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Project Title:	2022 Energy Code Pre-Rulemaking
TN #:	235845
Document Title:	Presentation-December 2, 2020 Energy Code on Pre-Rule Making Workshop
Description:	Staff Presentation on ACM Approval Manual Proposals for 2022, Economizer Provisions, Nonresidential Data Registry Provisions, and Restructuring of Multifamily. By Payam Bozorgchami on December 2, 2020 Energy Code on Pre-Rule Making Workshop
Filer:	Tajanee Ford-Whelan
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Docketed Date:	12/3/2020

2022 Pre-Rulemaking for Building Energy Efficiency Standards

Payam Bozorgchami, P.E.

December 2, 2020

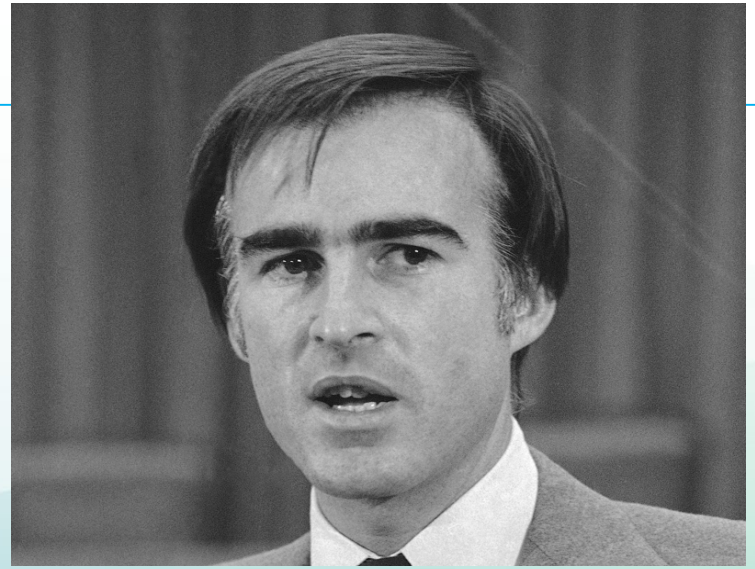
Start Time: 9:00 AM

What We Will Cover Today

- **Some Basic Background**
- **How Title 24, Part 6 is Developed**
- **RJ Wichert**
  - ACM Approval Manual Proposals for 2022
- **Ronal Balneg**
  - Economizer Provisions
- **Joe Loyer**
  - Nonresidential Data Registry Provisions
- **Javier Perez**
  - Restructuring of Multifamily

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

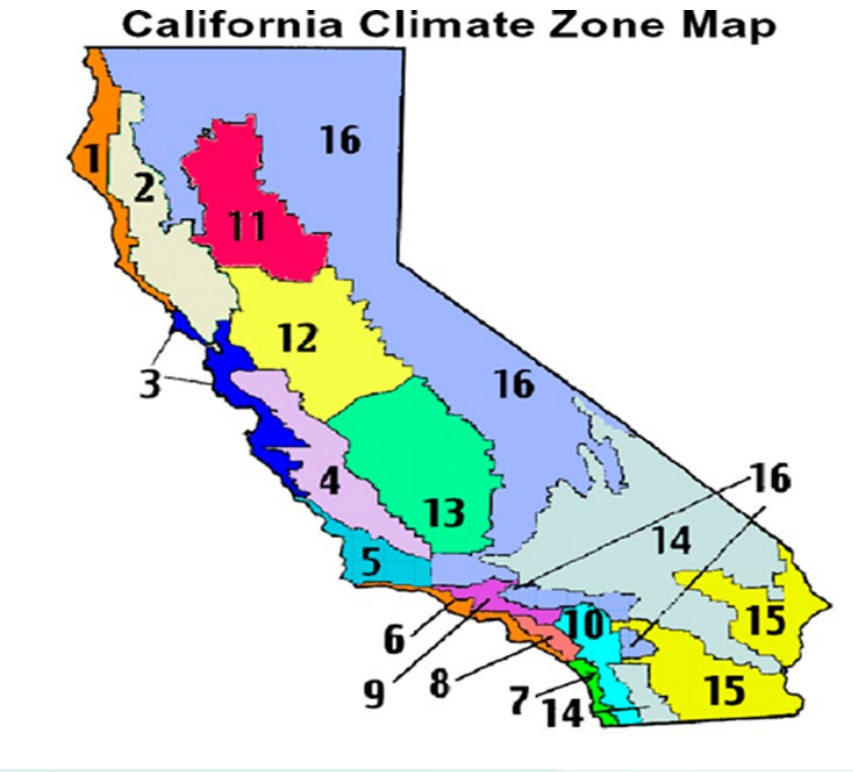
CEC staff, with input from utility partners and industry stakeholders, develop the triennial standards update

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
- **September 30**
  - Indoor Air Quality Roundtable discussion with the outside world

Tentative Pre-Rulemaking Schedule (Cont.)

- **October 6 and December 8**
  - Solar Photo Voltaic and HeatPump Baseline
  - 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 (Commissioner roundtable discussion on September 30 on IAQ)**
  - Indoor Air Quality Roundtable discussion with the outside world
  - Nonresidential Reduced Infiltration
- **December 2**
  - Alternate Compliance Method Approval Manual
  - Economizer Provisions
  - Nonresidential Data Registry Provisions
  - Restructuring of Multifamily Buildings

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 December 18, 2020

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Comments For Todays Workshop

Due Date: December 18, 2020 By 5:00 PM

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

Questions ?

ACM Approval Manual Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenters: RJ Wichert, Mechanical Engineer

Date: December 2, 2020

Proposal Summary

- Staff has not received any proposals to make substantial changes to the 2019 ACM Approval Manual.
- Staff may consider non-substantive language cleanup as needed to ensure clarity and correct errata.
- Stakeholder feedback and suggested changes to ACM Approval Manual are encouraged.

Sections Affected

- 2022 ACM Approval Manual

Detailed Description

- The Alternative Calculation Method Approval Manual explains the requirements for approval of compliance software used to demonstrate compliance with the performance compliance approach.
- The manual also gives an overview of the compliance manager capability and user manual requirements for applicant software, specifies update and decertification procedures, and outlines required software tests.
- Not to be confused with the non-regulatory Reference Manuals, which are developed after adoption and approved by the Energy Commission at a Business Meeting.

Staff Questions

Staff is highly interested in input on the following questions:

- Q1: Are there any changes to the ACM Approval Manual that staff should investigate (substantive or language cleanup)?
- Q2: Are there any other concerns stakeholders would like to bring to staff, with regards to ACM requirements?

Questions?

Comments for Todays Workshop

Due Date December 18, 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!

Nonresidential HVAC Controls

Staff Pre-Rulemaking Workshop

Presenter: Ronald Balneg, Mechanical Engineer

Date: December 2, 2020

Expand Economizer Requirements

CASE Team Final Report

Codes and Standards Enhancement (CASE) Initiative 2022 California Energy Code

Nonresidential HVAC Controls

2022-NR-HVAC4-D | Nonresidential HVAC | September 2020 FINAL CASE REPORT

Prepared by Energy Solutions and Red Car Analytics

Please send comments to info@title24stakeholders.com.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

2022 Code Update Sections Affected

Building Energy Efficiency Standards for Residential and Nonresidential Buildings:

- Section 120.2
- Section 140.4

Reference Appendices:

- JA 6.3

Proposed Changes

- Reduce threshold requirements for Fault Detection and Diagnostics from 54,000 Btu/hr and greater to 33,000 Btu/hr and greater
- Reduce threshold requirements for economizers from 54,000 Btu/hr and greater to 33,000 Btu/hr and greater.
- Changes exception 6 to Section 140.4(e)1 from 100% outside air ventilation at all times to heating and cooling systems decoupled from ventilation that have dedicated outdoor air systems (DOAS) for ventilation in accordance with 140.4(p)1B (proposed measure for DOAS).
- Code clean up language to Table 140.4-D to align with ASHRAE 90.1.

Prototype Buildings Modeled

Prototype Name	Number of Stories	Floor Area (square feet)	Description
RestaurantFastFood	1	2,501	Fast food restaurant with a small kitchen and dining areas. 14% WWR. Pitched roof with an unconditioned attic.
RetailMixedUse	1	9,375	Retail building with WWR -10%. Roof is adiabatic
RetailStripMall	1	9,375	Strip Mall building with WWR -10%
SchoolPrimary	1	24,413	Elementary school with WWR of 0.36

Energy Savings Methodology

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

Prototype ID	Climate Zone	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
RestaurantFast Food	All	Economizer Controls: Control Method	NoEconomizer	DifferentialDryBulb
RetailMixedUse	All except Climate Zone 15*	Economizer Controls: Control Method	NoEconomizer	DifferentialDryBulb
RetailStripMall	All except Climate Zones 6, 7, 10, and 15*	Economizer Controls: Control Method	NoEconomizer	DifferentialDryBulb
PrimarySchool	All except Climate Zones 8, 9, 10, 11, 13, 14, 15 and 16*	Economizer Controls: Control Method	NoEconomizer	DifferentialDryBulb

*Note: The design cooling capacity of air handlers varies based on the climate zone and several prototypes were not applicable.

