05	0.09	0.92	0.12	0.10	0.19	0.27	0.25	(0.17)	0.15
HotelSmall	0.60	0.29	0.39	0.19	0.23	0.13	0.11	0.12	0.14	0.17	0.31	0.27	0.26	0.30	0.21	0.57
OfficeLarge	0.22	0.17	0.19	0.12	0.12	0.22	0.16	0.09	0.09	0.15	0.14	0.12	0.17	0.24	0.08	0.20
OfficeMedium	0.40	0.25	0.28	0.15	0.17	0.14	0.12	0.12	0.13	0.15	0.23	0.20	0.20	0.22	0.16	0.36
OfficeMediumLab	0.55	0.33	0.49	0.24	0.31	0.23	0.19	0.16	0.18	0.20	0.25	0.27	0.16	0.25	0.06	0.45
OfficeSmall	0.58	0.37	0.38	0.25	0.23	0.25	0.21	0.25	0.22	0.30	0.42	0.37	0.39	0.40	0.40	0.65
RestaurantFast Food	1.41	0.95	1.33	0.75	0.87	0.71	0.58	0.59	0.64	0.70	0.87	0.84	0.76	0.83	1.08	0.93
RetailLarge	0.31	0.10	0.22	0.07	0.13	0.04	0.02	0.08	0.02	0.00	0.08	0.16	0.18	0.08	0.02	0.28
RetailMixedUse	0.58	0.26	0.28	0.19	0.10	(0.02)	0.01	0.11	0.02	0.02	0.35	0.27	0.28	0.53	0.28	0.62
RetailStandAlone	0.70	0.44	0.54	0.34	0.32	0.28	0.17	0.40	0.18	0.28	0.39	0.27	0.52	0.35	0.37	0.73
RetailStripMall	0.88	0.50	0.68	0.26	0.44	0.04	0.13	0.06	0.17	0.07	0.41	0.46	0.45	0.43	0.54	0.88
SchoolPrimary	0.49	0.28	0.36	0.21	0.22	0.17	0.13	0.17	0.17	0.20	0.31	0.27	0.27	0.29	0.23	0.49
SchoolSecondary	0.35	0.21	0.28	0.15	0.20	0.13	0.10	0.11	0.12	0.13	0.21	0.19	0.22	0.20	0.11	0.29
Warehouse	0.61	0.27	0.35	0.17	0.19	0.09	0.07	0.07	0.09	0.11	0.28	0.23	0.19	0.20	0.05	0.49

Energy Cost Savings Results – 30 Year

- 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 the following tables/slides.
  - Note: The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods

30-Year TDV Energy Cost Savings – New Construction, OfficeLarge – Walls

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	($0.01)	$0.06	$0.05
2	$0.01	$0.04	$0.05
3	($0.00)	$0.05	$0.05
4	$0.01	$0.03	$0.04
5	($0.00)	$0.03	$0.03
6	$0.03	$0.05	$0.08
7	$0.02	$0.04	$0.06
8	$0.02	$0.02	$0.04
9	$0.01	$0.02	$0.03
10	$0.03	$0.03	$0.06
11	$0.02	$0.04	$0.05
12	$0.01	$0.03	$0.04
13	$0.04	$0.04	$0.07
14	$0.06	$0.05	$0.11
15	$0.03	$0.01	$0.04
16	($0.02)	$0.06	$0.04

Incremental Cost

- The incremental costs include the incremental material cost of additional insulation.
- No additional labor cost
- No anticipated incremental maintenance and replacement costs

Incremental Cost – Walls

Building Prototype	Building Area (ft^2)	Measure Component Area (Wall, Area ft^2)	Total Incremental Cost	Per Unit Incremental First Cost (2023 PV$/building area)
Grocery	50,002	20,775	$2,077.52	$0.04
Hospital	241,374	46,709	$4,670.93	$0.02
OfficeLarge	460,281	76,604	$7,660.40	$0.02
OfficeMedium	53,633	14,262	$1,426.23	$0.03
OfficeMediumLab	53,633	14,262	$1,426.23	$0.03
OfficeSmall	5,503	2,388	$238.80	$0.04
RestaurantFastFood	2,501	1,721	$172.09	$0.07
RetailLarge	240,023	44,124	$4,412.43	$0.02
RetailMixedUse	9,376	4,966	$496.60	$0.05
RetailStandAlone	24,566	11,767	$1,176.70	$0.05
RetailStripMall	9,376	6,241	$624.07	$0.07
SchoolPrimary	24,415	8,988	$898.76	$0.04
SchoolSecondary	210,907	42,083	$4,208.33	$0.02

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.

