Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

Nonresidential Fenestration

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Contents

Tables

Executive Summary

This proposal presents updates to nonresidential vertical fenestration requirements for consideration in the 2028 California Energy Code (Title 24, Part 6 or Energy Code). The proposals were developed by the Statewide Codes and Standards Enhancement (CASE) Team to improve building envelope performance, strengthen compliance clarity, and support California's long-term energy efficiency and greenhouse gas (GHG) reduction goals. The CASE Report evaluates two measures applicable to nonresidential buildings: New Construction/Additions Vertical Fenestration and Vertical Fenestration Alterations.

The Statewide CASE Team developed these proposed measures for submission to the California Energy Commission (CEC) for potential inclusion in the 2028 update to Title 24, Part 6. To be adopted, each measure must be technically feasible and cost effective. The proposed measures focus on updating prescriptive U-factor and related vertical fenestration performance requirements for applicable nonresidential projects, while excluding California Building Code Group R occupancies and their common or public use areas.

Stakeholder engagement included public stakeholder meetings held September 30, 2025 and March 17, 2026, along with outreach to over a dozen stakeholders representing the fenestration industry and manufacturing. The Statewide CASE Team used stakeholder feedback and input to refine the proposal and determine where U-factor and relative solar heat gain coefficient (RSHGC) improvements would be cost effective in California.

The Statewide CASE Team recognizes ongoing systemic inequities in environmental and social justice (ESJ) communities and is developing code change proposals with careful consideration of potential unintended impacts.

Measure 1: New Construction and Additions—Vertical Fenestration

Proposed Code Change

This proposed measure would update maximum allowable prescriptive U-factors for vertical fenestration in nonresidential new construction and additions. It would apply to fixed windows in Climate Zones 1-4, and 16, and to operable windows in Climate Zones 1-5, and 9-16.

The fixed-window requirement would change from U-0.36 to U-0.34 in the applicable climate zones. The operable-window requirement would change from U-0.46 to U-0.43

in the applicable climate zones. Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT) requirements would remain unchanged, and the measure would not apply to skylights, glazed doors, storefront, curtain wall, or other fenestration types.

Benefits of the Proposed Change

The proposed U-factor improvements would reduce heat transfer through windows and improve envelope performance in new nonresidential buildings and additions. Because the measure improves the building envelope rather than relying on operational controls, the benefits would persist regardless of occupant behavior.

More efficient windows would improve comfort by reducing cold surfaces, drafts, and localized temperature imbalances near fenestration. Higher-performance windows may also reduce exterior noise transmission and support long-term building quality and occupant satisfaction.

Compliance and Enforcement

The measure would not add or modify acceptance tests. Compliance would be verified through existing compliance documentation and verification processes, with updates to compliance forms, schema logic, and Section 5.5.7 of the ACM manual to reflect the revised U-factor requirements and table structure.

Market Assessment

The fixed and operable windows proposed for this measure are already required in several climate zones and are readily available across California. Stakeholders interviewed indicated that the proposal is technically feasible and is a market-ready upgrade. The Statewide CASE Team does not anticipate technical or market challenges and expects only a minor economic impact, with no major impact on jobs.

Cost Effectiveness

The proposed code change is cost effective across all applicable California climate zones. Benefit-to-cost ratios (BCR)[1] for fixed windows range from 1.27 to 2.30, and BCRs for operable windows range from 1.39 to 5.02, depending on climate zone and prototypical building type. The analysis used an incremental cost of $0.58 per square foot of window, with no anticipated increase in labor cost.

[1] The benefit-to-cost ratio (BCR) compares benefits or cost savings to costs over the 30-year period of analysis. Proposed code changes with a BCR of 1.0 or greater are cost effective.

First-Year Statewide Impacts

Table 1: Summary of Statewide Impacts — New Construction/Additions Vertical Fenestration

Metric [a]	Fixed Windows	Operable Windows	Total
Annual Electricity Savings (GWh)	0.04	0.07	0.11
Peak Demand Reduction (MW)	0.02	0.04	0.06
Annual Natural Gas Savings (Million Therms)	0.01	0.00	0.01
Annual Source Energy Savings (Million kBtu)	0.93	0.62	1.55
30-Year Long-term System Cost Savings (Million 2029 PV$)	1.37	1.30	2.67
Annual Avoided GHG (Metric Tons CO2e/yr)	55.0	35.0	90.0

a. Values represent impacts from buildings permitted during the first year the code is in effect. Total values reflect the sum of the weighted impacts associated with the applicable fenestration types included in the proposal.

Vertical Fenestration Alterations

Proposed Code Change

This proposed measure would make two changes for vertical fenestration alterations in nonresidential buildings. First, when one hundred percent of any one fenestration type is replaced, the replacement fenestration would be required to meet the U-factor, RSHGC, and VT requirements for new construction.

Second, when fewer than one hundred percent of any one fenestration type is replaced, a new Table 301.5-A.2 would provide updated U-factor and SHGC values for individual vertical fenestration types. The proposal would apply across all climate zones and would not apply to California Building Code Group R occupancies or their common or public use areas.

Benefits of Proposed Change

The alterations measure would improve envelope performance in existing nonresidential buildings by updating fenestration requirements for replacement projects. These changes would reduce heat transfer, improve comfort, and provide durable energy benefits that continue over the life of the installed fenestration.

The proposal also helps align major replacement projects with new construction performance expectations while providing separate requirements for partial replacement

projects. This structure supports energy savings while recognizing the practical differences between full and partial fenestration replacement scopes.

Compliance and Enforcement

The proposal would require documentation of the percentage of each fenestration type being replaced so that the applicable performance values are clear. Stakeholder feedback indicated that a seventy-five percent threshold could create compliance documentation and enforcement challenges, so the Statewide CASE Team revised the trigger to one hundred percent replacement of any one fenestration type.

Designers and specifiers would need to be aware of the revised requirements and provide accurate information in compliance forms submitted to the authority having jurisdiction. Training through Energy Code Ace and related resources would support designers, contractors, and enforcement personnel.

Market Assessment

The proposed U-factor and RSHGC requirements for fenestration alterations are based on products widely available in the market. Stakeholders interviewed indicated that the proposal is technically feasible and is a market-ready upgrade. The Statewide CASE Team does not anticipate technical or market challenges to meet the requirements and expects a minor economic impact with no major impact on jobs.

Cost Effectiveness

The one hundred percent replacement trigger is cost effective because the new construction fenestration requirements were shown to be cost effective in the climate zones included in the proposal. For partial replacements, fixed windows have BCRs from 1.35 to 10.98; glazed doors have BCRs from 1.90 to 2.00 in Climate Zones 3 and 5; and storefront and curtain wall systems have BCRs from 1.31 to 4.19 across applicable climate zones.

Incremental costs used in the analysis were $0.58 per square foot of window for fixed windows, $0.90 per square foot of window for operable windows and glazed doors, and $1.25 per square foot of window for storefront and curtain wall systems.

First-Year Statewide Impacts

Table 2: Summary of Statewide Impacts — Vertical Fenestration Alterations

Metric [a]	Fixed Windows	Storefront/ Curtain Wall	Glazed Doors	Total
Annual Electricity Savings (GWh)	1.26	1.32	0.02	2.6
Peak Demand Reduction (MW)	0.24	0.02	0.00	0.26
Annual Natural Gas Savings (Million Therms)	0.05	0.00	0.00	0.05
Annual Source Energy Savings (Million kBtu)	6.62	0.36	0.09	7.07
30-Year Long-term System Cost Savings (Million 2029 PV$)	15.74	8.67	0.23	24.64
Annual Avoided GHG (Metric Tons CO2e/yr)	386.0	19.0	6.0	411

a. Values represent impacts from buildings permitted during the first year the code is in effect. Total values reflect the sum of the weighted impacts associated with the applicable fenestration types included in the proposal.

Acronyms

Table 3 presents a list of acronyms used in this report. The website Title24stakeholders.com also maintains a glossary of terms.

Table 3: Acronyms

Acronym	Definition
ACM	Alternative Calculation Method
ADA	Americans with Disabilities Act
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ATT	Acceptance Test Technician
BCR	Benefit-to-cost Ratio
BEM	Building Energy Modeling
Btu	British Thermal Units
CALGreen	California Green Building Standards Code
Cal/OSHA	California Division of Occupational Safety and Health
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBSC	California Building Standards Commission
CBECC	California Building Energy Code Compliance Software
CBECC-Res	California Building Energy Code Compliance for Residential Buildings Software
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CBO	Community-Based Organization
CPUC	California Public Utilities Commission
CSE	California Simulation Engine
CTF	Conduction Transfer Functions
CZ	Climate Zone
DAC	Disadvantaged Community
DGS	California Department of General Services
DOAS	Dedicated Outdoor Air System
DOSH	Division of Occupational Safety and Health
ECC	Energy Code Compliance
EIR	Environmental Impact Report
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice

Acronym	Definition
FSOR	Final Statement of Reasons
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISOR	Initial Statement of Reasons
kBtu/sf	One Thousand British Thermal Units per Square Foot
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LED	Light Emitting Diode
LPD	Lighting Power Density
LSC	Long-term System Cost
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
NAICS	North American Industry Classification System
NPDI	Net Private Domestic Investment
PEP	Public Engagement Plan
PV	Present Value
SDD	Standards Data Dictionary
SHGC	Solar Heat Gain Coefficient
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
UL	Underwriters Laboratories
VT	Visible Transmittance
W	Watt
WWR	Window-to-Wall Ratios

1. Introduction

1.1 Report Context

This proposal describes energy efficiency code changes, referred to as "measures," aimed at reducing wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. These measures are submitted to the California Energy Commission (CEC) for consideration and potential inclusion in California's Energy Code (Title 24, Part 6), which sets statewide energy efficiency requirements for newly constructed buildings and for additions and alterations to existing buildings. Measures may also be considered for inclusion in CALGreen (Title 24, Part 11) as voluntary energy efficiency standards, which would take effect only if adopted by a local jurisdiction seeking to exceed the minimum requirements of the Energy Code. Measures submitted to the CEC will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. To be included in the Energy Code, proposed measures must be both cost-effective and technically feasible.

1.2 Proposal Sponsors

Three California investor-owned utilities (IOUs)—Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison jointly sponsored this effort. Where the term "Statewide CASE Team" is used in this report, it refers to the authors and State Building Codes Advocacy activities supported through the Codes and Standards program

1.3 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and the associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders, including building officials, manufacturers, builders, utility incentive program managers, Title 24 energy analysts, state agencies, and others involved in the code compliance process. The proposal incorporates feedback received during public stakeholder workshops that the Statewide CASE Team held on September 30, 2025 and March 17, 2026.

See Appendix E for details on the Statewide CASE Team's stakeholder engagement.

1.4 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in environmental and social justice (ESJ) communities.[2] These issues persist today. To minimize the risk of perpetuating inequity, code change proposals were developed with intentional consideration of the unintended consequences on ESJ communities.