Energy Savings

Energy Savings Summary Per Year Per Square Foot – Restaurant Fast Food

Climate Zone	Electricity Savings (kWh/ft2)	Peak Electricity Demand Reductions (kW/ft2)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/ft2)
1	0.500	0.000	(0.016)	9.889
2	0.724	0.000	(0.013)	15.073
3	0.932	0.000	(0.014)	20.558
4	0.832	0.000	(0.011)	17.712
5	0.944	0.000	(0.016)	24.349
6	1.109	0.000	(0.010)	25.950
7	1.159	0.000	(0.008)	27.715
8	0.943	0.000	(0.008)	21.587
9	0.880	0.000	(0.008)	19.778
10	0.806	0.000	(0.009)	17.866
11	0.548	0.000	(0.009)	10.969
12	0.695	0.000	(0.010)	14.399
13	0.571	0.000	(0.007)	11.521
14	0.627	0.000	(0.010)	12.400
15	0.516	0.000	(0.004)	12.118
16	0.639	0.000	(0.012)	13.460

Energy Savings

Energy Savings Summary Per Year Per Square Foot – Retail Mixed Use

Climate Zone	Electricity Savings (kWh/ft2)	Peak Electricity Demand Reductions (kW/ft2)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/ft2)
1	0.267	0.000	(0.006)	4.479
2	0.378	0.000	(0.004)	7.504
3	0.577	0.000	(0.002)	12.566
4	0.439	0.000	(0.002)	9.060
5	0.569	0.000	(0.003)	13.804
6	0.624	0.000	(0.000)	14.496
7	0.732	0.000	0.000	17.534
8	0.486	0.000	(0.000)	10.870
9	0.436	0.000	(0.001)	9.559
10	0.366	0.000	(0.001)	7.817
11	0.249	0.000	(0.002)	4.661
12	0.335	0.000	(0.003)	6.589
13	0.268	0.000	(0.002)	5.366
14	0.310	0.000	(0.003)	5.919
15	N/A	N/A	N/A	N/A
16	0.296	0.000	(0.003)	6.126

Energy Savings

Energy Savings Summary Per Year Per Square Foot – Retail Strip Mall

Climate Zone	Electricity Savings (kWh/ft2)	Peak Electricity Demand Reductions (kW/ft2)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/ft2)
1	0.156	0.000	(0.007)	1.757
2	0.287	0.000	(0.004)	4.924
3	0.458	0.000	(0.004)	9.092
4	0.351	0.000	(0.003)	8.251
5	0.453	0.000	(0.005)	9.873
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	0.345	0.000	(0.002)	6.537
9	0.331	0.000	(0.002)	6.809
10	N/A	N/A	N/A	N/A
11	0.176	(0.000)	(0.003)	2.578
12	0.250	0.000	(0.003)	4.603
13	0.209	0.000	(0.002)	3.867
14	0.225	0.000	(0.003)	3.859
15	N/A	N/A	N/A	N/A
16	0.249	0.000	(0.004)	4.839

Energy Savings

Energy Savings Summary Per Year Per Square Foot – Primary School

Climate Zone	Electricity Savings (kWh/ft2)	Peak Electricity Demand Reductions (kW/ft2)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/ft2)
1	0.028	0.000	(0.001)	0.367
2	0.047	0.000	(0.000)	0.902
3	0.071	0.000	(0.000)	1.441
4	0.060	0.000	(0.000)	1.191
5	0.067	0.000	(0.000)	1.517
6	0.070	(0.000)	(0.000)	1.172
7	0.086	0.000	(0.000)	2.002
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	0.049	0.000	(0.000)	0.951
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Incremental Cost

Economizer + FDD	$1,200
Additional Maintenance	$292
FDD Maintenance Savings	($57-$38)
Total Incremental Cost	$790

- Economizer + FDD costs based on CASE Team research informed by AHRI
- Additional Maintenance cost at year 7.5 for 48% of instances: $292
- FDD Maintenance Savings: $57 to $38 per year [decreases per year based on 3% discount rate]
- More details on incremental costs will be docked in the next couple days

Energy Cost Savings

New Construction, Alterations, and Additions

Construction Type	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (PV$ million)
New Construction	7	0.34	(0.06)	13.1
Additions and Alterations	15	0.75	(0.13)	29.3
TOTAL	22	1.09	(0.19)	42.4

Benefit Cost Ratio Summary

Climate Zone	RestaurantFastFood	RetailMixedUse	RetailStripMall	PrimarySchool
1	2.78	1.58	0.62	1.01
2	4.24	2.64	1.73	2.48
3	5.79	4.42	3.2	3.96
4	4.99	3.19	2.9	3.27
5	6.86	4.86	3.47	4.17
6	7.31	5.1	N/A	3.22
7	7.8	6.17	N/A	5.5
8	6.08	3.82	2.3	N/A
9	5.57	3.36	2.4	N/A
10	5.03	2.75	N/A	N/A
11	3.09	1.64	0.91	N/A
12	4.05	2.32	1.62	2.61
13	3.24	1.89	1.36	N/A
14	3.49	2.08	1.36	N/A
15	3.41	N/A	N/A	N/A
16	3.79	2.16	1.7	N/A

Questions?

Comments for Todays Workshop

Due Date December 18, 2020 By 5:00 PM

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

Contact Information

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Thank You!

2022 Energy Code

Alternative for the Nonresidential Data Registry

Joe Loyer, Senior Mechanical Engineer

Standards Compliance Office

December 2, 2020

California Energy Commission, Sacramento

Background

ATTCP Program

- Established in 2013 Energy Code
- Improved acceptance testing compliance
- Private organizations approved by the CEC
- Train, certify, and provide oversight for ATTs/ATEs
- Providers currently host database forms tracking systems

Nonresidential Data Registry

- Established in 2008 Energy Code
- CEC-approved registry for nonresidential compliance documents
- Private 3rd party organizations
- More than one NDR may be established
- Data source for CEC's data repository
- No NDRs approved by CEC to date

Alternative for the Nonresidential Data Registry

Issue

Current law requires compliance documents be tracked by both a Nonresidential Data Registry, if one is approved by the CEC, and by ATTCPs.

March 10, 2020 Workshop

Options presented at the workshop:

- Define the ATTCP as an authorized user
- Define the ATTCP as an EDDS
- Create a new section in Energy Code

Comments Received

California Energy Alliance comment:

- ATTCPs submit directly to the CEC repository
- ATTCP collect relevant planning documents

No other comments received

Staff amend to the CEA Proposal

- Eliminate the NDR from the Energy Code

Evaluation Criteria

- Avoid double charging consumers
- Market stability and transparency
- Level playing field for ATTCPs
- Support data efficacy over document efficacy
- Avoid project site workflow impedance
- Avoid impacting CEC repository
- Potential cost savings and benefits

Evaluation Results

	ATTCP as Authorized User	ATTCP as EDDS	New Section (JA7)	CEA Proposal
Avoid Double Charging	Pass	Pass, with conditions	Pass	Pass
Market Stability and Transparency	Pass, with conditions	Pass, with conditions	Pass	Pass
Level Playing Field	Does not pass	Does not pass	Pass	Pass
Supports data efficacy over document efficacy	Does not pass	Pass	Pass	Pass
Project Workflow	Pass, with conditions	Pass, with conditions	Pass, with conditions	Pass
Avoid Impacting the CEC Repository	Pass	Does not pass	Pass	Pass

Staff Recommendations

1. Repeal all references and requirements to NDR
2. ATTCPs submit data monthly to the CEC

1. Changes to Definitions

This include Title 1, Sections 10-102, 10-103(a)1, 10-103(a)3, 10-103(a)4, and Joint Reference Appendix Sections: JA1 and JA7.5. Deleting references to the NDR.

~~**NONRESIDENTIAL DATA REGISTRY** is a data registry that is maintained by the Registration Provider approved by the Commission that provides for registration, when required by Part 6, of all nonresidential documentation. However, nonresidential data registries may not provide for registration of nonresidential Certificate of Verification.~~

2. New Requirements

New requirement for the ATTCPs, Sections 10-103.1(c)3I and 10-103.2(c)3I:

Compliance Document Recording and Repository Reporting Requirement:

I. The ATTCP shall record all certificates of compliance [Section 10-103(a)1], certificates of installation [Section 10-103(a)3], and certificates of acceptance [Section 10-103(a)4] associated with any acceptance test specified in Part 6, Section 130.4 or 120.5.

II. Contingent upon Energy Commission approval of the threshold [Section 10-103.1(b) or 10-103.2(b)] and upon availability and approval of an electronic document repository by the Executive Director, the ATTCP shall submit monthly data transfer packets to the Energy Commission to an electronic document repository for retention consistent with Energy Commission instructions.

Questions?

Comments for Todays Workshop

Due Date December 18, 2020 By 5:00 PM

Comments to be submitted to:
Docket number 19-BSTD-03

The staff report and this presentation are available at the following event page:
Staff Workshop - Acceptance Testing Provisions

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Closing Remarks and Thank You!

Multifamily Restructuring Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenter: Javier Perez, Energy Commission Specialist II

Date: December 2, 2020

Proposal Summary

Submeasures pertaining to multifamily restructuring

- Relocate language pertaining to multifamily buildings from high-rise residential and low-rise residential subchapters to newly created multifamily subchapters.

Submeasures pertaining to multifamily efficiency requirements

- Where appropriate and cost effective, apply more stringent/efficient requirements across low- and high-rise multifamily buildings, increasing uniformity and simplicity.
  - Envelope
  - Mechanical

2022 Code Update Sections Affected

Restructuring of Multifamily Requirements

Relocate language pertaining to multifamily buildings (including low- and high-rise)

2019 Subchapters

- High-Rise Residential Subchapters (§120.0-§141.1)
  - Subchapters 3 and 4 – Mandatory Measures
  - Subchapter 5 – Performance and Prescriptive Compliance Approaches
  - Subchapter 6 – Additions and Alterations
- Low-rise Residential Subchapters (§150.0-§150.2)
  - Subchapter 7 – Mandatory Measures
  - Subchapter 8 – Performance and prescriptive Compliance Approaches
  - Subchapter 9 – Additions, Alterations, and Repairs

2022 Newly Created Subchapters

- Newly Created Subchapters (§160.0-§180.4)
  - Subchapter 10 – Multifamily Buildings – Mandatory Measures
  - Subchapter 11 – Multifamily Buildings – Performance and Prescriptive Compliance Approaches
  - Subchapter 12 – Multifamily Buildings – Additions, Alterations, and Repairs

Multifamily New Construction Prototypes

Prototypes	Stories	Floor Area (ft^2)	Description
2-Story Garden Style	2	7,680	8-unit residential building with, slab on-grade foundation, wood framed wall construction and a sloped roof. Individual space conditioning and domestic hot water systems serving each unit. Window to Wall Ratio 0.15.
3-Story Loaded Corridor	3	40,000	36-unit residential building with slab on-grade foundation, wood framed wall construction, and a flat roof. Window to Wall Ratio 0.25. Dwelling units flank and central corridor and common area spaces included on bottom floor. Individual space conditioning systems and shared domestic hot water system.
5-Story Mixed Use	5	113,100	88-unit building with 4-story residential plus 1-story commercial. Concrete podium construction with underground parking, wood framed wall construction, and flat roof. Window to Wall Ratio-0.10 (ground floor) 0.25 (residential floors). Individual space conditioning systems and a central domestic hot water system.
10-Story Mixed Use	10	125,400	117-unit building with 9-story residential + 1-story commercial. Concrete podium construction with underground parking, steel framed wall construction, and a flat roof. Window to Wall Ratio-0.10 (ground floor) 0.40 (residential floors). Individual space conditioning systems and a central domestic hot water system.