Benefit-to-Cost Ratio – Walls

Climate Zone / Building Prototype	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ApartmentHighRise	4.15	2.92	2.68	2.08	1.56	0.81	0.43	1.45	1.64	1.94	3.45	2.86	3.02	3.31	2.45	4.57
Assembly	0.70	0.43	(0.74)	1.45	(0.67)	(0.45)	(0.37)	0.02	0.67	(0.03)	1.05	0.45	0.70	0.56	1.51	2.14
Grocery	5.29	4.27	5.02	4.22	3.00	2.61	2.92	3.25	3.83	3.97	5.51	4.78	5.44	6.40	4.81	6.02
Hospital	(1.30)	0.36	(0.24)	3.14	(0.62)	(8.96)	0.27	2.37	29.35	3.17	2.26	3.36	4.19	5.13	(0.36)	2.81
HotelSmall	4.30	2.63	3.01	1.75	1.65	1.22	1.03	1.61	1.94	2.15	3.65	2.83	3.36	3.46	4.03	4.64
OfficeLarge	3.18	3.29	2.94	2.50	1.83	4.67	3.39	2.38	1.70	3.82	3.04	2.53	4.38	6.50	2.36	2.54
OfficeMedium	3.92	3.11	3.04	2.20	1.74	1.79	1.54	2.11	2.55	2.47	3.84	2.94	3.78	3.80	3.77	4.05
OfficeMediumLab	5.38	3.96	5.09	3.73	3.14	2.70	2.20	2.44	2.75	2.87	3.68	3.53	2.80	4.09	2.56	4.51
OfficeSmall	3.86	4.33	3.89	3.18	2.01	3.74	2.97	3.88	3.30	4.24	5.47	4.50	5.29	5.02	6.78	5.78
RestaurantFastFood	6.13	5.35	6.73	4.52	4.30	4.63	3.54	4.24	4.44	4.83	5.49	5.15	5.12	5.17	15.32	4.69
RetailLarge	4.63	(1.98)	3.52	2.52	2.35	5.81	(0.87)	(0.70)	(1.87)	3.11	0.23	2.17	4.11	(6.47)	1.16	4.17
RetailStandAlone	3.51	2.87	5.34	3.97	1.72	3.76	(0.01)	3.40	2.64	(1.15)	3.01	(4.95)	11.06	3.46	19.83	4.53
RetailStripMall	3.30	2.61	4.06	1.37	2.83	(0.65)	0.91	0.09	2.27	(1.08)	1.33	4.01	2.41	2.54	5.38	3.80
SchoolPrimary	3.68	3.18	3.98	2.66	2.04	2.58	1.85	2.73	2.82	3.08	4.06	3.20	3.89	3.82	4.56	4.55
SchoolSecondary	4.81	3.33	3.85	2.54	3.39	2.03	1.47	2.12	2.33	2.46	3.78	3.15	4.93	3.87	2.84	4.71
Warehouse	3.13	1.43	1.90	0.92	1.01	0.54	0.40	0.40	0.53	0.45	1.54	1.26	1.03	1.12	0.30	2.64
Construction-weighted Benefit-to-Cost Ratio	**3.59**	**2.05**	**3.02**	**2.34**	**1.79**	**2.27**	**1.31**	**1.60**	**2.93**	**2.34**	**2.83**	**2.59**	**3.78**	**1.98**	**3.22**	**3.89**

Questions

Simplification of Hotel/Motel Envelope Requirements

Existing 2019 Code Requirements

- Currently, hotel/motel buildings are subject to two different sets of envelope requirements; the nonresidential space types must comply with requirements in Table 140.3-B that apply to nonresidential buildings, and guestroom spaces must comply with the requirements in Table 140.3-C.

What is Being Proposed for 2022?

- The envelope requirements for hotel/motel be aligned with the requirements for nonresidential buildings.

- For this code cycle, the envelope requirements that apply to high-rise residential would be moved to the new multifamily section. What would remain in Table 140.3-C would apply to guestroom spaces within hotel/motel buildings.

Recommended Envelope Requirements for Hotel/Motel

- The table on the next slide (Table 194) presents existing requirements in Table 140.3-B, which apply to all nonresidential buildings except hotel/motel and high-rise residential, and Table 140.3-C.

- The table also presents the recommended requirements that would apply to the entire hotel/motel building.

- The recommended envelope requirements are consistent with the proposed envelope requirements presented in this report.