When analyzing impacts for nonresidential buildings, the Statewide CASE Team reviewed each nonresidential building type through the lens of the four criteria: cost, health, resiliency, and comfort. The Statewide CASE Team examined which building types are used by ESJ communities most frequently and evaluated the allocation of impacts related to the following areas among all populations. Some building types have unique environmental justice concerns due to their common uses, location, or other factors.

The Statewide CASE Team will continue to build relationships with CBOs and other stakeholders to improve the identification of potential impacts for future code cycles and is open to additional resources that can contribute to this effort.

[2] The CPUC refers to ESJ communities as "low-income or communities of color that have been underrepresented in the policy setting or decision-making process, are subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socioeconomic investments in their communities" (CPUC 2022). ESJ communities also include the CPUC definition for Disadvantaged Communities, which comprises "(1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0 (1,984 tracts); (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores (19 tracts); (3) Census tracts identified in the 2017 DAC designation as disadvantaged, regardless of their scores in CalEnviroScreen 4.0 (307 tracts); and (4) Lands under the control of federally recognized Tribes (OEHHA 2022).

2. New Construction/Additions Fenestration

2.1 New Construction/Additions Fenestration—Measure Description

2.1.1 Proposed Code Change

This Title 24, Part 6 proposal would update the maximum allowable prescriptive U-factors for vertical fenestration in nonresidential new construction and additions for all nonresidential building types excluding California Building Code Group R occupancies and their common or public use areas. The proposal applies to fixed windows in Climate Zones 1-4, and 16, and applies to operable windows in Climate Zones 1-5, and 9-16. It does not apply to skylights, glazed doors, storefront, curtain wall, or other fenestration types.

The current maximum U-factor requirement for fixed windows in Climate Zones 1-4 and 16 is U-0.36. The proposed requirement for fixed windows in these climate zones would be U-0.34, as these are the climate zones where the Statewide CASE Team has determined the change to be cost-effective.

The current maximum U-factor requirement for operable windows in all climate zones is U-0.46. This proposal would revise the requirement to U-0.43 in Climate Zones 1-5, and 9-16,as these are the climate zones where the Statewide CASE Team has determined the change to be cost-effective.

For both window types, the Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT) requirements would remain unchanged.

The proposal would not add or modify acceptance tests or require any technology not previously regulated. Compliance would be verified through the existing verification process and the published compliance documentation forms.

Table 4 summarizes the scope of the proposed code change.

Table 4: Scope of Proposed Code Change

Note: A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☒ New Construction	☐ Mandatory
☐ Multifamily	☒ Additions	☒ Prescriptive
☒ Nonresidential (not Group R uses)	☐ Alterations	☒ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Fixed Windows: CZs 1, 2, 4, and 16 Operable Windows: CZs 1-5, 9, and 11-16	Subchapter 3 Envelope, Section 301.3.4.2 *[Section 140.3(a)5B]*	NRCC-ENV-E NRCC-PRF-E NRCA-ENV-02-F	Section 5.5.7

Third-party Verification	Updates to Compliance Software
☒ No changes to third-party verification	☐ No updates
☐ Update existing verification requirements	☒ Update existing feature
☐ Add new verification requirements	☐ Add new feature

2.1.2 Benefits of Proposed Change

The proposed code change addresses inefficiencies in current fenestration U-factor requirements across a broad range of California climate zones, contributing to reduced heating energy use and improved thermal performance in new nonresidential buildings and additions to existing buildings. By improving envelope performance rather than relying on operational or control measures, the proposal delivers stable, long-term benefits that persist regardless of occupant behavior.

In colder and heating-dominated climate zones, improved U-factors reduce conductive heat loss through windows, lowering heating energy demand and improving occupant comfort during extended heating seasons. In moderate and mixed climates, including many coastal and inland regions, enhanced U-factor performance reduces heat loss during cool mornings, evenings, and shoulder seasons, when buildings frequently operate in heating mode despite otherwise mild conditions. These effects are particularly relevant given the large volume of new construction, including additions to existing buildings, occurring in these climate zones.

Across all evaluated regions, more energy-efficient windows contribute to improved indoor comfort by reducing cold surfaces, drafts, and localized temperature imbalances near fenestration. Improved comfort can reduce the likelihood of occupants adjusting thermostats to compensate for discomfort, helping to limit unnecessary heating or cooling energy use over time.

Enhanced fenestration performance may also support downstream system benefits. As building heating loads are reduced, future HVAC system replacements may allow for smaller, more appropriately sized equipment, improving system efficiency and part-load performance.

In addition to thermal benefits, higher-performance windows reduce the transmission of exterior noise, improving indoor acoustic conditions. Improved acoustic environments are associated with reduced stress and improved cognitive performance, particularly in office, school, and healthcare settings. Modernized fenestration systems also contribute to improved building aesthetics, supporting long-term building value and occupant satisfaction.

Together, these benefits demonstrate that the proposed U-factor improvements provide meaningful and durable performance gains across both colder and moderate California climate zones, with energy savings driven primarily by heating reductions and supported by improved comfort, acoustics, and building quality.

2.1.3 Background Information

Windows are a critical component of the building envelope for commercial construction. Heat transfer through the building envelope and associated air leakage are the largest factors impacting HVAC loads in most climates. While walls can be many inches thick and full of insulation that slows heat transfer between the exterior and interior of a building, windows are the weakest link in the thermal envelope. Windows account for a significant amount of energy transfer through the envelope, both in terms of thermal heat transfer and solar heat gain.[3]

Windows play a key role in determining levels of comfort, natural lighting, ventilation, and the amount of energy required to condition a building. The efficiency of windows depends on thermal indices (U-factor, SHGC, and VT) and on climate and other building characteristics. The term “U-factor” refers to the measurement of the relative level of heat transfer through building envelope components such as windows or walls. The lower the U-factor, the lower the rate of heat transfer. Therefore, the lower the U-factor, the better the insulating quality of the component.

This proposal builds on the Statewide CASE Team’s effort from previous code cycles to update the stringency of fixed and operable fenestration U-factors. The last update to Title 24 fenestration U-factors occurred in 2022, when the requirement for fixed fenestration in Climate Zone 9, and Climate Zones 11–15 was changed from U-0.36 to U-0.34. Prior to this, at least as far back as the 2013 code, the requirement for fixed fenestration for all climate zones was U-0.36 and for operable fenestration was U-0.46.

[3] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. “Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption.” Accessed September 23, 2025. https://www.nrel.gov/docs/fy22osti/80171.pdf

This proposal represents the first update to the prescriptive U-factors for many Climate Zones since at least the 2013 code cycle.

2.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 2.6 of this report for detailed revisions to code language.

2.1.4.1 Energy Code Change Summary

The existing Table 301.3-C *[Table 140.3-B]* would be split into three separate tables. The first table 301.3-C.1, the content of which would be unchanged, would cover the prescriptive opaque envelope criteria for nonresidential buildings, including relocatable public school buildings, where manufacturers certify use only in specific climate zones, and excluding guest rooms of hotel/motel buildings.

The new Table 301.3-C.2 would address the prescriptive fenestration criteria for any nonresidential buildings with California Building Code Group R occupancies and their common or public use areas. The values in this table would be unchanged from those existing in Table 140.3-B.

Finally, a new Table 301.3-C.3 would address the prescriptive fenestration criteria for nonresidential buildings including relocatable public school buildings, where manufacturer certifies use only in specific climate zones, and excluding hotel/motel buildings and any nonresidential buildings with California Building Code Group R occupancies and their common or public use areas. This new table would reflect the changed U-factors and RSHGC (Relative Solar Heat Gain Coefficient) values proposed in the new construction measure for fixed windows in Climate Zones 1-4 and 16, and the new U-factors and RSHGC values proposed for operable windows in Climate Zones 1-5, and 9-16.

Table 301.3-D *[Table 140.3-C]* would remain unchanged for guest rooms of hotel/motel buildings.

Table 301.3-E [*Table 140.3-D]* would remain unchanged for relocatable public school buildings for use in all climate zones.

2.1.4.2 Reference Appendices Change Summary

The proposed changes would not impact the reference appendices, as fenestration is not covered in those documents.

2.1.4.3 Compliance Manuals Change Summary

The Nonresidential Compliance Manual would be updated to explain the differences in occupancy types and when to reference the correct proposed tables for each occupancy type, as proposed in Section 2.1.4.1.

2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

Section 5.5.7 of the ACM manual would be updated to reference the correct proposed tables for each occupancy type, as proposed in Section 2.1.4.1.

2.1.4.5 Compliance Forms Change Summary

The nonresidential compliance forms would be updated to support the split of existing Table 301.3-C into the additional tables proposed in Section 2.1.4.1 and when each table is referenced based on occupancy type. The schema logic supporting compliance within the prescriptive forms will need to be updated to reflect the reduced U-factor requirements.

2.1.4.6 Comparable Model Codes or Standards

The following model codes are relevant to this proposed measure:

1. ASHRAE 90.1- 2025
2. IECC 2027 (proposed)

This proposal and the IECC proposal were based on prescriptive revisions made in the 2025 edition of ASHRAE 90.1, where it was shown to have positive lifecycle energy savings. Overall, this proposal provides an incremental advancement in nonresidential fenestration requirements that is cost-effective and practical.

2.1.4.7 Interactions with Other Regulations

Federal Laws and Regulations: There are no relevant federal laws or regulations with which this measure would be in conflict.

State laws and requirements: There are no relevant state laws or regulations with which this measure would be in conflict.

Interactions with California Building Code: There are no relevant conflicts with the other sections of the California Building Code.

Local requirements: There are no relevant local ordinances with which this measure would be in conflict.

2.2 New Construction/Additions Fenestration—Compliance and Enforcement

2.2.1 Compliance Considerations

The proposed measure will have no significant impact on current compliance and enforcement practices, other than verification of the updated performance requirements. It is assumed that building departments will be required to guide construction permit applicants regarding the appropriate compliance path. We strongly recommend the suggested education in Table 5.

2.2.2 Impact on Market Actors

Table 5 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements. All market actors will need to understand the impacts from California Assembly Bill 130 on certain nonresidential buildings.

Table 5: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/ Developer[a]	Building owners may need to adjust design and budgets to ensure that the installed fenestration products meet the updated NFRC-certified U-factor requirements. Over time, these higher-performance products will reduce energy bills and improve occupant comfort.	EnergyCodeAce Training and Fact Sheets summarizing updated fenestration requirements
Design Professional[b]	Architects need to specify and detail fenestration that meets the updated U-factor requirement. They will need to verify that selected fenestration products can achieve these lower performance targets, which may require shifting from familiar product lines to higher-efficiency framing systems. U-factors should be clearly listed on the fenestration specifications, and designers should confirm which fenestration types (e.g., curtain wall, storefront) are subject to the new limits.	EnergyCodeAce Training and Fact Sheets focused on window product selection, performance labeling, and compliance documentation.