Multifamily Existing Building Prototypes - Fenestration

Prototypes	Stories	Floor Area (ft^2)	Description
Prototype D Existing Building	2	6960	8-unit residential building with, slab on-grade foundation, wood framed wall construction and a steep-sloped roof with attic. Individual space conditioning and domestic hot water systems serving each unit.
High-Rise Existing	10	125,400	117-unit building with 9-story residential + 1-story commercial. Concrete podium construction with underground parking, steel framed wall construction, and a flat roof. Window to Wall Ratio-0.10 (ground floor) 0.40 (residential floors). Individual space conditioning systems.

Multifamily Prototype Weighting

Prototypes	Stories	Weighted Factors for New Construct Impact Analysis	Weighting Factor for Existing Building Impact Analysis
2-Story Garden Style	2	4%	40%
3-Story Loaded Corridor	3	33%	18%
5-Story Mixed Use	5	58%	18%
10-Story Mixed Use	10	5%	24%

Envelope Unification Measure Proposals

Roof/Ceiling Assemblies

Create uniform requirements across multifamily buildings based on building and assembly type

- Mandatory Measures
  - Apply low-rise residential max U-factor of 0.043 for ceiling/rafter roof to multifamily buildings with attics.
  - Apply mandatory nonresidential max U-factor of 0.098 for metal roofs.
  - Apply mandatory nonresidential max U-factor of 0.075 for wood framed and other non-attic roofs in buildings < 4 habitable stories.
- Prescriptive Measures
  - Apply prescriptive low-rise residential requirements to multifamily buildings with attics, including Option B (below deck insulation HPA) and Option C (ducts in conditioned space).
  - Apply high-rise residential prescriptive U-factor requirements using both metal and wood-framed/other roof categories.

Roof/Ceiling Assemblies

Create new prescriptive option for multifamily buildings without an attic

- Reduces overall stringency of roof/ceiling assemblies for low-rise multifamily buildings without an attic
  - 2019 Code measures these non-attic buildings against a building with an attic.
- This aligns insulation and roofing product requirements across low- and high-rise multifamily buildings for buildings without an attic.
- Metal building max U-factor: 0.041
- Wood framed and other max U-factor:
  - CZs 1, 2, 4, 8-16: 0.028
  - CZs 3, 5, 6: 0.034
  - CZ 7: 0.039
- Apply roofing product requirements across low- and high-rise multifamily buildings
  - Low-sloped roofs in CZs 9-11, 13-16:
    - Min Aged Solar Reflectance (ASR): 0.63
    - Min Thermal Emittance (TE): 0.75
  - Steep-sloped roofs in CZs 2-15:
    - Min ASR: 0.20
    - Min TE: 0.75

Roof/Ceiling Assemblies

Table 40: First-Year Energy Impacts Per Dwelling Unit– Low-Slope New Requirement of Insulation plus 0.63 ASR, 2-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(0.40)	(0.00)	(0.59)	(230)
2	2.07	0.00	0.04	29
3	(1.23)	(0.00)	(0.16)	(394)
4	(0.76)	(0.01)	0.49	(307)
5	(0.98)	(0.00)	(0.31)	(240)
6	(9.27)	(0.01)	(0.05)	(586)
7	(11.07)	(0.02)	(0.20)	(749)
8	7.69	0.00	0.04	557
9	67.71	0.05	(1.13)	2,515
10	78.86	0.05	(1.43)	2,294
11	75.75	0.04	(2.91)	2,554
12	4.53	(0.00)	(0.73)	10
13	(15.35)	(0.01)	(0.90)	(1,066)
14	51.34	0.04	(3.68)	1,286
15	(39.89)	(0.03)	(0.13)	(1,574)
16	0.96	(0.00)	(0.70)	(221)
Statewide Weighted Average	**21.65**	**0.01**	**(0.60)**	**609**

Table 41: First-Year Energy Impacts Per Dwelling Unit– Low-Slope New Requirement of Insulation plus 0.63 ASR, 3-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(6.54)	0.00	(3.81)	(1,522)
2	6.01	0.00	(2.20)	(200)
3	(3.33)	(0.00)	(1.02)	(522)
4	2.26	(0.00)	(0.76)	(478)
5	(4.35)	(0.00)	(1.09)	(578)
6	(10.54)	(0.01)	(0.19)	(467)
7	(13.76)	(0.02)	(0.07)	(689)
8	15.89	0.00	(0.11)	1,078
9	68.38	0.04	(0.73)	2,511
10	80.39	0.04	(1.27)	2,311
11	65.53	0.03	(3.42)	1,856
12	13.36	0.00	(2.38)	(133)
13	(23.53)	(0.02)	(2.40)	(1,989)
14	37.20	0.03	(3.80)	744
15	(65.07)	(0.04)	(0.11)	(2,378)
16	(3.58)	(0.00)	(4.83)	(1,833)
Statewide Weighted Average	**22.40**	**0.01**	**(1.13)**	**525**

Roof/Ceiling Assemblies

Table 42: First-Year Energy Impacts Per Dwelling Unit– Low-Slope Increase to 0.63 ASR, 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	8.82	0.00	(0.08)	240
10	9.01	0.00	(0.10)	225
11	6.99	0.00	(0.15)	181
12	N/A	N/A	N/A	N/A
13	8.78	0.00	(0.17)	182
14	7.05	0.00	(0.21)	172
15	11.36	0.00	(0.04)	291
16	N/A	N/A	N/A	N/A
Statewide Weighted Average	**3.27**	**0.00**	**(0.04)**	**85**

Table 43: First-Year Energy Impacts Per Dwelling Unit– Low-Slope Increase to 0.63 ASR, 10-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	3.63	0.00	(0.04)	98
10	3.76	0.00	(0.04)	94
11	2.83	0.00	(0.06)	71
12	N/A	N/A	N/A	N/A
13	3.64	0.00	(0.06)	78
14	2.97	0.00	(0.07)	78
15	4.62	0.00	(0.02)	114
16	N/A	N/A	N/A	N/A
Statewide Weighted Average	**1.35**	**0.00**	**(0.02)**	**35**

Roof/Ceiling Assemblies

Table 74: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction – Roof Assembly Change, 2-Story Prototype Building

Climate Zone	30-Year TDV Electricity Cost Savings (2023 PV$)	30-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 30-Year TDV Energy Cost Savings (2023 PV$)
1	($1.66)	($38.20)	($39.86)
2	$3.32	$1.66	$4.98
3	($56.47)	($11.63)	($68.09)
4	($83.04)	$29.89	($53.15)
5	($21.59)	($19.93)	($41.52)
6	($97.99)	($3.32)	($101.31)
7	($116.26)	($13.29)	($129.54)
8	$93.00	$3.32	$96.33
9	$506.54	($71.41)	$435.13
10	$488.28	($91.34)	$396.93
11	$624.46	($182.69)	$441.77
12	$49.82	($48.16)	$1.66
13	($126.22)	($58.13)	($184.35)
14	$456.72	($234.17)	$222.55
15	($264.07)	($8.30)	($272.37)
16	$4.98	($43.18)	($38.20)
Statewide Weighted Average	**$144**	**-$39**	**$105**

Table 75: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction – Roof Assembly Change, 3-Story Prototype Building

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	($34.60)	($228.74)	($263.34)
2	$99.96	($134.56)	($34.60)
3	($26.91)	($63.43)	($90.34)
4	($34.60)	($48.06)	($82.66)
5	($32.68)	($67.28)	($99.96)
6	($69.20)	($11.53)	($80.73)
7	($113.41)	($5.77)	($119.18)
8	$194.14	($7.69)	$186.46
9	$478.63	($44.21)	$434.42
10	$478.63	($78.81)	$399.82
11	$532.46	($211.44)	$321.01
12	$124.94	($148.01)	($23.07)
13	($196.07)	($148.01)	($344.08)
14	$363.30	($234.51)	$128.79
15	($403.67)	($7.69)	($411.36)
16	($24.99)	($292.18)	($317.17)
Statewide Weighted Average	**$161**	**-$70**	**$91**

Roof/Ceiling Assemblies

Table 76: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction – Low-Slope Roof Products, 5-Story Prototype Building

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	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	N/A	N/A	N/A
8	N/A	N/A	N/A
9	$45.36	($3.89)	$41.47
10	$43.80	($4.80)	$39.00
11	$38.47	($7.12)	$31.35
12	N/A	N/A	N/A
13	$42.50	($10.96)	$31.54
14	$39.58	($9.89)	$29.68
15	$53.14	($2.85)	$50.29
16	N/A	N/A	N/A

Table 77: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– New Construction – Low-Slope Roof Products, 10-Story Prototype Building

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	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	N/A	N/A	N/A
8	N/A	N/A	N/A
9	$18.54	($1.67)	$16.87
10	$18.17	($1.91)	$16.26
11	$15.02	($2.65)	$12.37
12	N/A	N/A	N/A
13	$17.57	($4.16)	$13.42
14	$16.69	($3.13)	$13.55
15	$21.01	($1.21)	$19.80
16	N/A	N/A	N/A

Roof/Ceiling Assemblies

- Because this proposes a new prescriptive option and does not replace existing requirements, cost-effectiveness analysis was not done.
- The increased stringency in roofing product requirements for high-rise residential buildings with low-sloped roofs did not result in any cost increase.
  - Products were readily available at the proposed 0.63 ASR requirement at the same price as products that meet the 2019 Code's 0.55 ASR.