Recommended Envelope Requirements for Hotel/Motel

			Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Roof	Table 140.3-B	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
	Table 140.3-C	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
	Recommendation	**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**
	Table 140.3-B	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
	Table 140.3-C	Wood Framed and Other		0.028	0.028	0.034	0.028	0.034	0.034	0.039	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	Recommendation	**Wood Framed and Other**		**0.030**	**0.030**	**0.030**	**0.030**	**0.030**	**0.042**	**0.042**	**0.042**	**0.030**	**0.030**	**0.030**	**0.030**	**0.030**	**0.030**	**0.030**	**0.030**
Walls	Table 140.3-B	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
	Table 140.3-C	Metal-framed		0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
	Recommendation	**Metal-framed**		**0.060**	**0.055**	**0.071**	**0.055**	**0.055**	**0.060**	**0.060**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**	**0.055**
Roofing Products	Table 140.3-B	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
	Table 140.3-C	Low-Sloped Aged Solar Reflectance		NR	NR	NR	NR	NR	NR	NR	NR	0.55	0.55	0.55	NR	0.55	0.55	0.55	NR
	Recommendation	**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**
	Table 140.3-B	Low-Sloped 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
	Table 140.3-C	Low-Sloped Thermal Emittance		NR	NR	NR	NR	NR	NR	NR	NR	0.75	0.75	0.75	NR	0.75	0.75	0.75	NR
	Recommendation	**Low-Sloped 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**

Recommended Envelope Requirements for Hotel/Motel

		Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Roofing Products	Table 140.3-B	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
	Table 140.3-C	Steep-Sloped Aged Solar Reflectance	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
	Recommendation	**Steep-Sloped Aged Solar Reflectance**	**0.20**	**0.25**	**0.20**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**
	Table 140.3-B	Steep-Sloped 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
	Table 140.3-C	Steep-Sloped Thermal Emittance	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
	Recommendation	**Steep-Sloped Thermal Emittance**	**0.75**	**0.80**	**0.75**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**
Roof Replacements	Current Requirement for NR (Table 141.0-C)	Continuous Insulation	R-8	R-14	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-14	R-14	R-14	R-14	R-14	R-14	R-14
	Current Requirement for Guestrooms (Table 141.0-C)	Continuous Insulation	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14	R-14
	Recommendation	**U-factor**	**R-23**	**R-23**	**R-23**	**R-23**	**R-23**	**R-17**	**R-17**	**R-17**	**R-23**	**R-23**	**R-23**	**R-23**	**R-23**	**R-23**	**R-23**	**R-23**

Energy Savings Methodology

- Key assumptions:
  - The steep-sloped cool roof and roof recover proposed requirements were not modeled for the HotelSmall prototype.
  - It was also assumed that hotel/motels would not be affected by the curtainwall/storefront window requirements so those were also not modeled.

Energy Savings Methodology

- Software used for evaluation: CBECC-Com 2022 RV & EnergyPlus

- Prototype used for evaluation:
  - HotelSmall, 4-story hotel with 77 guest rooms
    - Floor area = 43,206 ft^2
    - WWR = 11%

Per-Unit First Year Energy Impacts

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

Energy Savings – New Construction

Climate Zone	Electricity Savings (Wh/ft²)	Peak Electricity Demand Reductions (W/ft²)	Natural Gas Savings (millitherms/ft²)	TDV Energy Savings (TDV/kBtu/ft²)
1	(1.16)	0.00	2.14	0.69
2	25.00	0.00	0.42	1.31
3	6.41	0.00	1.39	0.79
4	23.63	0.00	1.04	1.26
5	10.71	0.00	(0.07)	0.29
6	42.19	0.00	(0.61)	1.05
7	44.54	0.00	0.47	1.31
8	56.03	0.00	(0.71)	1.65
9	29.79	0.00	0.63	1.39
10	20.10	0.00	1.50	1.23
11	39.30	0.00	2.23	2.23
12	47.02	0.00	0.89	2.01
13	45.00	0.00	1.50	2.13
14	36.05	0.00	1.58	1.90
15	55.65	0.00	(0.14)	1.67
16	24.56	0.00	4.34	2.05

Energy Savings – Alterations

Climate Zone	Electricity Savings (Wh/ft^2)	Peak Electricity Demand Reductions (W/ft^2)	Natural Gas Savings (millitherms/ft^2)	TDV Energy Savings (TDV/kBtu/ft^2)
1	5.91	0.00	3.59	1.44
2	68.76	0.00	1.12	2.44
3	30.43	0.00	2.82	1.81
4	86.02	0.00	3.15	3.55
5	41.09	0.00	2.99	1.81
6	77.88	0.00	0.29	1.96
7	69.39	0.00	0.29	1.62
8	121.64	0.00	0.77	3.54
9	121.79	0.00	2.27	4.03
10	36.42	0.00	2.96	1.90
11	37.28	0.00	4.79	2.71
12	97.48	0.00	1.78	3.29
13	47.07	0.00	3.69	2.60
14	37.51	0.00	4.86	2.79
15	67.24	0.00	1.45	2.45
16	63.44	0.00	3.43	2.52