Market Actor	Impact(s)	Suggested Outreach and Education
Construction Team[c]	The construction team needs to purchase and install fenestration with the updated U-factor requirements and confirm that selected products are NFRC-certified to those performance ratings. Teams will need to verify product documentation before installation and may need to adjust delivery schedules to account for longer lead times associated with higher-efficiency framing systems.	EnergyCodeAce Training and Fact Sheets focused on verifying NFRC certification and planning for product availability and lead times.
Building Department[d]	Building plan reviewers and inspectors (AHJs) using the prescriptive compliance method will need to verify whether the construction documents match the compliance forms. Inspectors must verify that installed products have NFRC-certified ratings consistent with the design documents.	EnergyCodeAce Training and Fact Sheets focused on U-factor updates, NFRC product labeling, and field verification guidance for AHJs.
Verification Tester[e]	N/A	N/A
Manufacturers and Distributors	Manufacturers and distributors need to ensure that there are readily available products that are NFRC-certified meeting the updated performance requirements.	EnergyCodeAce Training and Fact Sheets. Feedback to suppliers from contractors and installers.

a. Owner/Developer is funding the project and is the primary decision maker.
b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, glazing consultants, and energy consultants.
c. Construction team includes general contractors, home builders, design-build contractors, installation contractors, commissioning agents, and tradespeople. It also includes glass manufacturers, frame manufacturers, fabricators, and glazing contractors.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code changes presented in this report, this measure focuses on manufacturers and architects, since these market actors are expected to experience the most direct impacts from the updated window performance requirements. The

following provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Owner/Developer. The proposed change would likely affect nonresidential building owners and project developers for both new construction and additions. The proposed code change would have incremental costs and would reduce building owners' utility bills throughout the measure lifetime. The commercial building sector includes a wide array of building types, including offices, restaurants, retail, mixed-use establishments, and warehouses. Energy use by occupants of commercial buildings, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating. See the 2028 CASE Methodology Report for a description of how LSC savings relate to occupant utility bill savings.

Design Professional. Design professionals will need to understand the updated U-factor requirements to ensure that designs for applicable projects contain correct product specifications. Adjusting design practices to comply with changing building codes is a normal practice for building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training to remain current with changes to design practices and building codes.

Building Department. Building plan reviewers and inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team anticipates the proposed changes would have no impact on the scope of building inspectors in conducting energy efficiency evaluations and inspections.

Construction Team. The proposed change would likely affect commercial builders; however, it would not significantly impact firms focused on non-building or heavy industrial construction, such as utility systems, public infrastructure, or other civil projects, where fenestration products are generally not used. The proposed change would not affect all firms and workers in the commercial building industry equally; instead, it would primarily affect specific subsectors within the industry. Table 6 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

See the 2028 CASE Methodology Report for a description of how LSC savings relate to occupant utility bill savings.

Table 6: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Glass and Glazing Contractors	307	5,079	$0.5
Nonresidential Finish Carpentry Contractors	313	3,697	$0.3

Source: (State of California n.d.)

*An establishment is single economic unit, typically at one physical location, which engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. https://www.bls.gov/opub/hom/cew/concepts.htm

2.2.3 Compliance Software Updates

If this proposal is adopted for new construction (New Tables 301.3-C.1, 301.3-C.2, and 301.3-C.3), California Building Code Compliance Software (CBECC) will require only minor adjustments to reflect the updated prescriptive fenestration requirements.

The update would involve revising the prescriptive U-factor tables in the software to align with the new standards. No new compliance pathways or calculation methods are needed.

No new EnergyPlus objects are needed. CBECC already references NFRC-rated U-factors and SHGC values through existing EnergyPlus fenestration objects (such as WindowMaterial:SimpleGlazingSystem, WindowMaterial:Glazing, and FenestrationSurface:Detailed). No additional data inputs are required from users beyond what is already collected: fenestration area, orientation, and product ratings.

This measure represents only a minor compliance software update limited to updating reference values, not structural changes to the ruleset.

2.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

Plan review function would consist of reviewing NRCC-ENV-E (or NRCC-PRF-E) and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing NRCI-ENV-E and NRCA-ENV-02-F and ensuring that the information on the forms is consistent with the approved NRCC-ENV-E (or NRCC-PRF-E) forms and with what is actually installed.

2.3 New Construction/Additions Fenestration—Market and Economic Analysis

2.3.1 Market Structure and Availability

2.3.1.1 Current Market Structure and Availability

The nonresidential building envelope market involves many market actors in a variety of roles, including designers, architects, component manufacturers, installers, suppliers, construction companies, and certification/compliance specialists.

The fixed windows proposed for new construction in Climate Zones 1-4 and 16 are already required in several other climate zones and compliant fenestration products are readily available across California. The proposed operable window requirement is new for Climate Zones 1-5 and 9-16, but compliant products are also readily available in the state.

During the 2025 code adoption cycle, the Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general and individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during the public stakeholder meetings that the Statewide CASE Team held on September 30, 2025, and March 17, 2026, as well as during the previous 2025 code cycle: February 14, 2023, and May 22, 2023.

Within the current market, there has been an increase of façade engineering in the design consulting world—which implies an increased appreciation of energy-efficient fenestration systems. The production of double-glazed windows has become the norm for top window manufacturers. Today, while visibility and aesthetics are top

considerations for fenestration choices, there is increased recognition that fenestration performance is a key point.

2.3.1.2 Market Challenges and Solutions

Commercial grade fenestration products are already readily available from numerous manufacturers. No new materials or processes would need to be developed for any of the nonresidential envelope measures to be successful.

The proposed U-factor requirement for vertical fenestration is based on products widely available in the market. The Statewide CASE Team does not anticipate technical or market challenges to meet this requirement within the time frame of when this code change would take effect (January 1, 2029).

See Section 2.2 for a description of workforce training that may be needed to ensure effective design, installation, and commissioning.

2.3.2 Design and Construction Practices

2.3.2.1 Current Design and Construction Practices

Building designers must be aware of code changes to the fenestration U-factors. The qualified design reviewer, per commissioning requirements, as well as energy consultants and compliance documentation authors must verify that plans and specifications match and meet the requirements of Title 24, Part 6. There is no change required to complete NRCC compliance documents.

See Section 2.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

2.3.2.2 Health and Safety Considerations

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

2.3.3 Energy Equity and Environmental Justice

Each measure in this CASE Report was evaluated for ESJ impacts using 4 criteria: cost, health, resiliency, and comfort. The details of that evaluation can be found in Section 1.4 and the 2028 CASE Methodology Report.

Based on a preliminary review, this proposal is not expected to have significant negative or positive impacts on ESJ communities. The Statewide CASE Team expects a modest increase in cost for fenestration, but it is largely outweighed by the benefits, as shown in Table 7. This proposal has the potential to benefit comfort and health of ESJ communities as tighter building envelopes would result in reduced air infiltration, improved indoor air quality, and improved indoor comfort. There are no expected impacts on ESJ communities regarding resilience.

2.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. The Statewide CASE Team estimates the proposed change would have virtually no effect on employment and a minor effect on economic output directly and indirectly through its impact on builders. Table 7, outlines the statewide implications for the construction sector. The Statewide CASE Team does not anticipate any significant impact on building designers/energy consultants or building inspectors as a result of the proposed change. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

The Statewide CASE Team does not anticipate that the proposed changes would lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy.

Table 7: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Commercial Builders)	0.01	$740	$850	$1,450
Indirect Effect (Additional spending by firms supporting Commercial Builders)	0.00	$200	$320	$580
Total Economic Impacts	**0.01**	**$940**	**$1,170**	**$2,030**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[4]

The proposed change represents a modest adjustment to U-factors for new construction, including additions to existing buildings, which is not expected to excessively burden or competitively disadvantage California businesses, nor is it

[4] IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

expected to lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee the proposed code changes resulting in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[5] Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have advantageous or an adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling resulted in an estimated $218 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).7 As Table 8 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

[5] Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

Table 8: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2020	389	2,212	18
2021	545	2,888	19
2022	825	2,951	28
2023	836	3,069	27
2024	885	3,441	26
5-Year Average	Intentionally blank	Intentionally blank	23

Source: (Federal Reserve Economic Data (FRED) n.d.)

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a $51 increase in net private investment by California businesses.

2.3.5 Economic and Fiscal Impacts

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to a significant increase or decrease in investment, directly or indirectly, in any affected sectors of California's economy. The proposed change would not result in economic disruption to any sector of the California economy. For more information on the Statewide CASE Team's economic and fiscal impacts methodology, see the 2028 CASE Methodology Report.

Adoption of this code change proposal would result in minor economic impacts through the additional direct spending by those in the commercial building industry. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2028 code cycle regulations would result in additional spending by those businesses.

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

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

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be

allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with code change proposals. The impact on state-owned buildings will be a modest increase in costs due to higher-performance components, but these costs have been found to be cost-effective.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not an incremental cost associated with the 2028 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 2.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments. The impact on local government-owned buildings will be a modest increase in costs due to higher-performance components, but these costs have been found to be cost-effective.

2.3.5.2 Mandates on Local Agencies or School Districts

Local agencies or school districts undertaking new construction or building envelope renovation projects would be impacted by the updated fenestration provisions proposed.

2.3.5.3 Costs to Local Agencies or School Districts

The proposed changes would impose a modest increase in cost due to higher-performance components, but these costs have been found to be cost-effective.

2.3.5.4 Costs or Savings to Any State Agency

Any state agency undertaking new construction or building envelope renovation projects would be impacted by the updated fenestration provisions proposed. The proposed changes would impose a modest increase in cost due to higher-performance components, but these costs have been found to be cost-effective.

2.3.5.5 Other Nondiscretionary Cost or Savings Imposed on Local Agencies

There are no added nondiscretionary costs or savings to local agencies.

2.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state.

2.4 New Construction/Additions Fenestration—Cost Effectiveness

2.4.1 Cost-Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on Long-term System Cost (LSC), which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are more expensive than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

2.4.1.1 Climate-Zone Weighted Cost-Effectiveness Results

For climate-zone-specific cost-effectiveness summaries presented in this report, the incremental costs and benefits shown are weighted average values and do not represent different assumed fenestration product costs by climate zone. The underlying incremental measure costs are developed at the prototype level; however, climate-zone-level cost-effectiveness results vary because each climate zone has a different projected mix of building types.

To develop climate-zone-specific results, the Statewide CASE Team converted prototype-level incremental costs and 30-year present-valued benefits into a single weighted average value for each climate zone based on affected prototype floor space within that climate zone. For each climate zone, both costs and benefits were calculated using the following weighted-average equation:

$$CZ\ Value = \frac{\sum_b \left(Value_b * Floorspace_{b,CZ}\right)}{\sum_b Floorspace_{b,CZ}}$$

where $Value_b$is either the prototype incremental cost per square foot or the prototype 30-year present-value benefit per square foot for prototype b, and $Floorspace_{b,CZ}$is the projected affected floor space associated with prototype b in climate zone CZ.