Roof/Ceiling Assemblies

Any questions on the roof/ceiling assembly measures?

Wall U-Factor Unification

Create uniform requirements across multifamily buildings, varying by assembly type and climate zone

- Differentiate assembly types by fire rating for select wall assemblies.
  - Allows high-fire rating wall types to adhere to less stringent U-factor requirements.
    - ❖ Variances in insulation by assembly include:
      - ➢ Metal Buildings
      - ➢ Framed (wood/metal), high fire rating (2 or 3 hour)
      - ➢ Framed (wood/metal), low fire rating (0 or 1 hour), and other wall types
      - ➢ Heavy mass (>15 btu/ft^2-F)
      - ➢ Light mass (7-15 btu/ft^2-F)

Wall U-Factor Unification

Technical Feasibility – Framed Walls

- The California Fire Code mandates zero-hour to four-hour fire ratings for walls.
- These requirements vary based on building size and proximity to neighboring structures.
- It is challenging for an assembly to achieve both high fire rating and low U-factors.
  - Can lead to higher cost, complicated construction methods, thicker assemblies, limited options.
- For this reason proposal includes two different categories for wood/metal framed walls:
  - Zero to one-hour fire rated walls
  - Two to three-hour fire rated walls

Wall U-Factor Unification

Table 5: Proposed Wall U-factors by Wall Assembly Type and Climate Zone

Wall Type	Climate Zones	Mandatory Assembly U-factor	Prescriptive Assembly U-factor
Metal Buildings	CZ 1-10	Metal Buildings = 0.113 Spandrel Panels and Curtain Walls = 0.280	0.061
	CZ 11-16		0.057
Framed (wood or metal), high fire rating (2- or 3-hours)	CZ 1-5,8-10, 12, & 13	2x4 framing = 0.102 2x6 framing = 0.071 non-framed = 0.102	0.059
	CZ 6 & 7		0.065
	CZ 11, & 14-16		0.051
Framed (wood or metal), low fire rating (0- or 1-hours), and other wall types	CZ 1-5, 8-16		0.051
	CZ 6 & 7		0.065

Wall U-Factor Unification

Table 5: Proposed Wall U-factors by Wall Assembly Type and Climate Zone

Wall Type	Climate Zones	Mandatory Assembly U-factor	Prescriptive Assembly U-factor
Heavy mass (>15 Btu/ft^2-F)	CZ 1-3, 16	0.690	0.160
	CZ 4, 11, 14, & 15		0.184
	CZ 5, 13		0.211
	CZ 6-10		0.690
	CZ 12		0.253
Light mass (7-15 Btu/ft^2-F)	CZ 1-15	0.440	0.077
	CZ 16		0.059

Wall U-Factor Unification

Table 44: First-Year Energy Impacts Per Dwelling Unit – Framed, High Fire Rating (2- and 3-hr), 3-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(3.57)	(0.00)	(1.72)	(689)
2	(2.04)	0.00	(0.92)	(400)
3	(1.83)	0.00	(0.58)	(278)
4	(0.80)	0.00	(0.52)	(233)
5	(1.74)	0.00	(0.52)	(222)
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	(0.32)	(0.00)	(0.07)	(89)
9	(0.64)	(0.00)	(0.21)	(167)
10	(1.90)	(0.00)	(0.35)	(244)
11	N/A	N/A	N/A	N/A
12	(2.11)	0.00	(0.83)	(444)
13	(6.62)	(0.00)	(0.70)	(533)
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A
Statewide Weighted Average	**(1.24)**	**(0.00)**	**(0.37)**	**(213)**

Table 45: First-Year Energy Impacts Per Dwelling Unit– Framed, Low Fire Rating (0- or 1- hour), 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	4.00	(0.00)	1.96	825
2	7.85	(0.00)	1.32	729
3	2.93	(0.00)	0.87	347
4	4.70	(0.00)	0.77	447
5	3.98	(0.00)	0.88	312
6	1.34	(0.00)	(0.12)	(246)
7	1.55	(0.00)	(0.09)	(191)
8	4.95	(0.00)	0.32	262
9	5.66	0.00	0.43	322
10	7.99	0.00	0.61	393
11	(12.78)	(0.01)	(1.56)	(1,891)
12	9.70	0.00	1.47	915
13	12.10	0.00	0.94	711
14	(11.11)	(0.01)	(1.51)	(1,827)
15	(21.76)	(0.01)	(0.23)	(1,318)
16	(7.78)	(0.01)	(3.30)	(2,188)
Statewide Weighted Average	**4.44**	**(0.00)**	**0.53**	**340**

Wall U-Factor Unification

Table 46: First-Year Energy Impacts Per Dwelling Unit– Framed, High Fire Rating, 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	1.34	(0.00)	(0.12)	(246)
7	1.55	(0.00)	(0.09)	(191)
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	(12.78)	(0.01)	(1.56)	(1,891)
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	(11.11)	(0.01)	(1.51)	(1,827)
15	(21.76)	(0.01)	(0.23)	(1,318)
16	(7.78)	(0.01)	(3.30)	(2,188)
Statewide Weighted Average	**(0.54)**	**(0.00)**	**(0.10)**	**(128)**

Table 47: First-Year Energy Impacts Per Dwelling Unit– Framed, High Fire Rating, 10-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	1.30	(0.00)	(0.11)	(35)
7	1.51	(0.00)	(0.07)	(9)
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	(20.88)	(0.02)	(2.57)	(1,752)
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	(18.74)	(0.01)	(2.42)	(1,620)
15	(32.93)	(0.02)	(0.42)	(1,457)
16	(12.35)	(0.01)	(4.93)	(1,644)
Statewide Weighted Average	**(0.99)**	**(0.00)**	**(0.14)**	**(93)**

Wall U-Factor Unification

Table 94: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – New Construction – Framed (Wood or Metal) and Others, ≤ 1 hr Fire Rating, 5-Story Prototype Building

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	$121.84	$41.61	3.43
2	$112.74	$41.61	3.03
3	$50.22	$41.61	1.44
4	$70.16	$41.61	1.86
5	$42.99 $	$41.61	1.30
6	N/A	N/A	3.43
7	N/A	N/A	N/A
8	$42.85	$41.61	1.09
9	$52.14	$41.61	1.34
10	$61.89	$41.61	1.63
11	N/A	N/A	N/A
12	$144.97	$41.61	3.80
13	$114.21	$41.61	2.96
14	N/A	N/A	N/A
15	N/A	N/A	N/A
16	N/A	N/A	N/A

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

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

Wall U-Factor Unification: Staff Questions

Any feedback on incremental costs or data that can be shared would be welcome.

Fenestration Area

Create uniform requirements across multifamily buildings

- Apply the prescriptive low-rise residential 20% window-to-conditioned-floor-area limit to high-rise residential buildings.
- Apply the prescriptive high-rise residential 40% window-to-wall area limit and 5% skylight-to-roof ratio limit to low-rise buildings.
- Both limits must be met.
- Include penalties when those thresholds are exceeded via the performance approach.
- Remove the 5% window-to-floor area limit for west-facing glazing (currently in low-rise residential requirements.

Fenestration Area

Create uniform requirements across multifamily buildings

- Area limitations apply to:
  - Newly constructed buildings construction,
  - Additions greater than 700 ft^2 in building size, and
  - Alterations of more than 150 ft^2 of fenestration area.
- CASE team found no technical feasibility challenges with meeting this measure.
- No energy simulation was performed.
- No energy cost savings because there were no energy savings impacts.
- Measure did not increase stringency, and thus, no cost increase, and no cost effectiveness analysis necessary.

Fenestration Area: Staff Questions

Q: Are there any concerns about requiring compliance with two area limitation calculations for multifamily buildings moving forward?

Fenestration Properties – New Construction

Create uniform requirements across multifamily buildings based on fenestration type and climate zone

- Mandatory Measures
  - Apply low-rise residential weighted average maximum U-factor requirement to multifamily buildings taller than three habitable stories.
- Prescriptive Measures – Three Categories
  - Curtain wall and storefront windows
  - Performance Class All Weather (AW) rated windows as per NASF-2017, AAMA/WDMA/CSA/ 101/I.S.2/A440
  - All other windows

Fenestration Properties – New Construction

Prescriptive fenestration requirements by fenestration type and climate zone

Window Type	Climate Zones	Max U-Factor	Max SHGC	Min VT
Curtainwall / Storefront	1	0.38	0.35	0.46
	2-15	0.41	0.26	0.46
	16	0.38	0.25	0.46
Class AW	1	0.38	0.35	0.37
	2-15	0.40	0.24	0.37
	16	0.38	0.24	0.37
All Other	1	0.30	0.35*	No Requirement
	2-5, 8-16	0.30	0.23*	No Requirement
	6, 7	0.34	0.23	No Requirement

*Low-rise multifamily buildings (3 habitable stories or less) in climate zones 1, 3, 5, and 16, will continue to have no max SHGC requirements.

Fenestration Properties – New Construction

Create uniform requirements across multifamily buildings based on fenestration type

- Harmonize recognition of shading for windows
  - Current code has different methodologies for solar heat gain coefficient (SHGC) and the effects of shading for residential buildings compared to all other types.
  - Proposal recommends use of RSHGC methodology for prescriptive compliance with all multifamily buildings.