Incremental Cost

- To estimate incremental costs of the proposed changes for hotel/motel, the Statewide CASE team determined the incremental cost of the following on a per square foot basis.
  - Incremental cost of the current requirements that apply to nonresidential spaces within the hotel/motel relative to the proposed requirement.
  - Incremental cost of current requirements that apply to guestroom spaces relative to the proposed requirements.
- The Statewide CASE team then used the building geometry in the prototypical hotel/motel building, to develop a weighted average incremental cost per square foot of impacted envelope element.

Incremental Cost – New Construction

Measure	Climate Zone	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (2023$/ft² of nonresidential space)	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (2023$/ft² of guestroom space)	Weighted Average incremental First Cost (2023$/ft² of impacted building space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (Nominal$/ft² of nonresidential space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (Nominal$/ft² of guestroom space)	Weighted Average Incremental Maintenance Cost (Nominal$/ft² of impacted building space)	Total Incremental Cost per Square Foot of Entire Building (2023$/ft²)
Cool Roof	1	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	2	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	3	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	4	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	5	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	6	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	7	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	8	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	9	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	10	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	11	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	12	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	13	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	14	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	15	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	16	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17

Measure	Climate Zone	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (2023$/ft² of nonresidential space)	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (2023$/ft² of guestroom space)	Weighted Average incremental First Cost (2023$/ft² of impacted building space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (Nominal$/ft² of nonresidential space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (Nominal$/ft² of guestroom space)	Weighted Average Incremental Maintenance Cost (Nominal$/ft² of impacted building space)	Total Incremental Cost per Square Foot of Entire Building (2023$/ft²)
Wall Insulation	1	$0.10	$0.10	$0.10	$0.00	$0.00	$0.00	$0.04
	2	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	3	$0.10	($0.02)	$0.04	$0.00	$0.00	$0.00	$0.02
	4	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	5	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	6	$0.10	$0.10	$0.10	$0.00	$0.00	$0.00	$0.04
	7	$0.10	$0.33	$0.22	$0.00	$0.00	$0.00	$0.10
	8	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	9	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	10	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	11	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	12	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	13	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	14	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
	15	$0.10	($0.12)	($0.02)	$0.00	$0.00	$0.00	($0.01)
	16	$0.10	$0.17	$0.14	$0.00	$0.00	$0.00	$0.06
Roof Insulation	1	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	2	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	3	$0.30	$0.30	$0.30	$0.00	$0.00	$0.00	$0.08
	4	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	5	$0.30	$0.30	$0.30	$0.00	$0.00	$0.00	$0.08
	6	$0.30	($0.42)	($0.27)	$0.00	$0.00	$0.00	($0.07)
	7	$0.30	($0.14)	($0.04)	$0.00	$0.00	$0.00	($0.01)
	8	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	9	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	10	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	11	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	12	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	13	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	14	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	15	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)
	16	$0.30	($0.18)	($0.08)	$0.00	$0.00	$0.00	($0.02)

Measure	Climate Zone	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (2023$/ft² of nonresidential space)	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (2023$/ft² of guestroom space)	Weighted Average incremental First Cost (2023$/ft² of impacted building space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (Nominal$/ft² of nonresidential space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (Nominal$/ft² of guestroom space)	Weighted Average Incremental Maintenance Cost (Nominal$/ft² of impacted building space)	Total Incremental Cost per Square Foot of Entire Building (2023$/ft²)
Windows	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	2	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	5	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	6	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	7	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	8	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	9	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	10	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	11	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	12	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	13	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	14	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	15	$1.75	$1.75	$1.75	$0.00	$0.00	$0.00	$0.08
	16	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
All Measures	1							$0.20
	2							$0.30
	3							$0.27
	4							$0.21
	5							$0.39
	6							$0.23
	7							$0.34
	8							$0.30
	9							$0.30
	10							$0.14
	11							$0.22
	12							$0.30
	13							$0.22
	14							$0.22
	15							$0.15
	16							$0.21