This approach ensures climate-zone results reflect the actual building stock composition contributing to statewide impacts. Climate zones with a greater share of high-window-to-wall-ratio prototypes such as offices and schools may show higher weighted incremental costs and benefits per square foot, while climate zones dominated by lower-window-to-wall-ratio prototypes such as warehouses and hotels may show lower weighted values. Variation across climate zones therefore reflects differences in prototype composition, not differences in assumed measure costs by climate zone.

2.4.2 Fixed Windows—Energy and Energy Cost Savings Results

Energy savings (electricity, natural gas, and source energy) are presented in Table 9 through Table 11 for the evaluated nonresidential building prototypes in California Climate Zones 1–4 and 16. These results reflect improved thermal performance of fixed glazing systems, which primarily reduces conductive heat transfer through the building envelope.

As shown in Table 9, per-unit first-year electricity savings are generally very small and vary by prototype and climate zone. Reported values are typically near zero and range from small negative to small positive values, approximately -0.01 to 0.04 kWh/sf, reflecting minor shifts in cooling and electric heating energy use. There are no peak demand reductions on a per-square-foot basis across all evaluated prototypes and climate zones. As a result, the measure does not affect peak electric demand and should not be characterized as a demand-reduction measure.

By contrast, heating-related savings are larger. The proposed reduction in fenestration U-factor lowers heating loads across most building types and climate zones. For prototypes with natural gas heating systems, these reductions appear as natural gas savings, ranging from approximately 0.00 to 0.31 kBtu/sf, with larger savings in colder climate zones and heating-dominated occupancies such as schools, offices, assembly buildings, and restaurants, as shown in **Error! Reference source not found.**. For prototypes served by electric heating systems, the same heating load reductions appear as changes in electricity consumption and are reflected in the electricity savings results. These heating energy reductions drive positive source energy savings for most prototypes and climate zones. As shown in Table 11, first-year source energy savings generally range from near zero to approximately 0.29 kBtu/sf, with higher values occurring in colder climates and heating-intensive building types.

Table 12 presents total per-unit energy cost savings for fixed windows in new construction and additions, expressed as LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. LSC results range from approximately -$0.06/sf to $0.33/sf, with the vast majority of prototype-climate combinations yielding positive lifecycle savings. Many building types, particularly schools, offices, assembly buildings, and restaurants in colder climate zones, exhibit positive lifecycle savings driven primarily by avoided heating energy costs. In contrast, some prototypes and milder climate zones show limited or negative LSC savings where heating benefits are smaller and incremental costs outweigh energy savings. Savings are more pronounced in colder climate zones, where heating loads are higher and reductions in heat loss through glazing have a greater impact.

Overall, the results demonstrate that improved fixed window thermal performance primarily enhances heating-season energy efficiency, with limited effects on cooling energy use and peak electricity demand. Because fenestration thermal performance is stable over time and not influenced by occupant behavior or equipment degradation, first-year heating savings are expected to persist throughout the 30-year analysis period.

Table 9: First-Year Electricity Savings (kWh) Per Square Foot for Fixed Windows—New Construction / Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ16
Assembly	0.00	0.00	-0.01	0.00	0.00
Hospital	0.00	0.00	0.00	0.00	0.00
Laboratory	0.02	0.01	0.01	0.02	0.01
Large Office	0.00	0.00	0.00	0.00	0.00
Large Retail	0.00	0.00	0.00	0.00	-0.01
Large School	0.00	0.00	0.00	0.00	0.01
Medium Office	0.02	0.01	0.01	0.01	0.04
Medium Retail	0.00	0.00	0.00	-0.01	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00
Restaurant	0.00	0.00	0.00	0.00	0.00
Small Office	0.00	0.00	0.00	0.00	0.00
Small School	0.01	0.01	0.00	0.01	0.00
Strip Mall	0.00	0.00	0.00	0.00	0.00

Table 10: First-Year Natural Gas Savings (kBtu) Per Square Foot for Fixed Windows—New Construction / Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ16
Assembly	0.22	0.16	0.12	0.14	0.31
Hospital	0.08	0.06	0.05	0.06	0.09
Laboratory	0.00	0.00	0.00	0.00	0.08
Large Office	0.11	0.09	0.07	0.09	0.17
Large Retail	0.01	0.00	0.00	0.00	0.05
Large School	0.19	0.14	0.12	0.12	0.23
Medium Office	0.00	0.00	0.00	0.00	0.00
Medium Retail	0.03	0.00	0.00	0.00	0.06
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.01
Restaurant	0.16	0.11	0.08	0.09	0.24
Small Office	0.00	0.00	0.00	0.00	0.21
Small School	0.05	0.00	0.00	0.00	0.31
Strip Mall	0.05	0.00	0.00	0.00	0.11

Table 11: First-Year Source Energy Savings (kBtu) Per Square Foot for Fixed Windows—New Construction / Addition - Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ16
Assembly	0.20	0.15	0.11	0.14	0.28
Hospital	0.07	0.05	0.04	0.05	0.08
Laboratory	0.07	0.05	0.04	0.05	0.12
Large Office	0.10	0.08	0.06	0.08	0.15
Large Retail	0.01	0.00	0.00	0.00	0.03
Large School	0.17	0.13	0.11	0.12	0.22
Medium Office	0.07	0.06	0.03	0.06	0.10
Medium Retail	0.03	0.00	0.00	0.01	0.05
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.01
Restaurant	0.14	0.09	0.06	0.08	0.20
Small Office	0.02	0.02	0.01	0.02	0.19
Small School	0.08	0.04	0.02	0.04	0.29
Strip Mall	0.05	0.01	0.01	0.01	0.09

Table 12: Total 30-Year LSC Savings (2029 PV$) Per Square Foot for Fixed Windows—New Construction/Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ16
Assembly	0.23	0.15	0.09	0.14	0.28
Hospital	0.06	0.05	0.03	0.05	0.08
Large Office	0.09	0.07	0.05	0.07	0.14
Laboratory	0.22	0.09	0.15	0.17	0.06
Large Retail	0.02	0.00	0.00	0.01	-0.03
Large School	0.19	0.15	0.12	0.15	0.28
Medium Office	0.25	0.17	0.09	0.16	0.33
Medium Retail	0.03	0.00	0.01	-0.06	0.09
Non-refrigerated Warehouse	0.01	0.00	0.00	0.00	0.02
Restaurant	0.14	0.09	0.06	0.08	0.21
Small Office	0.06	0.04	0.01	0.04	0.21
Small School	0.18	0.11	0.06	0.11	0.31
Strip Mall	0.06	0.04	0.02	0.03	0.12

2.4.3 Operable Windows—Energy and Energy Cost Savings Results

Energy savings (electricity, natural gas, and source energy for operable windows are presented in Table 13 through Table 16 for the evaluated nonresidential building prototypes in California Climate Zones 1 through 5 and 9 through 16. These results reflect improved thermal performance of operable window systems, which primarily reduces conductive heat transfer through the building envelope.

As shown in Table 13, per-unit first-year electricity savings are generally small and vary by prototype and climate zone. Reported values are typically near zero and range from small negative to small positive values, approximately -0.03 to 0.06 kWh/sf, reflecting minor shifts in cooling and electric heating energy use. There are no peak demand reductions on a per-square-foot basis across all evaluated prototypes and climate zones. As a result, the measure does not affect peak electric demand and should not be characterized as a demand-reduction measure.

Heating-related savings are more substantial. The proposed reduction in fenestration U-factor lowers heating loads across most building types and climate zones. For prototypes with natural gas heating systems, these reductions appear as natural gas savings, ranging from approximately 0.00 to 0.43 kBtu/sf, with larger savings in colder climate zones and heating-dominated occupancies such as schools, offices, assembly buildings, and restaurants, as shown in Table 14. For prototypes served by electric heating systems, the same heating load reductions appear as changes in electricity

consumption and are reflected in the electricity savings results. These heating energy reductions drive positive source energy savings for most prototypes and climate zones. As shown in Table 15, first-year source energy savings generally range from near zero up to approximately 0.42 kBtu/sf, with higher values occurring in colder climates and heating-intensive building types. Isolated negative source energy impacts are observed in a small number of prototype-climate combinations, but overall source energy savings are positive for the vast majority of cases.

Table 16 presents total per-unit energy cost savings for operable windows in new construction and additions, expressed as LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. LSC results range from approximately -$0.17/sf to $0.61/sf, with the majority of prototype-climate combinations producing positive lifecycle savings. Many building types, particularly schools, offices, assembly buildings, and restaurants in colder climate zones, exhibit positive lifecycle savings driven primarily by avoided heating energy costs. In contrast, some prototypes and milder climate zones show limited or negative LSC savings where heating benefits are smaller and incremental costs outweigh energy savings. Savings are generally more pronounced in colder climate zones, where heating loads are higher and reductions in heat loss through glazing have a greater impact.

Overall, the results demonstrate that improved operable window thermal performance primarily enhances heating-season energy efficiency, with limited effects on cooling energy use and peak electricity demand. Because fenestration thermal performance is stable over time and not influenced by occupant behavior or equipment degradation, first-year heating savings are expected to persist throughout the 30-year analysis period.