Fenestration Properties – New Construction

Table 50: First-Year Energy Impacts Per Dwelling Unit – Curtainwall/Storefronts, 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(26.14)	(0.02)	5.86	1,240
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	(3.77)	(0.00)	3.22	995

Table 51: First-Year Energy Impacts Per Dwelling Unit – Curtainwall/Storefronts, 10-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(61.51)	(0.02)	8.47	1,241
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	(14.67)	(0.00)	4.82	1,245

Fenestration Properties – New Construction

Table 52: First-Year Energy Impacts Per Dwelling Unit – Combined Category *Performance Class AW*, 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(25.93)	(0.02)	5.99	1,626
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	(0.93)	(0.00)	2.19	833

Table 53: First-Year Energy Impacts Per Dwelling Unit – Combined Category *Performance Class AW* 10-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(66.37)	(0.03)	8.21	1,526
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	(5.48)	(0.00)	3.19	1,091

Fenestration Properties – New Construction

Table 54: First-Year Energy Impacts Per Dwelling Unit – Combined Category *All Others*, 2-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	3.87	0.01	(0.82)	(105.6)
7	4.83	0.00	(0.45)	105.6
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Table 55: First-Year Energy Impacts Per Dwelling Unit – Combined Category *All Others*, 3-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	7.68	0.01	(0.44)	15.38
7	7.82	0.01	(0.17)	40.37
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Fenestration Properties – New Construction

Table 56: First-Year Energy Impacts Per Dwelling Unit – Combined Category *All Others*, 5-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(30.36)	(0.03)	11.74	3,696
2	(1.95)	(0.00)	4.06	1,701
3	(9.70)	(0.01)	2.91	914
4	(7.48)	(0.00)	2.24	960
5	(11.74)	(0.01)	2.49	600
6	(4.25)	(0.00)	0.47	105
7	(6.00)	(0.00)	0.36	(42)
8	(12.24)	(0.00)	0.86	234
9	(9.36)	0.00	1.25	505
10	(2.57)	0.00	1.72	804
11	12.73	0.01	4.38	2,417
12	1.31	0.00	3.63	1,740
13	12.80	0.01	3.09	1,937
14	8.80	0.01	3.88	2,073
15	28.07	0.01	0.59	1,389
16	3.85	(0.00)	9.91	3,930
Statewide Weighted Average	**(5.03)**	**(0.00)**	**2.13**	**887**

Table 57: First-Year Energy Impacts Per Dwelling Unit – Combined Category *All Others* 10-Story Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(91.82)	(0.04)	16.61	4,081
2	(16.45)	(0.01)	6.17	2,341
3	(28.85)	(0.01)	4.53	1,154
4	(22.91)	(0.00)	3.35	1,220
5	(32.02)	(0.01)	3.77	592
6	(10.97)	(0.00)	0.73	82
7	(11.78)	(0.00)	0.64	(81)
8	(28.50)	0.00	1.22	120
9	(24.22)	0.00	1.89	582
10	(14.59)	0.01	2.47	979
11	11.44	0.01	7.11	3,693
12	(9.79)	0.00	5.67	2,491
13	10.15	0.01	4.76	2,822
14	1.31	0.01	5.73	2,868
15	37.32	0.02	0.80	2,001
16	(11.16)	(0.01)	14.91	5,414
Statewide Weighted Average	**(18.05)**	**(0.00)**	**3.25**	**1,158**

Fenestration Properties – Alterations and Additions

Create uniform requirements across multifamily buildings based on fenestration type and climate zone

- Additions and alterations
  - Mandatory Measures
    - ❖ Apply low-rise residential weighted average maximum U-factor requirement to multifamily buildings taller than three habitable stories.
      - ➢ Not applicable to curtain wall fenestration types.
  - Prescriptive Measures – Three Categories
    - ❖ Curtain wall and storefront windows
    - ❖ Performance Class All Weather (AW) rated windows as per NASF-2008, AAMA/WDMA/CSA/ 101/I.S.2/A440
    - ❖ All other windows
- Proposal calls for less restrictive requirements when < 150 ft2 is being added/altered

Fenestration Properties – Alterations and Additions

Create uniform requirements across multifamily buildings based on fenestration type and climate zone

Table 7: Proposed Fenestration Thermal Properties by Type and Climate Zone; Alterations and Additions

Window Type	Climate Zones	U-Factor (maximum)	SHGC (maximum)	VT (minimum)
Curtain wall / Storefront/ Glazed Doors	CZ 1	0.38	0.35	0.46
	CZ 2-15	0.41	0.26	0.46
	CZ 16	0.38	0.25	0.46
Class AW Fixed Windows	CZ 1	0.38	0.35	0.37
	CZ 2-5, 9-16	0.38	0.25	0.37
	CZ 6-8	0.41	0.26	0.37
Class AW Operable Windows	CZ 1	0.43	0.35	0.37
	CZ 2-16	0.43	0.24	0.37
All-others	CZ 1	0.30	0.23	NR
	CZ 2-5, 8-16	0.30	0.23	NR
	CZ 6, 7	0.34	0.23	NR
Alterations or Additions <150 ft^2	CZ 1	0.47	0.35	NR
	CZ 2-16	0.47	0.31	NR

Low-rise residential buildings in CZs 1, 3, 5, and 16, will continue to have no SHGC requirement

Fenestration Properties – Alterations and Additions

Table 58: First-Year Energy Impacts Per Dwelling Unit – Curtainwall/Storefronts, High-Rise Existing Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	81.67	0.01	5.86	3,984
2	43.69	0.01	3.62	2,986
3	273.04	0.04	4.31	8,510
4	43.95	0.01	2.07	2,509
5	306.21	0.04	4.21	8,290
6	41.74	0.01	1.03	1,577
7	36.10	0.01	0.82	1,179
8	47.50	0.01	1.14	2,022
9	53.32	0.01	1.39	2,400
10	61.44	0.02	1.73	2,619
11	66.19	0.03	3.49	3,801
12	50.26	0.02	2.99	3,062
13	64.94	0.03	2.44	3,429
14	76.33	0.02	3.36	3,876
15	109.99	0.03	0.84	3,889
16	313.15	0.07	1.97	7,476

Fenestration Properties – Alterations and Additions

Table 59: First-Year Energy Impacts Per Dwelling Unit – Class AW Fixed, High-Rise Existing Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	81.67	0.01	5.86	3,984
2	27.55	0.01	6.17	3,754
3	255.81	0.04	6.25	8,915
4	22.34	0.01	3.58	2,812
5	288.69	0.03	6.09	8,604
6	41.74	0.01	1.03	2,617
7	36.10	0.01	0.82	2,123
8	47.50	0.01	1.14	2,979
9	29.89	0.01	2.36	2,442
10	41.34	0.02	2.92	2,822
11	53.20	0.03	5.88	4,788
12	31.24	0.02	5.09	3,712
13	50.86	0.03	4.22	4,183
14	65.26	0.02	5.79	4,867
15	105.24	0.04	1.37	4,446
16	313.15	0.07	1.97	7,476

Table 60: First-Year Energy Impacts Per Dwelling Unit – Class AW Operable, High-Rise Existing Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	82.51	0.02	(0.59)	1,565
2	66.74	0.02	1.46	2,778
3	299.15	0.05	2.53	8,501
4	74.46	0.02	0.73	2,743
5	336.13	0.05	2.60	8,412
6	85.88	0.02	0.41	2,401
7	80.64	0.01	0.32	2,063
8	87.32	0.02	0.51	2,708
9	92.48	0.02	0.55	3,014
10	98.36	0.02	0.73	3,089
11	88.45	0.03	1.39	3,502
12	76.08	0.02	1.17	2,970
13	88.66	0.03	0.84	3,325
14	107.50	0.03	1.20	3,773
15	141.56	0.03	0.38	4,334
16	346.92	0.08	(6.85)	4,777

Fenestration Properties – Alterations and Additions

Table 61: First-Year Energy Impacts Per Dwelling Unit – Combined All-Others, High-Rise Existing Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	73.51	0.00	16.16	7,718
2	68.79	0.01	11.79	7,350
3	277.91	0.04	10.29	11,100
4	57.80	0.02	6.87	5,551
5	315.06	0.03	9.97	10,567
6	66.00	0.01	2.34	2,804
7	53.84	0.01	1.87	1,946
8	57.04	0.02	3.51	3,774
9	71.44	0.02	4.43	4,804
10	95.23	0.03	5.51	5,559
11	125.21	0.05	11.39	9,477
12	80.59	0.03	9.78	7,367
13	123.09	0.05	8.06	8,322
14	137.40	0.04	10.96	9,330
15	226.50	0.07	2.54	8,792
16	352.52	0.07	12.48	12,411

Table 62: First-Year Energy Impacts Per Dwelling Unit – Combined All-Others, Prototype D Existing Low-Rise Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A
6	6.16	0.01	(1.27)	(182.40)
7	6.88	0.01	(0.80)	67.20
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Fenestration Properties – Alterations and Additions

Table 86: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit – Alterations - Curtainwall/Storefronts, High-Rise Existing Prototype Building

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	$318.67	$370.63	$689.30
2	$287.06	$229.45	$516.50
3	$1,197.23	$274.92	$1,472.15
4	$301.18	$132.86	$434.04
5	$1,165.84	$268.36	$1,434.20
6	$206.17	$66.59	$272.76
7	$150.36	$53.69	$204.05
8	$275.99	$73.89	$349.88
9	$325.51	$89.67	$415.18
10	$341.12	$111.91	$453.04
11	$433.01	$224.50	$657.50
12	$337.86	$191.85	$529.70
13	$435.88	$157.41	$593.29
14	$454.43	$216.06	$670.49
15	$618.30	$54.55	$672.85
16	$1,163.18	$130.16	$1,293.34

Table 87: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– Alterations Class AW Fixed, High-Rise Existing Prototype Building

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	$318.67	$370.63	$689.30
2	$258.43	$391.10	$649.53
3	$1,143.64	$398.71	$1,542.35
4	$256.87	$229.68	$486.56
5	$1,101.60	$386.90	$1,488.51
6	$248.10	$204.65	$452.76
7	$188.74	$178.47	$367.20
8	$312.95	$202.46	$515.41
9	$270.06	$152.37	$422.42
10	$298.96	$189.32	$488.28
11	$450.09	$378.17	$828.26
12	$315.99	$326.25	$642.23
13	$451.37	$272.22	$723.59
14	$469.50	$372.57	$842.07
15	$679.82	$89.30	$769.13
16	$1,163.18	$130.16	$1,293.34

Fenestration Properties – Alterations and Additions

Table 88: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– Alterations Class AW Operable, High-Rise Existing Prototype Building