Incremental Cost – Alterations

Measure	Climate Zone	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (2023$/ft² of nonresidential space)	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (2023$/ft² of guestroom space)	Weighted Average incremental First Cost (2023$/ft² of impacted building space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (Nominal$/ft² of nonresidential space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (Nominal$/ft² of guestroom space)	Weighted Average Incremental Maintenance Cost (Nominal$/ft² of impacted building space)	Total Incremental Cost per Square Foot of Entire Building (2023$/ft²)
Cool Roof Alterations	1	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	2	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	3	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	4	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	5	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	6	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	7	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	8	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	9	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	10	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	11	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	12	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17
	13	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	14	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	15	$0.00	$0.30	$0.24	$0.00	$0.30	$0.24	$0.10
	16	$0.00	$0.53	$0.42	$0.00	$0.53	$0.42	$0.17

Measure	Climate Zone	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (2023$/ft² of nonresidential space)	Incremental First Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (2023$/ft² of guestroom space)	Weighted Average incremental First Cost (2023$/ft² of impacted building space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Nonresidential Space to Proposed (Nominal$/ft² of nonresidential space)	Incremental Maintenance Cost per Square Foot of Impacted Building Floorspace Baseline Guestroom Space to Proposed (Nominal$/ft² of guestroom space)	Weighted Average Incremental Maintenance Cost (Nominal$/ft² of impacted building space)	Total Incremental Cost per Square Foot of Entire Building (2023$/ft²)
Roof Replacements	1	$1.21	$0.71	$0.82	$0.00	$0.00	$0.00	$0.20
	2	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	3	$1.21	$0.71	$0.82	$0.00	$0.00	$0.00	$0.20
	4	$1.21	$0.71	$0.82	$0.00	$0.00	$0.00	$0.20
	5	$1.21	$0.71	$0.82	$0.00	$0.00	$0.00	$0.20
	6	$0.74	$0.47	$0.53	$0.00	$0.00	$0.00	$0.13
	7	$0.74	$0.47	$0.53	$0.00	$0.00	$0.00	$0.13
	8	$0.74	$0.47	$0.53	$0.00	$0.00	$0.00	$0.13
	9	$1.21	$0.71	$0.82	$0.00	$0.00	$0.00	$0.20
	10	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	11	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	12	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	13	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	14	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	15	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
	16	$0.71	$0.71	$0.71	$0.00	$0.00	$0.00	$0.18
All Measures	1							$0.38
	2							$0.35
	3							$0.38
	4							$0.38
	5							$0.38
	6							$0.30
	7							$0.30
	8							$0.30
	9							$0.38
	10							$0.27
	11							$0.27
	12							$0.35
	13							$0.27
	14							$0.27
	15							$0.27
	16							$0.35

Cost Effectiveness

- 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.

Cost-Effectiveness Summary – New Construction

Climate Zone	2023 PV $ Energy Cost Savings + Other PV Savings per ft^2	Cost Total Incremental PV Costs	Benefit-to-Cost Ratio
1	$0.11	$0.20	0.54
2	$0.20	$0.30	0.68
3	$0.12	$0.27	0.46
4	$0.19	$0.21	0.91
5	$0.04	$0.39	0.11
6	$0.16	$0.23	0.70
7	$0.20	$0.34	0.59
8	$0.25	$0.30	0.86
9	$0.21	$0.30	0.73
10	$0.19	$0.14	1.37
11	$0.34	$0.22	1.57
12	$0.31	$0.30	1.05
13	$0.33	$0.22	1.50
14	$0.29	$0.22	1.33
15	$0.26	$0.15	1.70
16	$0.32	$0.21	1.48

Cost-Effectiveness Summary - Alterations

Climate Zone	2023 PV $ Energy Cost Savings + Other PV Savings per ft^2	Cost Total Incremental PV Costs	Benefit-to-Cost Ratio
1	$0.22	$0.38	0.58
2	$0.38	$0.35	1.06
3	$0.28	$0.38	0.73
4	$0.55	$0.38	1.43
5	$0.28	$0.38	0.73
6	$0.30	$0.31	0.98
7	$0.25	$0.31	0.81
8	$0.54	$0.31	1.77
9	$0.62	$0.38	1.63
10	$0.29	$0.28	1.05
11	$0.42	$0.28	1.50
12	$0.51	$0.35	1.43
13	$0.40	$0.28	1.44
14	$0.43	$0.28	1.54
15	$0.38	$0.28	1.35
16	$0.39	$0.35	1.09

Staff Questions

Staff is highly interested in input on this proposal.

- Appendix M. – Recommended Simplifications for Hotel/Motel Envelope Requirements

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 November 3, 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

Thank You!