Table 13: First-Year Electricity Savings (kWh) Per Square Foot for Operable Windows—New Construction / Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ05	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Assembly	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Hospital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Laboratory	0.03	0.01	0.01	0.00	0.02	0.04	-0.01	0.06	-0.01	-0.02	0.04	0.00	0.01
Large Office	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Retail	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	-0.01	0.00
Large School	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Medium Office	0.04	0.02	0.01	0.02	0.01	0.00	0.00	0.02	0.02	0.01	0.02	0.01	0.06
Medium Retail	0.00	0.00	0.00	0.00	0.01	0.00	0.01	-0.03	-0.01	-0.01	0.01	0.02	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Small Office	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
Small School	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.02	0.01	0.02
Strip Mall	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	-0.01	0.00

Table 14: First-Year Natural Gas Savings (kBtu) Per Square Foot for Operable Windows—New Construction / Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ05	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Assembly	0.31	0.24	0.17	0.21	0.16	0.10	0.09	0.22	0.19	0.13	0.21	0.06	0.43
Hospital	0.11	0.10	0.08	0.09	0.08	0.05	0.06	0.09	0.08	0.07	0.08	0.05	0.13
Laboratory	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.12
Large Office	0.17	0.14	0.11	0.13	0.11	0.06	0.06	0.12	0.11	0.08	0.13	0.05	0.25
Large Retail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Large School	0.26	0.19	0.17	0.17	0.16	0.09	0.09	0.17	0.16	0.12	0.16	0.05	0.33
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Prototype	CZ01	CZ02	CZ03	CZ04	CZ05	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Medium Retail	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.24	0.16	0.11	0.14	0.10	0.05	0.05	0.15	0.13	0.09	0.14	0.02	0.34
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Small School	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Strip Mall	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16

Table 15: First-Year Source Energy Savings (kBtu) Per Square Foot for Operable Windows—New Construction / Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ05	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Assembly	0.29	0.23	0.16	0.20	0.15	0.09	0.08	0.21	0.18	0.13	0.21	0.07	0.39
Hospital	0.10	0.08	0.07	0.07	0.07	0.04	0.05	0.08	0.07	0.06	0.07	0.05	0.11
Laboratory	0.10	0.08	0.04	0.04	0.05	0.09	0.01	0.09	0.01	0.09	0.13	0.05	0.13
Large Office	0.15	0.12	0.10	0.12	0.10	0.05	0.06	0.11	0.10	0.07	0.12	0.05	0.22
Large Retail	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.05
Large School	0.24	0.18	0.16	0.16	0.15	0.09	0.08	0.17	0.15	0.11	0.16	0.06	0.31
Medium Office	0.11	0.09	0.05	0.09	0.06	0.03	0.03	0.09	0.07	0.06	0.09	0.03	0.15
Medium Retail	0.04	0.01	0.00	0.02	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.00	0.08
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Restaurant	0.21	0.14	0.09	0.12	0.09	0.04	0.04	0.13	0.11	0.08	0.12	0.03	0.29
Small Office	0.03	0.03	0.02	0.03	0.01	0.01	0.01	0.03	0.02	0.02	0.04	0.01	0.26
Small School	0.11	0.05	0.04	0.05	0.03	0.03	0.02	0.07	0.05	0.04	0.08	0.01	0.42
Strip Mall	0.07	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.02	0.00	0.14

Table 16: Total 30-Year LSC Savings (2029 PV$) Per Square Foot for Operable Windows—New Construction/Addition—Vertical Fenestration

Prototype	CZ01	CZ02	CZ03	CZ04	CZ05	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Assembly	0.35	0.30	0.17	0.25	0.16	0.10	0.09	0.27	0.19	0.18	0.28	0.16	0.43
Hospital	0.09	0.08	0.06	0.08	0.06	0.05	0.06	0.09	0.08	0.07	0.08	0.08	0.11
Laboratory	0.30	0.18	0.12	0.09	0.17	0.62	-0.10	0.45	-0.08	0.35	0.45	0.07	0.13
Large Office	0.14	0.11	0.08	0.12	0.06	0.05	0.05	0.13	0.10	0.09	0.13	0.09	0.22
Large Retail	0.03	0.02	0.00	0.02	0.03	0.07	0.07	-0.04	0.05	0.01	0.03	-0.03	0.08
Large School	0.28	0.21	0.17	0.21	0.16	0.10	0.10	0.23	0.18	0.16	0.22	0.14	0.39
Medium Office	0.42	0.29	0.16	0.26	0.15	0.06	0.06	0.26	0.19	0.16	0.24	0.15	0.51
Medium Retail	0.05	0.04	0.01	0.12	0.05	0.00	0.05	-0.17	-0.10	-0.04	0.07	0.11	0.11
Non-refrigerated Warehouse	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	-0.01	0.00	-0.01	0.01
Restaurant	0.21	0.13	0.08	0.12	0.07	0.04	0.04	0.15	0.12	0.10	0.14	0.09	0.31
Small Office	0.10	0.06	0.03	0.06	0.00	0.00	0.02	0.10	0.06	0.06	0.10	0.09	0.31
Small School	0.27	0.15	0.18	0.16	0.11	0.11	0.07	0.24	0.13	0.11	0.22	0.04	0.61
Strip Mall	0.08	0.05	0.02	0.10	0.02	0.01	-0.02	0.10	0.07	0.05	0.05	-0.02	0.16

2.4.4 Incremental First Cost

Incremental first costs (or incremental costs) reflect the difference in material and labor costs of installing window units with properties meeting the proposed measure as compared to those with properties meeting existing code requirements.

The Statewide CASE Team has conducted interviews and surveys with manufacturers, trade associations, builders, national laboratories, and other stakeholders to gain knowledge on window pricing and installation labor. Based on those conversations and available industry data, the Statewide CASE Team used incremental costs of $0.58 per square foot of window (obtained in March 2026); in Table 17 below, this figure was converted to a cost per square foot of building for each prototype.

Most labor costs associated with window installation will remain unchanged from the current requirements of the code. One possible impact raised by stakeholders is the additional weight and associated costs if triple-paned windows start to displace double-paned windows, but this proposal does not require heavier triple-paned windows. The Statewide CASE Team does not anticipate any increase in labor for the windows with U-factors proposed in this measure, as these U-factors can be readily achieved with one additional efficiency feature such as an improved thermal break, nonmetal pressure plate, argon gas-fill, second low-e coating, or warm edge spacer.

2.4.5 Incremental Maintenance and Replacement Costs

In general, fenestration is only replaced on an as-needed basis, like in the case of accidental damage. Maintenance and replacement are typically associated with moisture-related damage and for condensation issues in the frame assembly.

Items requiring maintenance include inspections for adjacent building elements providing water drainage at the building such as window head flashing, roof drains, scuppers, transition flashing, and gutters. Sealant joints are typically employed to transition between different cladding and fenestration types within the building envelope. These sealant joints are often a critical component in the durability of a building envelope and also merit annual inspection. While regular inspections are best practice for the opaque envelope, it is also true that most building owners do not inspect their property to ensure drainage. In cases such as these, wholesale replacement of sections of the vertical fenestration is often required. The timing, frequency, and magnitude of these costs are not quantified for this CASE Report.

If building drainage elements are inspected as noted above, the only common replacement cost for windows is exterior sealant joints exposed to the weather and solar UV radiation. The frequency of replacement would depend on the type of sealants used as some are more resistant to the elements than others, but for the purposes of this

report the Statewide CASE Team assumes a period of ten years between sealant joint replacement.

Incremental maintenance cost is the incremental cost of replacing windows, as well as periodic maintenance and repair required to keep windows operating relative to current practices over the 30-year period of analysis. The present value of window maintenance cost (or savings) was calculated using a three percent discount rate, which is consistent with the discount rate used when developing the 2028 LSC hourly factors.

Description of the incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report.

Table 17: Vertical Fenestration in Newly Constructed Buildings and Additions—Incremental Cost per Square Foot of Building Area – Fixed Windows

Building Prototype	Net Window Area (ft^2)	Incremental Cost per Square Foot of Window	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/ft^2$)
Large Office	48,134	$0.58	$27,918	498,589	$0.06
Medium Office	7,027	$0.58	$4,076	53,628	$0.08
Small Office	642	$0.58	$372	5,502	$0.07
Large Retail	5,881	$0.58	$3,411	240,000	$0.01
Large School	22,162	$0.58	$12,854	210,866	$0.06
Small School	4,964	$0.58	$2,879	24,413	$0.12
Assembly	60,207	$0.58	$34,920	315,339	$0.11
Hospital	9,133	$0.58	$5,297	249,985	$0.02
Laboratory	7,027	$0.58	$4,076	53,628	$0.08
Small Restaurant	280	$0.58	$162	2,501	$0.06
Medium Retail	904	$0.58	$524	24,563	$0.02
Retail Strip Mall	558	$0.58	$324	9,375	$0.03
Warehouse	190	$0.58	$110	52,050	$0.00

Table 18: Vertical Fenestration in Newly Constructed Buildings and Additions—Incremental Cost per Square Foot of Building Area – Operable Windows

Building Prototype	Net Window Area (ft^2)	Incremental Cost per Square Foot of Window	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/ft^2$)
Large Office	48,134	$0.58	$27,918	498,589	$0.06
Medium Office	7,027	$0.58	$4,076	53,628	$0.08
Small Office	642	$0.58	$372	5,502	$0.07
Large Retail	5,881	$0.58	$3,411	240,000	$0.01
Large School	22,162	$0.58	$12,854	210,866	$0.06
Small School	4,964	$0.58	$2,879	24,413	$0.12
Assembly	60,207	$0.58	$34,920	315,339	$0.11
Hospital	9,133	$0.58	$5,297	249,985	$0.02
Laboratory	7,027	$0.58	$4,076	53,628	$0.08
Small Restaurant	280	$0.58	$162	2,501	$0.06
Medium Retail	904	$0.58	$524	24,563	$0.02
Retail Strip Mall	558	$0.58	$324	9,375	$0.03
Warehouse	190	$0.58	$110	52,050	$0.00

2.4.6 Cost Effectiveness

Results of the per-unit cost-effectiveness analyses are presented in Table 19 for new construction/additions for fixed windows and Table 20 for operable windows. For clarity, the Statewide CASE Team has included the results for all climate zones, including those for which the proposed changes are not cost-effective (BCR<1.0). The code change proposal does not include those climate zones.

Table 19: 30-Year Cost-Effectiveness Summary Per Square Foot of Fixed Window Area—New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	0.14	0.06	2.30
2	0.08	0.06	1.33
3	0.07	0.05	1.27
4	0.07	0.05	1.47
5	0.04	0.06	0.68
6	-0.01	0.05	-0.11
7	0.02	0.06	0.34
8	0.00	0.05	0.02
9	N/A	N/A	N/A
10	0.02	0.05	0.38
11	N/A	N/A	N/A
12	N/A	N/A	N/A
13	N/A	N/A	N/A
14	N/A	N/A	N/A
15	N/A	N/A	N/A
16	0.15	0.05	3.10

Table 20: 30-Year Cost-Effectiveness Summary Per Square Foot of Operable Window Area—New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	0.27	0.06	4.60
2	0.20	0.06	3.28
3	0.15	0.05	2.86
4	0.20	0.05	3.99
5	0.11	0.06	1.93
6	0.03	0.05	0.54
7	0.01	0.06	0.13
8	0.02	0.05	0.46
9	0.07	0.05	1.44
10	0.07	0.05	1.31

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
11	0.23	0.04	5.16
12	0.13	0.05	2.48
13	0.11	0.05	2.26
14	0.21	0.05	4.06
15	0.10	0.04	2.24
16	0.50	0.05	9.97

2.5 New Construction/Additions—Vertical Fenestration—Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

Statewide results are presented separately for fixed and operable window measures based on the weighted statewide construction forecasts, fenestration subtype distributions, and climate zone applicability assumptions described in Appendix C. The statewide savings estimates reflect the assumed distribution of fenestration subtypes across building types and the climate zone applicability of each proposed measure.

Table 21 presents first-year statewide savings for fixed windows in new construction and additions. The fixed window measure results in approximately 0.01 million therms of first-year natural gas savings and 0.93 million kBtu of first-year source energy savings statewide. First-year electricity savings total approximately 0.04 GWh, while peak demand is reduced by 0.02 MW.