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	$302.41	($31.61)	$270.81
2	$388.26	$92.29	$480.55
3	$1,308.93	$161.82	$1,470.75
4	$427.80	$46.65	$474.45
5	$1,289.23	$165.96	$1,455.19
6	$388.67	$26.74	$415.42
7	$335.63	$21.25	$356.88
8	$435.56	$32.86	$468.42
9	$485.59	$35.81	$521.39
10	$487.12	$47.24	$534.36
11	$516.44	$89.34	$605.79
12	$439.16	$74.58	$513.74
13	$521.35	$53.81	$575.15
14	$575.67	$77.12	$652.80
15	$724.64	$25.13	$749.77
16	$1,253.34	($426.97)	$826.37

Table 89: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per Dwelling Unit– Alterations - Combined All Others, High-Rise Existing Prototype Building

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	$320.16	$1,015.00	$1,335.16
2	$523.38	$748.22	$1,271.60
3	$1,263.70	$656.67	$1,920.38
4	$519.06	$441.25	$960.31
5	$1,194.24	$633.89	$1,828.13
6	$333.52	$151.61	$485.13
7	$214.80	$121.85	$336.64
8	$424.66	$228.20	$652.86
9	$544.49	$286.68	$831.17
10	$604.22	$357.43	$961.65
11	$906.01	$733.53	$1,639.55
12	$646.25	$628.29	$1,274.53
13	$919.57	$520.22	$1,439.79
14	$907.94	$706.23	$1,614.17
15	$1,355.04	$166.02	$1,521.06
16	$1,350.83	$796.28	$2,147.11

Fenestration Properties – Alterations and Additions

Table 102: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – Additions and Alterations – Curtainwall/Storefronts, High-Rise Existing Prototype Building

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	$689.30	$336.79	2.05
2	$649.53	$332.87	1.95
3	$1,542.35	$673.01	2.29
4	$651.23	$332.87	1.96
5	$1,488.51	$673.01	2.21
6	$452.76	$332.87	1.36
7	$367.20	$332.87	1.10
8	$515.41	$332.87	1.55
9	$595.47	$332.87	1.79
10	$624.30	$332.87	1.88
11	$828.26	$332.87	2.49
12	$642.23	$332.87	1.93
13	$723.59	$332.87	2.17
14	$842.07	$332.87	2.53
15	$791.39	$332.87	2.38
16	$1,293.34	$652.53	1.98

Table 103: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – Additions and Alterations – Class AW Fixed, High-Rise Existing Prototype Building

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	$689.30	$200.78	3.43
2	$649.53	$390.38	1.66
3	$1,542.35	$866.52	1.78
4	$486.56	$390.38	1.25
5	$1,488.51	$866.52	1.72
6	$452.76	$319.92	1.42
7	$367.20	$319.92	1.15
8	$515.41	$319.92	1.61
9	$422.42	$390.38	1.08
10	$488.28	$390.38	1.25
11	$828.26	$390.38	2.12
12	$642.23	$390.38	1.65
13	$723.59	$390.38	1.85
14	$842.07	$390.38	2.16
15	$769.13	$390.38	1.97
16	$1,293.34	$516.78	2.50

Fenestration Properties – Alterations and Additions

Table 104: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – Additions and Alterations – Class AW Operable, High-Rise Existing Prototype Building

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	$270.81	$121.79	2.22
2	$480.55	$216.86	2.22
3	$1,470.75	$722.34	2.04
4	$474.45	$216.86	2.19
5	$1,455.19	$722.34	2.01
6	$415.42	$216.86	1.92
7	$356.88	$216.86	1.65
8	$468.42	$216.86	2.16
9	$521.39	$216.86	2.40
10	$534.36	$216.86	2.46
11	$605.79	$216.86	2.79
12	$513.74	$216.86	2.37
13	$575.15	$216.86	2.65
14	$652.80	$216.86	3.01
15	$749.77	$216.86	3.46
16	$826.37	$311.93	2.65

Table 105: 30-Year Cost-Effectiveness Summary Per Dwelling Unit – Additions and Alterations – Combined All Others High-Rise Existing Prototype Building

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	$1,335.16	$58.29	22.91
2	$1,271.60	$58.29	21.81
3	$1,920.38	$58.29	32.94
4	$960.31	$58.29	16.47
5	$1,828.13	$58.29	31.36
6	$485.13	$4.86	99.87
7	$336.64	$4.86	69.30
8	$652.86	$58.29	11.20
9	$831.17	$58.29	14.26
10	$961.65	$58.29	16.50
11	$1,639.55	$58.29	28.13
12	$1,274.53	$58.29	21.87
13	$1,439.79	$58.29	24.70
14	$1,614.17	$58.29	27.69
15	$1,521.06	$58.29	26.09
16	$2,147.11	$58.29	36.83

Fenestration Properties: Staff Questions

Any feedback on incremental costs or data that can be shared would be welcome.

Mechanical Unification Measure Proposals

Space Conditioning – Duct Insulation

Create uniform requirements across all multifamily buildings

- Mandatory Measures
  - Apply high-rise requirement of R-4.2 mandatory duct insulation on supply ducts inside of indirectly conditioned space to all multifamily buildings.
  - No change to uninsulated ducts exposed to directly conditioned space.
  - Apply low-rise R-6 mandatory duct insulation requirement to ducts in all other spaces.
- Prescriptive Measures
  - Apply low-rise R-8 duct insulation requirements to ducts in all other locations in climate zones 1-2, 4, and 8-16.
- Results in less restrictive requirements overall.
  - It was not cost-effective to apply more stringent requirements across all multifamily buildings.

Space Conditioning – Duct Insulation

Table 63: First-Year Energy Impacts Per Dwelling Unit – Three-Story Loaded Corridor Prototype Building New Construction – Duct Insulation for Ducts in Unconditioned Space

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	(2)	(0.001)	(0.1)	(340)
4	N/A	N/A	N/A	N/A
5	(2)	(0.001)	(0.1)	(188)
6	(9)	(0.010)	(0.0)	(521)
7	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A
11	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Table 64: First-Year Energy Impacts Per Dwelling Unit – Three-Story Loaded Corridor Prototype Building Alteration – Duct Insulation for Ducts in Unconditioned Space

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(5)	0.000	(0.5)	(295)
2	(6)	(0.004)	(0.3)	(787)
3	(2)	(0.001)	(0.1)	(340)
4	(7)	(0.008)	(0.1)	(400)
5	(2)	(0.001)	(0.1)	(188)
6	(9)	(0.010)	(0.0)	(521)
7	(10)	(0.015)	0.0	(552)
8	(9)	(0.010)	(0.0)	(430)
9	(9)	(0.010)	(0.0)	(424)
10	(10)	(0.011)	(0.1)	(491)
11	N/A	N/A	N/A	N/A
12	(8)	(0.007)	(0.2)	(515)
13	(11)	(0.009)	(0.2)	(575)
14	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A

Space Conditioning – Duct Insulation

Table 65: First-Year Energy Impacts Per Dwelling Unit – Three-Story Loaded Corridor Prototype Building – Duct Insulation for Ducts in Conditioned Space

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	2	0.000	(1.6)	(492)
2	0	(0.001)	(0.8)	(339)
3	(0)	0.000	(0.5)	(208)
4	(2)	(0.003)	(0.4)	(394)
5	0	0.000	(0.4)	(186)
6	(2)	(0.004)	(0.1)	(175)
7	(2)	(0.004)	(0.0)	(153)
8	(3)	(0.004)	(0.1)	(186)
9	(3)	(0.005)	(0.2)	(230)
10	(3)	(0.005)	(0.3)	(284)
11	(3)	(0.006)	(0.7)	(459)
12	(1)	(0.004)	(0.7)	(383)
13	(4)	(0.007)	(0.5)	(416)
14	(5)	(0.006)	(0.7)	(481)
15	(8)	(0.006)	(0.0)	(317)
16	2	(0.003)	(1.5)	(470)

Space Conditioning – Duct Insulation

Cost Savings and Effectiveness

- These measures are not increasing stringency.
- Costs and cost effectiveness analysis do not apply.

Space Conditioning – Duct Insulation

Any question on the duct insulation measures?

Space Conditioning – Duct Leakage Testing

Create semi-uniform requirements across all multifamily buildings

- Apply mandatory duct sealing for multifamily buildings three habitable stories or less to multifamily buildings four habitable stories or greater.
  - Only when ducted systems serving individual dwelling units.
  - No HERS verification.
  - Installer testing and reporting requirement proposed.
- Regardless of duct location, max 12% total leakage, or max 6% leakage to outside.
- For alterations/additions, max 15% total leakage, or 10% max leakage to outside.
- 2019 Energy Code requires leakage testing for high-rise residential buildings prescriptively for:
  - Single zone, constant volume systems serving less than 5,000 ft^2, where > 25% of duct surface area is in unconditioned space.
  - Max of 6% total leakage.
- Does not apply to high-rise residential buildings in climate zones 1, 5, and 7.