Over a 30-year analysis period, total present-valued LSC savings for the fixed window measure are estimated at approximately $1.37 million statewide (2029 PV$). Positive lifecycle savings are observed across all applicable climate zones, with the largest contributions occurring in Climate Zones 3 and 4, reflecting both the large weighted construction forecasts and heating-related savings in those regions.

These results are consistent with the measure's focus on improving fenestration U-factor without modifying SHGC. Because the fixed window measure primarily reduces conductive heat loss, its statewide benefits are driven mainly by heating-energy reductions rather than cooling or peak-demand impacts.

Table 22 presents first-year statewide savings for operable windows in new construction and additions. The operable window measure results in approximately 0.07 GWh of first-year electricity savings and 0.62 million kBtu of first-year source energy savings statewide. Natural gas savings are minimal at the statewide level. First-year peak demand reductions total approximately 0.04 MW.

Over a 30-year analysis period, total present-valued LSC savings for the operable window case are estimated at approximately $1.30 million statewide (2029 PV$). Positive lifecycle savings are observed across the evaluated climate zones, with the largest contributions occurring in Climate Zones 3, 4, 9, and 12, where the combination of weighted affected floorspace and heating-related savings is greatest.

As with the fixed window measure, statewide benefits are driven primarily by reductions in heating energy use resulting from improved thermal performance. Because SHGC values are unchanged, impacts on cooling energy use and peak demand remain limited.

Table 23 summarizes the combined statewide impacts of the proposed new construction fenestration measures. Across both fixed and operable windows, the proposal is estimated to save approximately 0.11 GWh of electricity, reduce peak demand by 0.06 MW, save approximately 0.01 million therms of natural gas, and reduce source energy use by approximately 1.55 million kBtu in the first year. Total present-valued lifecycle cost savings are estimated at approximately $2.67 million (2029 PV$) over the 30-year analysis period.

Table 21: Statewide Energy and LSC Impacts—New Construction and Addition Fixed Windows

Note: These totals reflect only the building prototypes modeled for this fenestration analysis and therefore represent a subset of the full statewide new construction forecast shown in Appendix C.

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2028 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	358,275	0.00	0.00	0.00	0.03	$0.05
2	2,049,341	0.01	0.00	0.00	0.11	$0.17
3	10,445,760	0.02	0.01	0.00	0.45	$0.69
4	4,998,366	0.01	0.01	0.00	0.28	$0.37
16	570,028	0.00	0.00	0.00	0.06	$0.09
Total	18,421,770	0.04	0.02	0.01	0.93	$1.37

Table 22: Statewide Energy and LSC Impacts—New Construction and Addition Operable Windows

Note: These totals reflect only the building prototypes modeled for this fenestration analysis and therefore represent a subset of the full statewide new construction forecast shown in Appendix C.

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2028 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	86,440	0.00	0.00	0.00	0.01	$0.02
2	521,600	0.01	0.00	0.00	0.05	$0.11
3	1,404,585	0.01	0.01	0.00	0.10	$0.21
4	793,050	0.01	0.00	0.00	0.07	$0.16
5	294,390	0.00	0.00	0.00	0.02	$0.03
9	2,449,365	0.00	0.01	0.00	0.09	$0.18
10	1,357,280	0.00	0.00	0.00	0.04	$0.09
11	407,580	0.01	0.00	0.00	0.03	$0.09
12	1,333,935	0.01	0.01	0.00	0.09	$0.17
13	824,750	0.01	0.00	0.00	0.04	$0.09
14	314,770	0.01	0.00	0.00	0.03	$0.06
15	212,735	0.00	0.00	0.00	0.00	$0.02
16	127,810	0.00	0.00	0.00	0.04	$0.06
Total	10,128,290	0.07	0.04	0.00	0.62	$1.30

Table 23: Statewide Energy and LSC Impacts—New Construction

Measure	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
Fixed Window	0.04	0.02	0.01	0.93	$1.37
Operable Window	0.07	0.04	0.00	0.62	$1.30
Total	**0.11**	**0.06**	**0.01**	**1.55**	**$2.67**

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Statewide results are presented separately for fixed and operable window measures based on the weighted statewide construction forecasts, fenestration subtype distributions, and climate zone applicability assumptions described in Appendix C. The statewide savings estimates reflect the assumed distribution of fenestration subtypes across building types and the climate zone applicability of each proposed measure.

Table 24 presents the estimated first-year statewide reduction in greenhouse gas (GHG) emissions resulting from the proposed new construction and addition vertical fenestration measures, disaggregated by fenestration type.

In the first year of compliance, the Statewide CASE Team estimates that the fixed window measure would avoid approximately 55 metric tons of carbon dioxide equivalent (CO_2e) emissions statewide. These reductions include approximately 15 metric tons CO_2e associated with electricity savings and 40 metric tons CO_2e associated with natural gas savings. The estimated monetary value of these avoided emissions is approximately $6,721 in the first year.

Operable window measures result in approximately 35 metric tons of CO_2e emissions reductions, with an associated monetary value of approximately $4,275. These reductions include approximately 16 metric tons CO_2e associated with natural gas savings and 19 metric tons CO_2e associated with electricity savings. The smaller overall impact reflects the more limited weighted share of operable windows within the statewide construction forecast.

These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the

CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Overall, the proposed fenestration measures provide modest but positive reductions in GHG emissions statewide. Fixed window measures achieve larger overall emissions reductions due to their larger weighted share of statewide fenestration area and their associated natural gas savings. Operable window measures provide additional emissions reductions through both electricity and natural gas savings within the climate zones where they apply.

Table 24: First-Year Statewide GHG Emissions Impacts—New Construction & Additions

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
Fixed Windows	15	40	55	6,721
Operable Windows	19	16	35	4,275
Total	**34**	**56**	**90**	**10,996**

2.5.3 Statewide Water Use Impacts

The proposed code change will not result in water use impacts.

2.5.4 Statewide Material Impacts

The Statewide CASE Team expects little to no changes to materials impacts because the proposed code change is only changing existing U-factors which should not necessarily translate to more or different materials being used.

For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

2.5.5 Environmental Impacts

This proposal would result in energy savings and GHG emissions reduction. The requirement ensures that less thermal energy is exchanged through windows, increasing the heating and cooling efficiency within spaces.

There are no identified indirect adverse environmental impacts nor indirect environmental benefits from this code change proposal.

2.5.6 Other Non-Energy Impacts

Improved insulation from better performing windows would provide tighter building envelopes, thus improving occupant comfort by better regulating indoor temperature, reducing noise, and contributing to indoor air quality.

2.6 New Construction/Additions Fenestration—Proposed Code Language

2.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions). New to the 2028 energy code is to italicize defined terms when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included with greyed highlight and italics.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.8 New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “Section 601.1 *[Section 130.0(a)]* General” contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from the requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

2.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

2.6.3 Reference Appendices

There are no proposed changes to the Reference Appendices.

2.6.4 Energy Code (Title 24, Part 6)

SUBCHAPTER 3 ENVELOPE

SECTION 301.3.4.2 *[Section 140.3(a)5B]* U-factor.

Vertical *windows* in *exterior walls* shall have an area-weighted average *U-factor* no greater than the applicable value in Tables 301.3-C.1, C.2, C.3, D or E *[Tables 140.3-B, C or D].*

SECTION 301.3.4.3 *[Section 140.3(a)5C]* Relative Solar Heat Gain Coefficient (RSHGC).

Vertical *windows* in *exterior walls* shall have an area-weighted average *relative solar heat gain coefficient, RSHGC*, excluding the effects of interior *shading*, no greater than the applicable value in Tables 301.3-C.1, C.2, C.3, D or E *[Tables 140.3-B, C or D].*

SECTION 301.3.4.4 *[Section 140.3(a)5D]* Visible Transmittance (VT).

Vertical *windows* in *exterior walls* shall have an area-weighted average *Visible Transmittance (VT)* no less than the applicable value in Tables 301.3-C.1, C.2, C.3, and D *[Tables 140.3-B and C],* or Equation 301.3-C *[Equation 140.3-B],* as applicable.

TABLE 301.3-C.1 *[Table 140.3-B].* PRESCRIPTIVE OPAQUE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS (INCLUDING RELOCATABLE PUBLIC SCHOOL BUILDINGS WHERE MANUFACTURER CERTIFIES USE ONLY IN SPECIFIC CLIMATE ZONE; NOT INCLUDING ~~HIGH-RISE RESIDENTIAL BUILDINGS AND~~ GUEST ROOMS OF HOTEL/MOTEL BUILDINGS)

(This table would include all rows from “Roof and Ceilings—Metal Building Max U-Factor” through “Exterior Doors—Swinging Maximum U-Factor”. All values in the table remain unchanged.)

TABLE 301.3-C.2 ***[New Table split from Table 140.3-B].*** **PRESCRIPTIVE FENESTRATION CRITERIA FOR HOTEL/MOTEL BUILDINGS AND NONRESIDENTIAL BUILDINGS WITH CALIFORNIA BUILDING CODE GROUP R OCCUPANCIES AND THEIR COMMON OR PUBLIC USE AREAS**

Fenestration—Vertical (All Climate Zones) (Area-Weighted Performance Rating)	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
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
Fixed Window (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
Fixed Window (Min VT)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Curtain Wall 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
Curtain Wall or Storefront (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
Curtain Wall or Storefront (Min VT)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Operable Window (Max U-factor)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Operable Window (Max RSHGC)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

Operable Window (Min VT)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Glazed Doors (Max U-factor)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Glazed Doors (Max RSHGC)	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Glazed Doors (Min VT)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

TABLE 301.3-C.3 ***[New Table].*** **PRESCRIPTIVE FENESTRATION CRITERIA FOR NONRESIDENTIAL BUILDINGS (INCLUDING RELOCATABLE PUBLIC SCHOOL BUILDINGS WHERE MANUFACTURER CERTIFIES USE ONLY IN SPECIFIC CLIMATE ZONE, NOT INCLUDING NONRESIDENTIAL BUILDINGS WITH CALIFORNIA BUILDING CODE GROUP R OCCUPANCIES AND THEIR COMMON OR PUBLIC USE AREAS)**

Fenestration—Vertical (All Climate Zones) (Area-Weighted Performance Rating)	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Fixed Window (Max U-factor)	0.34	0.34	0.34	0.34	0.36	0.36	0.36	0.36	0.34	0.36	0.34	0.34	0.34	0.34	0.34	0.34
Fixed Window (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
Fixed Window (Min VT)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Curtain Wall 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
Curtain Wall or Storefront (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
Curtain Wall or Storefront (Min VT)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Operable Window (Max U-factor)	0.43	0.43	0.43	0.43	0.43	0.46	0.46	0.46	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

Operable Window (Max RSHGC)	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -	0.22 -
Operable Window (Min VT)	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -	0.32 -
Glazed Doors (Max U-factor)	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -	0.45 -
Glazed Doors (Max RSHGC)	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -	0.23 -
Glazed Doors (Min VT)	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -	0.17 -

2.6.5 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

2.6.6 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

2.6.7 Compliance Forms

As discussed in Section 2.1.4.5, the NRCC-ENV-E, NRCC-PRF-E, and NRCA-ENV-02-F forms would need to be updated to reflect the proposed change, as well as the different scoping required by AB 130. The schema logic supporting compliance within the prescriptive forms will need to be updated to reflect these reduced U-factor requirements.