Space Conditioning – Duct Leakage Testing

Table 36: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change for Duct Leakage Testing

Prototype ID	Climate Zone	Software	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
5-story & 10-story (new construction & 10-story (existing)	All	CBECC-Com	Residential - Zone System - Cooling Coil - EER & SEER	12% leakage (multiply by factor of 0.8992)	6% leakage (multiply by factor of 0.9342)
			Residential - Zone System - Heating Coil - AFUE / HSPF	12% leakage (multiply by factor of 0.9260)	6% leakage (multiply by factor of 0.9633)

Space Conditioning – Duct Leakage Testing

Table 66: First-Year Energy Impacts Per Dwelling Unit – 5-Story Mixed-Use Prototype Building New Construction – Duct Leakage Testing

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	4.3	0.002	0.6	307
2	23.0	0.008	0.4	1,054
3	14.5	0.004	0.2	620
4	30.0	0.010	0.2	1,176
5	16.0	0.004	0.2	481
6	33.1	0.008	0.1	955
7	30.6	0.008	0.0	820
8	41.9	0.011	0.0	1,304
9	41.3	0.012	0.1	1,344
10	46.0	0.013	0.1	1,423
11	46.8	0.016	0.4	1,795
12	36.2	0.012	0.4	1,443
13	54.6	0.017	0.3	1,958
14	46.4	0.014	0.3	1,677
15	86.8	0.021	0.0	2,599
16	25.3	0.008	1.0	944

Table 67: First-Year Energy Impacts Per Dwelling Unit – 10-Story Mixed-Use Prototype Building New Construction – Duct Leakage Testing

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	4.7	0.001	0.7	343
2	23.3	0.008	0.4	1,078
3	15.0	0.004	0.2	653
4	30.9	0.010	0.2	1,208
5	16.7	0.004	0.2	512
6	34.6	0.009	0.0	1,003
7	31.8	0.008	0.0	869
8	43.3	0.011	0.0	1,341
9	43.0	0.012	0.1	1,397
10	47.8	0.013	0.1	1,483
11	50.0	0.017	0.5	1,929
12	36.7	0.012	0.4	1,475
13	56.0	0.017	0.3	2,020
14	49.6	0.014	0.4	1,801
15	92.0	0.021	0.0	2,733
16	25.7	0.008	1.3	1,027

Space Conditioning – Duct Leakage Testing

Table 68: First-Year Energy Impacts Per Dwelling Unit – 10-Story Mixed-Use Prototype Building Alteration– Duct Leakage Testing

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	9.2	0.002	2.1	849
2	25.2	0.007	1.7	1,603
3	20.9	0.004	1.2	1,106
4	31.3	0.009	0.9	1,555
5	23.6	0.004	1.1	940
6	32.7	0.008	0.3	1,131
7	29.3	0.007	0.2	916
8	43.5	0.010	0.4	1,595
9	43.5	0.012	0.5	1,690
10	49.5	0.013	0.7	1,849
11	52.2	0.018	1.9	2,526
12	38.2	0.013	1.5	1,975
13	58.5	0.018	1.3	2,531
14	51.5	0.014	1.6	2,339
15	97.7	0.022	0.3	3,226
16	32.9	0.008	3.4	1,855

Space Conditioning – Duct Leakage Testing

Table 106: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 5-Story Mixed-Use Dwelling Unit – New Construction Duct Leakage

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	$18	$30	$47
2	$144	$18	$162
3	$84	$11	$96
4	$173	$9	$181
5	$64	$10	$74
6	$145	$3	$147
7	$124	$2	$126
8	$198	$3	$201
9	$203	$4	$207
10	$213	$7	$219
11	$255	$21	$276
12	$204	$18	$222
13	$286	$15	$302
14	$242	$17	$258
15	$399	$2	$400
16	$96	$49	$145

Table 107: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 10-Story Mixed-Use Dwelling Unit – New Construction Duct Leakage

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	$19	$34	$53
2	$146	$20	$166
3	$89	$12	$101
4	$177	$9	$186
5	$69	$10	$79
6	$152	$2	$155
7	$132	$2	$134
8	$204	$2	$206
9	$211	$4	$215
10	$222	$7	$228
11	$271	$26	$297
12	$207	$20	$227
13	$294	$17	$311
14	$257	$20	$277
15	$419	$1	$421
16	$96	$62	$158

Space Conditioning – Duct Leakage Testing

Table 108: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 10-Story Mixed-Use Dwelling Unit – Alteration Duct Leakage

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	$33	$97	$131
2	$165	$82	$247
3	$114	$57	$170
4	$196	$44	$240
5	$94	$51	$145
6	$158	$16	$174
7	$129	$12	$141
8	$227	$18	$246
9	$235	$26	$260
10	$250	$35	$285
11	$298	$91	$389
12	$230	$74	$304
13	$328	$62	$390
14	$283	$77	$360
15	$484	$13	$497
16	$123	$163	$286

Space Conditioning – Duct Leakage Testing

Table 114: First Cost Summary for Duct Leakage Testing

Cost component	Cost per Dwelling Unit
Sealing Material	$10
Sealing Labor	$34
Test and Report	$103
Total Incremental First Cost	**$147**

Space Conditioning – Duct Leakage Testing

Table 119: 30-Year Cost-Effectiveness Summary Per 5-Story Mixed-Use Dwelling Unit – New Construction Duct Leakage

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	$47	$147	0.32
2	$162	$147	1.10
3	$96	$147	0.65
4	$181	$147	1.23
5	$74	$147	0.50
6	$147	$147	1.00
7	$126	$147	0.86
8	$201	$147	1.37
9	$207	$147	1.41
10	$219	$147	1.49
11	$276	$147	1.88
12	$222	$147	1.51
13	$302	$147	2.05
14	$258	$147	1.76
15	$400	$147	2.72
16	$145	$147	0.99

Table 120: 30-Year Cost-Effectiveness Summary Per 10-Story Mixed-Use Dwelling Unit – New Construction Duct Leakage

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	$53	$147	0.36
2	$166	$147	1.13
3	$101	$147	0.68
4	$186	$147	1.27
5	$79	$147	0.54
6	$155	$147	1.05
7	$134	$147	0.91
8	$206	$147	1.40
9	$215	$147	1.46
10	$228	$147	1.55
11	$297	$147	2.02
12	$227	$147	1.55
13	$311	$147	2.12
14	$277	$147	1.89
15	$421	$147	2.86
16	$158	$147	1.08

Space Conditioning – Duct Leakage Testing

Table 121: 30-Year Cost-Effectiveness Summary Per 10-Story Mixed-Use Dwelling Unit – Alterations Duct Leakage

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	$131	$147	0.89
2	$247	$147	1.68
3	$170	$147	1.16
4	$240	$147	1.63
5	$145	$147	0.98
6	$174	$147	1.19
7	$141	$147	0.96
8	$246	$147	1.67
9	$260	$147	1.77
10	$285	$147	1.94
11	$389	$147	2.65
12	$304	$147	2.07
13	$390	$147	2.65
14	$360	$147	2.45
15	$497	$147	3.38
16	$286	$147	1.94

Space Conditioning – Duct Leakage – Staff Questions

Any feedback on incremental costs or data that can be shared would be welcome.

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Create semi-uniform requirements across all multifamily buildings

- Apply low-rise mandatory airflow and fan efficacy testing for ducted cooling systems serving individual dwelling units to high-rise multifamily buildings.
  - Minimum 350 cfm/ton of cooling.
  - Minimum 0.45 W/cfm for central gas furnace fans, or minimum 0.58 W/cfm for all other air handlers.
  - No HERS verification.
  - Installer testing and reporting requirement proposed.
- Requirements would also apply to alterations/additions where ducted cooling system is completely replaced or completely new.
- Altered space conditioning systems with mechanical cooling will be subject to minimum 300 cfm/ton requirement.
- High-rise multifamily buildings in climate zone 1 are exempt.

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 37: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change for Space Cooling Airflow Rate and Fan Efficacy

Prototype ID	Climate Zone	Software	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
5-story & 10-story	All	CBECC-Com	Residential - Zone System - Fan – Flow Capacity	300 cfm/ton	350 cfm/ton
5-story & 10-story	All	CBECC-Com	Residential - Zone System - Fan – Power Per Flow	0.80 W/cfm	0.45 W/cfm

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 69: First-Year Energy Impacts Per Dwelling Unit – 5-Story Mixed-Use Prototype Building – Cooling Coil Airflow and Fan Efficacy

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	31.4	0.013	(0.7)	672
2	105.9	0.040	(0.6)	3,884
3	80.1	0.027	(0.3)	2,902
4	133.4	0.046	(0.2)	4,797
5	84.5	0.026	(0.2)	2,399
6	148.9	0.040	(0.1)	4,444
7	141.0	0.037	(0.0)	4,090
8	173.7	0.050	(0.1)	5,500
9	168.1	0.052	(0.1)	5,431
10	182.1	0.058	(0.2)	5,726
11	176.6	0.063	(0.7)	5,801
12	153.4	0.054	(0.6)	5,362
13	211.1	0.068	(0.5)	6,963
14	169.9	0.054	(0.5)	5,454
15	283.1	0.073	(0.0)	8,530
16	122.5	0.037	(1.8)	2,855

Table 70: First-Year Energy Impacts Per Dwelling Unit – 10-Story Mixed-Use Prototype Building – Cooling Coil Airflow and Fan Efficacy

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	30.4	0.012	(0.5)	658
2	96.2	0.036	(0.4)	3,404
3	78.7	0.025	(0.2)	2,772
4	123.8	0.042	(0.2)	4,267
5	82.1	0.025	(0.2)	2,393
6	144.7	0.038	(0.0)	4,238
7	137.6	0.036	(0.0)	3,989
8	161.8	0.044	(0.0)	4,967
9	154.8	0.045	(0.1)	4,825
10	164.7	0.050	(0.1)	5,070
11	158.6	0.053	(0.6)	4,996
12	136.2	0.046	(0.5)	4,594
13	184.1	0.055	(0.4)	5,898
14	152.1	0.046	(0.4)	4,737
15	238.9	0.056	(0.0)	6,984
16	111.3	0.033	(1.5)	2,544

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 109: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 5-Story Mixed-Use Dwelling Unit– New Construction (Ducted) Cooling Coil Airflow and Fan Efficacy

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	$135	($31)	$103
2	$626	($28)	$598
3	$460	($13)	$447
4	$750	($11)	$739
5	$380	($11)	$369
6	$688	($3)	$684
7	$632	($2)	$630
8	$851	($3)	$847
9	$842	($5)	$836
10	$891	($9)	$882
11	$927	($34)	$893
12	$856	($30)	$826
13	$1,098	($26)	$1,072
14	$863	($23)	$840
15	$1,316	($2)	$1,314
16	$528	($89)	$440

Table 110: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 10-Story Mixed-Use Dwelling Unit– New Construction (Ducted) Cooling Coil Airflow and Fan Efficacy

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	$128	($26)	$101
2	$546	($22)	$524
3	$436	($9)	$427
4	$665	($8)	$657
5	$376	($7)	$368
6	$654	($2)	$653
7	$616	($1)	$614
8	$767	($2)	$765
9	$747	($4)	$743
10	$788	($7)	$781
11	$801	($32)	$769
12	$732	($25)	$707
13	$928	($20)	$908
14	$750	($20)	$730
15	$1,077	($1)	$1,076
16	$464	($72)	$392

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 115: First Cost Summary for Cooling Coil Airflow and Fan Efficacy