3. Vertical Fenestration Alterations

3.1 Vertical Fenestration Alterations—Measure Description

3.1.1 Proposed Code Change

The Statewide CASE Team proposes two changes for alterations related to vertical fenestration. As with the proposal for new construction and additions, these proposals are not applicable to California Building Code Group R occupancies and their common or public use areas.

The first proposal would require the prescriptive U-factors and RSHGC for all vertical fenestration in nonresidential building alterations to align with the U-factor, RSHGC and VT requirements for new construction (new Tables 301.3-C.2 and 301.3-C.3) when one hundred percent of any one fenestration type (windows, curtain wall, storefront, or glazed doors) is replaced.

The second proposed code change addresses alterations related to vertical fenestration where less than one hundred percent of any one fenestration type is replaced. The existing Table 301.5-A *[Table 141.0-A]* provides a single U-factor and SHGC for every type of vertical fenestration, depending on the climate zone. For this code cycle, Table 301.5-A (relabeled as Table 301.5-A.1) will remain in use for nonresidential buildings with California Building Code Group R occupancies and their common or public use areas. This proposal adds a new Table 301.5-A.2 indicating updated U-factors and SHGC values for replacement of individual vertical fenestration types.

The current maximum U-factor requirement for window alterations is U-0.58 in Climate Zones 3 and 5, and U-0.47 in all other climate zones. The current maximum RSHGC for window alterations is 0.41 in Climate Zones 1, 3, 5, and 16, and 0.31 in all other climate zones.

In the energy modeling for this measure, alteration cases were treated as full replacement projects in which all modeled vertical fenestration of a given type was upgraded from the current alteration requirements to the proposed U-factor and RSHGC values. This approach is consistent with the proposed code trigger, which applies when one hundred percent of a fenestration type (fixed windows, operable windows, glazed doors, curtain wall, or storefront) is replaced. Because the CEC prototype models do not explicitly include curtain wall, storefront systems, operable windows, or glazed doors, all modeled savings were based on replacement of the prototype glazing systems and were subsequently allocated across fenestration types using the statewide weighting assumptions described in Appendix C.

The proposal would not add or modify acceptance tests or require any technology not previously regulated.

Table 25 summarizes the scope of the proposed code change.

Table 25: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Tpe(s)	Construction Type(s)	Type of Change
☐ Single Family	☐ New Construction	☐ Mandatory
☐ Multifamily	☐ Additions	☑ Prescriptive
☑ Nonresidential (not Group R uses)	☑ Alterations	☑ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
All Climate Zones	Subchapter 3 Envelope, Section 301.5.2.2.1 *[Section 141.00(b)2A]*	NRCC-ENV-E NRCC-PRF-E NRCA-ENV-02-F	Section 5.5.7

Third-party Verification)	Updates to Compliance Software
☐ No changes to third-party verification	☐ No updates
☑ Update existing verification requirements	☑ Update existing feature
☐ Add new verification requirements	☐ Add new feature

3.1.2 Benefits of Proposed Change

The proposed code change would directly address the inefficiencies in the current U-factors for alterations in all climate zones. More energy-efficient windows reduce energy costs, improve indoor occupant comfort, reduce noise infiltration, and can improve the building aesthetics.'

Enhancing indoor comfort improves an occupant’s experience in the building and promotes a sense of well-being. More comfortable occupants are less likely to adjust the thermostat, which reduces overall heating or cooling loads, and reduces energy bills in the long term.

When a substantial portion of the fenestration is upgraded, building owners may have the opportunity to install smaller capacity HVAC equipment during future system replacements, improving system performance and further increasing overall energy efficiency. In addition to the thermal benefits, better windows reduce the transmission of external noise. Improving the acoustic environment supports cognitive performance and reduces stress levels.

Together, these benefits foster healthier indoor spaces, promote overall well-being, and create environments that are more conducive to productivity and long-term occupant satisfaction.

3.1.3 Background Information

Windows are a critical component of the building envelope for commercial construction. Heat transfer through the building envelope and associated air leakage are the largest factors impacting HVAC loads in most climates. While walls can be many inches thick and full of insulation that slows heat transfer between the exterior and interior of a building, windows are the weakest link in the thermal envelope. Windows account for a significant amount of energy transfer through the envelope, both in terms of thermal heat transfer and solar heat gain.[6]

Windows play a role in determining levels of comfort, natural lighting, ventilation, and the amount of energy required to condition a building. The efficiency of windows depends on thermal indices (U-factor, SHGC, and VT) and on climate and other building characteristics. The term “U-factor” refers to the measurement of the relative level of heat transfer through building envelope components such as windows or walls. The lower the U-factor, the lower the rate of heat transfer. Therefore, the lower the U-factor, the better the insulating quality of the component.

The Relative Solar Heat Gain Coefficient (RSHGC) is the ratio of total incident solar gain entering the space, accounting for exterior shading. Lower RSHGC values indicate greater resistance to solar heat gain, which helps reduce cooling loads and improve occupant comfort in warm or sun-exposed spaces.

The required U-factors and RSHGC values for fenestration alterations have been unchanged since at least the 2013 code. In Title 24, these RSHGC limits directly reflect the SHGC requirements for rated products and do not use the IECC projection-factor method.

The Statewide CASE Team proposes to update these values by requiring that replacement fenestration, where one hundred percent of any one type of fenestration is being replaced, comply with the U-factor values for new construction. For alterations replacing less than one hundred percent of fixed windows and curtain wall or storefront, the Statewide CASE Team proposes new values in new Table 301.5-A.2. These updates would reduce unwanted solar gains across all climate zones and improve cooling season performance and comfort in sun-exposed spaces.

[6] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. “Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption.” Accessed September 23, 2025. https://www.nrel.gov/docs/fy22osti/80171.pdf

3.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 2.6 of this report for detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

Existing Table 301.5-A *[Table 141.0-A]* would be split into two separate tables. The first table 301.5-A.1, the content of which would be unchanged, would apply to vertical fenestration alterations in hotel/motel buildings and nonresidential buildings with group R occupancies. The second table 301.5-A.2 would apply to nonresidential buildings, including relocatable public school buildings (where manufacturers certify use only in specific climate zones), and excluding nonresidential buildings with California Group R Occupancies and their common and public use areas.

SECTION 301.5.2.2.1 *[Section 141.0(b)2A]* is modified to be applicable only to hotel/motel buildings and nonresidential buildings with California Building Code Group R occupancies and their common or public use areas.

SECTION 301.5.2.2.2 *[New Section]* is added to provide language specifying the proposed trigger for fenestration alterations that shall comply with the provisions for new construction, Sections 301.3.4.2 through 301.3.3.4 *[Sections 140.3(a)5B through 140.3(a)5D].*

The new section further provides requirements for alterations not required to comply with the provisions for new construction and adds Table 301.5-A.2 *[New Table].*

3.1.4.2 Reference Appendices Change Summary

The proposed changes would not impact on the reference appendices, as fenestration is not covered in those documents.

3.1.4.3 Compliance Manuals Change Summary

Applicable information within the manuals will be updated to reflect the new requirements. Clear guidance will be provided regarding the intent and application of the new rules regarding fenestration alterations.

3.1.4.4 Alternative Calculation Method Reference Manual Change Summary

Section 5.5.7 of the ACM manual would be updated to reference the correct proposed tables for each occupancy type, as proposed in Section 3.1.4.1.

3.1.4.5 Compliance Forms Change Summary

The nonresidential compliance forms will require changes to accommodate documentation of the one hundred percent replacement trigger and the different tables proposed for different occupancy types. Additionally, the schema logic supporting compliance within the prescriptive forms will need to be updated to reflect these reduced U-factor requirements.

3.1.5 Measure Context

3.1.5.1 Comparable Model Codes or Standards

The following model codes are relevant to this proposed measure:

- ASHRAE 90.1 – 2025
- IECC 2024

Section C503.2.2.1 of the IECC applies to replacement fenestration products and requires that when some or all of an existing fenestration unit is replaced, the replacement unit must meet the performance requirements for new construction. An exception applies if an area-weighted average is used for the replacement fenestration.

Similarly, Section 5.1.4 of ASHRAE 90.1 requires replacement fenestration to meet the performance criteria for new construction unless the total area of the replacement fenestration does not exceed 25 percent of the total fenestration area of the building.

3.1.5.2 Interactions with Other Regulations

- **Federal Laws and Regulations:** There are no relevant federal laws or regulations with which this measure would be in conflict.
- **State laws and requirements:** There are no relevant state laws or regulations with which this measure would be in conflict.
- **Interactions with California Building Code:** There are no relevant conflicts with the other sections of the California Building Code.
- **Local requirements:** There are no relevant local ordinances with which this measure would be in conflict.

3.2 Vertical Fenestration Alterations—Compliance and Enforcement

3.2.1 Compliance Considerations

The proposed alteration measures will have a significant impact on current compliance and enforcement practices. In addition to verification of the updated performance requirements, the design professional and the plan reviewer will need to recognize and

identify situations where one hundred percent of any one type of vertical fenestration is being replaced. Additionally, there will need to be multiple versions of the 2028 compliance forms to accommodate the different scoping required by AB 130.

3.2.2 Impact on Market Actors

Table 26 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 26: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/Developer[a]	Building owners may face expectations to replace all units of a given fenestration type (for example, all window or all storefront units on a façade) once alterations begin, potentially affecting project scope and budgets. Partial fenestration replacements can also create aesthetic inconsistencies or HVAC balancing issues between upgraded and non-upgraded spaces. Over time, these upgrades reduce energy bills and improve occupant comfort.	EnergyCodeAce Training and Fact Sheets summarizing updated alteration requirements. Outreach materials for planning considerations with partial window replacements and coordination with design teams to maintain visual and thermal consistency.
Design Professional [b]	Architects need to specify and detail replacement fenestration with the updated U-factor and RSHGC requirements. They will also need to document whether the project replaces 100% of any single fenestration type (windows, curtain wall, storefront, glazed doors), including clearly identifying which fenestration types are fully replaced and which are only partially replaced.	EnergyCodeAce Training and Fact Sheets on determining whether 100% replacement of a fenestration type has occurred, performing fenestration-area calculations, and documenting compliance in submittals.
Construction Team [c]	The construction team needs to purchase and install fenestration with the updated U-factor and RSHGC requirements and confirm that selected products are NFRC-certified to those performance ratings. Teams will need to verify	EnergyCodeAce Training and Fact Sheets focused on verifying NFRC certification and planning for product availability and lead times.