Cost component	Cost per Dwelling Unit
Material	$0
Labor	$0
Test and Report	$103
Total Incremental First Cost	**$103**

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 117: Cooling Coil Airflow and Fan Efficacy Summary of Replacement Cost

	Cost per Dwelling Unit
Incremental First Cost	$103
Present Value of Replacement Cost at Year 20	$57
Present Value of Remaining Useful Life at Year 30	($21)
Total Present Value of Incremental Cost	**$138**

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Table 122: 30-Year Cost-Effectiveness Summary Per 5-Story Mixed-Use Dwelling Unit – New Construction Cooling Coil Airflow and Fan Efficacy

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	$103	$138	0.75
2	$598	$138	4.32
3	$447	$138	3.23
4	$739	$138	5.33
5	$369	$138	2.67
6	$684	$138	4.94
7	$630	$138	4.55
8	$847	$138	6.12
9	$836	$138	6.04
10	$882	$138	6.37
11	$893	$138	6.45
12	$826	$138	5.96
13	$1,072	$138	7.74
14	$840	$138	6.07
15	$1,314	$138	9.49
16	$440	$138	3.17

Table 123: 30-Year Cost-Effectiveness Summary Per 10-Story Mixed-Use Dwelling Unit – New Construction Cooling Coil Airflow and Fan Efficacy

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	$101	$138	0.73
2	$524	$138	3.79
3	$427	$138	3.08
4	$657	$138	4.75
5	$368	$138	2.66
6	$653	$138	4.71
7	$614	$138	4.44
8	$765	$138	5.52
9	$743	$138	5.37
10	$781	$138	5.64
11	$769	$138	5.56
12	$707	$138	5.11
13	$908	$138	6.56
14	$730	$138	5.27
15	$1,076	$138	7.77
16	$392	$138	2.83

Space Conditioning – Cooling Air Flow Rate and Fan Efficacy

Any questions on the air flow rate and fan efficacy measures?

Space Conditioning – Refrigerant Charge Verification

Create semi-uniform requirements across all multifamily buildings

- Apply prescriptive requirement of refrigerant charge testing for multifamily buildings with 3 or fewer habitable stories to multifamily buildings of 4 or more habitable stories.
  - No HERS verification.
  - Installer testing and reporting requirement proposed.
- Applicable to cooling systems serving individual dwelling units.
- Applies to climate zones 2 and 8-15.
- Applies to new construction and to alterations of space cooling systems when refrigerant containing components are altered.

Space Conditioning – Refrigerant Charge Verification

Table 38: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change for Refrigerant Charge Verification

Prototype ID	Climate Zone	Software	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
5-story & 10-story (new construction) & 10-story (existing)	All	CBECC-Com	Residential - Zone System - Cooling Coil – EER & SEER	No refrigerant charge verification (multiply by factor of 0.913)	Refrigerant charge verification (multiply by factor of 0.965)

Space Conditioning – Refrigerant Charge Verification

Table 71: First-Year Energy Impacts Per Dwelling Unit – 5-Story Mixed-Use Prototype Building New Construction – Refrigerant Charge

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	5.6	0.004	0.0	146
2	30.1	0.013	0.0	1,251
3	22.9	0.008	0.0	876
4	40.3	0.015	0.0	1,525
5	24.6	0.008	0.0	724
6	47.5	0.013	0.0	1,432
7	44.7	0.012	0.0	1,317
8	55.7	0.016	0.0	1,785
9	54.9	0.017	0.0	1,815
10	58.8	0.019	0.0	1,879
11	57.3	0.023	0.0	2,180
12	45.4	0.018	0.0	1,750
13	66.2	0.024	0.0	2,399
14	58.9	0.020	0.0	2,068
15	106.7	0.029	0.0	3,430
16	30.4	0.013	0.0	753

Table 72: First-Year Energy Impacts Per Dwelling Unit – 10-Story Mixed-Use Prototype Building New Construction – Refrigerant Charge

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	6.8	0.004	0.0	176
2	29.1	0.012	0.0	1,121
3	23.9	0.008	0.0	865
4	38.8	0.014	0.0	1,373
5	25.8	0.008	0.0	764
6	47.4	0.013	0.0	1,391
7	45.2	0.012	0.0	1,324
8	53.1	0.014	0.0	1,637
9	51.9	0.015	0.0	1,631
10	54.4	0.016	0.0	1,684
11	51.9	0.019	0.0	1,869
12	41.7	0.016	0.0	1,510
13	58.6	0.019	0.0	2,022
14	54.4	0.017	0.0	1,820
15	90.5	0.022	0.0	2,797
16	30.3	0.012	0.0	736

Space Conditioning – Refrigerant Charge Verification

Table 73: First-Year Energy Impacts Per Dwelling Unit – 10-Story Mixed-Use Prototype Building Alterations – Refrigerant Charge

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	10.7	0.004	0.0	231
2	32.0	0.012	0.0	1,475
3	28.3	0.007	0.0	1,037
4	41.2	0.015	0.0	1,770
5	32.5	0.007	0.0	824
6	43.6	0.013	0.0	1,388
7	39.1	0.011	0.0	1,117
8	58.4	0.017	0.0	2,029
9	58.0	0.019	0.0	2,095
10	66.2	0.023	0.0	2,210
11	67.9	0.030	0.0	2,619
12	49.5	0.021	0.0	2,047
13	77.5	0.030	0.0	2,918
14	67.4	0.024	0.0	2,479
15	133.0	0.037	0.0	4,328
16	39.3	0.013	0.0	885

Space Conditioning – Refrigerant Charge Verification

Table 111: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 5-Story Mixed-Use Dwelling Unit – New Construction Refrigerant Charge

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	$22	$0	$22
2	$193	$0	$193
3	$135	$0	$135
4	$235	$0	$235
5	$112	$0	$112
6	$220	$0	$220
7	$203	$0	$203
8	$275	$0	$275
9	$279	$0	$279
10	$289	$0	$289
11	$336	$0	$336
12	$269	$0	$269
13	$369	$0	$369
14	$318	$0	$318
15	$528	$0	$528
16	$116	$0	$116

Table 112: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 10-Story Mixed-Use Dwelling Unit – New Construction Refrigerant Charge

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	$27	$0	$27
2	$173	$0	$173
3	$133	$0	$133
4	$211	$0	$211
5	$118	$0	$118
6	$214	$0	$214
7	$204	$0	$204
8	$252	$0	$252
9	$251	$0	$251
10	$259	$0	$259
11	$288	$0	$288
12	$233	$0	$233
13	$311	$0	$311
14	$280	$0	$280
15	$431	$0	$431
16	$113	$0	$113

Space Conditioning – Refrigerant Charge Verification

Table 113: 2023 PV TDV Energy Cost Savings Over 30-Year Period of Analysis – Per 10-Story Mixed-Use Dwelling Unit – Alteration Refrigerant Charge

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	$36	$0	$36
2	$227	$0	$227
3	$160	$0	$160
4	$273	$0	$273
5	$127	$0	$127
6	$214	$0	$214
7	$172	$0	$172
8	$312	$0	$312
9	$323	$0	$323
10	$340	$0	$340
11	$403	$0	$403
12	$315	$0	$315
13	$449	$0	$449
14	$382	$0	$382
15	$667	$0	$667
16	$136	$0	$136

Space Conditioning – Refrigerant Charge Verification

Table 116: First Cost Summary for Refrigerant Charge Verification

Cost component	Cost per Dwelling Unit
Material	$0
Labor	$0
Test and Report	$34
Total Incremental First Cost	**$34**

Space Conditioning – Refrigerant Charge Verification

Table 118: Refrigerant Charge Verification Summary of Replacement Cost

	Cost per Dwelling Unit
Incremental First Cost	$34
Present Value of Replacement Cost at Year 20	$19
Present Value of Remaining Useful Life at Year 30	($7)
Total Present Value of Incremental Cost	**$46**

For alterations, the same approach is applied to the incremental first cost of $103 for a total present value of incremental cost of $138.

Space Conditioning – Refrigerant Charge Verification

Table 124: 30-Year Cost-Effectiveness Summary Per 5-Story Mixed-Use Dwelling Unit – New Construction Refrigerant Charge

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	$22	$46	0.49
2	$193	$46	4.18
3	$135	$46	2.92
4	$235	$46	5.09
5	$112	$46	2.42
6	$220	$46	4.78
7	$203	$46	4.39
8	$275	$46	5.96
9	$279	$46	6.05
10	$289	$46	6.27
11	$336	$46	7.27
12	$269	$46	5.84
13	$369	$46	8.00
14	$318	$46	6.90
15	$528	$46	11.44
16	$116	$46	2.51

Table 125: 30-Year Cost-Effectiveness Summary Per 10-Story Mixed-Use Dwelling Unit – New Construction Refrigerant Charge

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	$27	$46	0.59
2	$173	$46	3.74
3	$133	$46	2.89
4	$211	$46	4.58
5	$118	$46	2.55
6	$214	$46	4.64
7	$204	$46	4.42
8	$252	$46	5.46
9	$251	$46	5.44
10	$259	$46	5.62
11	$288	$46	6.24
12	$233	$46	5.04
13	$311	$46	6.75
14	$280	$46	6.07
15	$431	$46	9.33
16	$113	$46	2.46

Space Conditioning – Refrigerant Charge Verification

Table 126: 30-Year Cost-Effectiveness Summary Per 10-Story Mixed-Use Dwelling Unit – Alterations Refrigerant Charge

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	$36	$138	0.26
2	$227	$138	1.64
3	$160	$138	1.15
4	$273	$138	1.97
5	$127	$138	0.92
6	$214	$138	1.54
7	$172	$138	1.24
8	$312	$138	2.26
9	$323	$138	2.33
10	$340	$138	2.46
11	$403	$138	2.91
12	$315	$138	2.28
13	$449	$138	3.25
14	$382	$138	2.76
15	$667	$138	4.81
16	$136	$138	0.98

Space Conditioning – Refrigerant Charge Verification

Any questions on the refrigerant charge verification measures?

Comments for Todays Workshop

Due Date: December 18, 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!