Market Actor	Impact(s)	Suggested Outreach and Education
	product documentation before installation and may need to adjust delivery schedules to account for longer lead times associated with higher-efficiency framing systems.	
Building Department [d]	Building plan reviewers and inspectors (AHJs) using the prescriptive compliance method will need to verify whether the construction documents match the compliance forms. Inspectors must verify that installed products have NFRC-certified ratings consistent with the design documents. and that the correct window components are installed.	EnergyCodeAce Training and Fact Sheets, supplemented by a calculator to help determine whether a project has replaced 100% of a fenestration type
Verification Tester [e]	N/A	N/A
Manufacturers and Distributors	Manufacturers and distributors need to ensure that there are readily-available products meeting the updated performance requirements.	EnergyCodeAce Training and Fact Sheets. Feedback to suppliers from contractors and installers.

a. Owner/Developer is funding the project and is the primary decision maker.
b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, home builders, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plan reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on owners/developers, design professionals, construction teams, building departments, and manufacturers and distributors, since these market actors are expected to experience the most direct impacts from the proposed changes to prescriptive requirements for vertical fenestration alterations. The following provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Owner/Developer. The proposed change would likely affect nonresidential building owners and project developers for renovation projects. The commercial building sector includes a wide array of building types, including offices, restaurants, retail, mixed-use establishments, and warehouses. Energy use by occupants of commercial buildings, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating.

Design Professional. Design professionals will need to understand the updated U-factor and RSHGC requirements to ensure that designs for applicable projects contain correct product specifications. Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain current with changes to design practices and building codes.

Building Department. Building plan reviewers and inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team anticipates the proposed changes would have no impact on the scope of building inspectors in conducting energy efficiency evaluations and inspections.

Construction Team. The proposed change would likely affect commercial builders; however, it would not significantly impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction, where fenestration products are generally not used. The proposed change would not affect all firms and workers in the commercial building industry equally; instead, it would primarily affect specific subsectors within the industry. Table 27 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Building occupants (owners and tenants). The proposed code change would have incremental costs and would reduce building owners' utility bills throughout the measure lifetime. See the 2028 CASE Methodology Report for a description of how LSC savings relate to occupant utility bill savings.

Table 27: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Glass and Glazing Contractors	307	5,079	$0.5
Nonresidential Finish Carpentry Contractors	313	3,697	$0.3

Source: (State of California n.d.)

*An establishment is single economic unit, typically at one physical location, which engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. https://www.bls.gov/opub/hom/cew/concepts.htm

3.2.3 Compliance Software Updates

If this proposal is adopted for alterations, CBECC will require only minor adjustments to reflect the updated prescriptive fenestration requirements.

The update would involve revising the prescriptive U-factor and SHGC tables in the software to align with the new standards. Because Tables 301.5-A and 301.5-A(1) *[Table 141.0-A and New Table]* express the solar gain in terms of the Relative Solar Heat Gain Coefficient (RSHGC), CBECC would convert these values to their equivalent SHGC values for use in EnergyPlus. Users will continue to enter NFRC-rated SHGC values, or provide the documentation required when using the alternate default fenestration procedure in the Nonresidential Appendix NA6. No new compliance pathways or calculation methods are needed.

No new EnergyPlus objects are needed. CBECC already references NFRC-rated U-factors and SHGC values through existing EnergyPlus fenestration objects such as WindowMaterial:SimpleGlazingSystem, WindowMaterial:Glazing, and FenestrationSurface:Detailed. No additional data inputs are required from users beyond what is already collected: fenestration area, orientation, and product ratings.

This measure represents only a minor compliance software update limited to focused reference values. The existing alteration compliance trigger in CBECC already covers window replacement projects, so no new trigger needs to be added. CBECC would simply adjust its internal logic to apply the updated prescriptive U-factor and RSHGC requirements when one hundred percent replacement of a fenestration type occurs.

3.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact on enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

Plan review function would consist of reviewing NRCC-ENV-E (or NRCC-PRF-E) and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing NRCI-ENV-E and NRCA-ENV-02-F and ensuring that the information on the forms is consistent with the approved NRCC-ENV-E (or NRCC-PRF-E) forms and with what is actually installed.

3.3 Vertical Fenestration Alterations—Market and Economic Analysis

3.3.1 Market Structure and Availability

3.3.1.1 Current Market Structure and Availability

The nonresidential building envelope market involves many market actors in a variety of roles, including designers, architects, component manufacturers, installers, suppliers, construction companies, and certification/compliance specialists.

Compliant fenestration products proposed for this measure are readily available across California.

During the 2025 code adoption cycle, the Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general and individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders, including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during the public stakeholder meetings that the Statewide CASE Team held on September 30, 2025, and March 17, 2026, as well as during the previous 2025 code cycle: February 14, 2023, and May 22, 2023.

In today's market, façade engineering and envelope retrofits have become increasingly common, reflecting a growing appreciation for energy-efficient fenestration systems in existing buildings. Double-glazed windows are now standard for leading window

manufacturers, making higher-performance options more accessible for alteration projects. Real estate owners are also pursuing façade and window upgrades to enhance building asset value and attract tenants in the post-pandemic era. While visibility and aesthetics remain important design considerations, there is a growing recognition within the alterations market that fenestration performance is a key factor in occupant comfort, operating costs, and long-term building value.

3.3.1.2 Market Challenges and Solutions

Commercial grade fenestration products are already readily available from numerous manufacturers. No new materials or processes would need to be developed for any of the nonresidential envelope measures to be successful.

The proposed U-factor and RSHGC requirements for vertical fenestration are based on products widely available in the market. The Statewide CASE Team does not anticipate technical or market challenges to meet this requirement within the time frame when this code change would take effect (January 1, 2029).

See Section 3.2 for a description of workforce training that may be needed to ensure effective design, installation, and commissioning.

3.3.2 Design and Construction Practices

3.3.2.1 Current Design and Construction Practices

Building designers must be aware of the code changes to the fenestration U-factors and RSHGC. The qualified design reviewer, per commissioning requirements, as well as energy consultants and compliance documentation authors must verify that plans and specifications match and meet the requirements of Title 24, Part 6. There is no change required to complete NRCC compliance documents.

For alterations, these design and documentation practices remain applicable but are limited to the vertical fenestration being replaced, with particular attention to identifying when one hundred percent of a fenestration type is being replaced and therefore must meet the new construction U-factor and RSHGC requirements. While no new floor area or envelope assemblies are created, the design and compliance team must still ensure that the replacement window systems meet the updated U-factor and RSHGC requirements and are properly documented in the compliance forms.

See in Section 2.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

3.3.2.2 Health and Safety Considerations

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California

Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.3.3 Energy Equity and Environmental Justice

Each measure in this CASE Report was evaluated for ESJ impacts using four criteria: cost, health, resiliency, and comfort. The details of that evaluation can be found in Section 1.4 and the 2028 CASE Methodology Report.

Based on a preliminary review, it is unlikely that this proposal would have significant negative impacts on ESJ communities. This proposal would result in tighter building envelopes and thus would result in improved indoor air quality, which could impact communities positively. The proposal would result in incremental costs assumed by the building owner, however the change would provide savings and has been shown to be cost effective in the applicable climate zones. The Statewide CASE Team does not expect this proposal to cause a disproportionate cost impact to ESJ building owners.

3.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. The Statewide CASE Team estimates the proposed change would have virtually no effect on employment and a minor effect on economic output directly and indirectly through its impact on builders. Table 28 and Table 29 outline the statewide implications for the construction sector for Fixed Windows and Storefront fenestration types, respectively. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

The Statewide CASE Team does not anticipate any significant impact on building designers/energy consultants or building inspectors as a result of the proposed change. The Statewide CASE Team does not anticipate that the proposed changes would lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy.

Table 28: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector—Fixed Windows

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Commercial Builders)	0.01	$440	$670	$1,450
Indirect Effect (Additional spending by firms supporting Commercial Builders)	0.00	$260	$440	$770
Total Economic Impacts	**0.01**	**$700**	**$1,110**	**$2,220**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[7]

Table 29: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector—Storefront

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Commercial Builders)	0.01	$950	$1,430	$3,100
Indirect Effect (Additional spending by firms supporting Commercial Builders)	0.01	$810	$950	$1,650
Total Economic Impacts	**0.02**	**$1,760**	**$2,380**	**$4,760**

The proposed change represents a modest adjustment to U-factors for alterations, which is not expected to excessively burden or competitively disadvantage California businesses, nor is it expected to lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state. Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have an advantageous or adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling resulted in an estimated $153 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business

[7] IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

income and that a portion of business income will be allocated to net business investment.

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).7 As Table 30 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

Table 30: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2020	389	2,212	18
2021	545	2,888	19
2022	825	2,951	28
2023	836	3,069	27
2024	885	3,441	26
5-Year Average	Intentionally blank	Intentionally blank	23

Source: (Federal Reserve Economic Data (FRED) n.d.)

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a $36 increase in net private investment by California businesses.

3.3.5 Economic and Fiscal Impacts

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to a significant increase or decrease in investment, directly or indirectly, in any affected sectors of California's economy. The proposed change would not result in economic disruption to any sector of the California economy. For more information on the Statewide CASE Team's economic and fiscal impacts methodology, see the 2028 CASE Methodology Report.

Adoption of this code change proposal would result in minor economic impacts through the additional direct spending by those in the commercial building industry. The Statewide CASE Team does not anticipate that money saved by commercial building

owners or other organizations affected by the proposed 2028 code cycle regulations would result in additional spending by those businesses.

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

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

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with code change proposals. The impact on state-owned buildings will be a modest increase in costs due to higher-performance components, but these costs have been found to be cost-effective.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not an incremental cost associated with the 2028 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 3.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments. The impact on local government-owned buildings will be a modest increase in cost due to higher performance components, but these costs have been found to be cost-effective.

*3.3.5.2 Mandates on Local Agencies or School Districts***.** Local agencies or school districts undertaking new construction or building envelope renovation projects would be impacted by the updated fenestration provisions proposed.

3.3.5.3 Costs to Local Agencies or School Districts

The proposed changes would impose a modest increase in costs due to higher performance components, but these costs have been found to be cost-effective.

3.3.5.4 Costs or Savings to Any State Agency

Any state agency undertaking new construction or building envelope renovation projects would be impacted by the updated fenestration provisions proposed. The proposed changes would impose a modest increase in costs due to higher performance components, but these costs have been found to be cost-effective.

3.3.5.5 Other Nondiscretionary Cost or Savings Imposed on Local Agencies

There are no added nondiscretionary costs or savings to local agencies.

3.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state.

3.4 Vertical Fenestration Alterations—Cost Effectiveness

The Statewide CASE Team did not conduct a separate cost-effectiveness analysis for the proposed requirement that requires compliance with new construction fenestration values when one hundred percent of any one fenestration type (windows, curtainwall, storefront, or glazed doors) is replaced. The proposed and existing new construction fenestration values are significantly more stringent than the existing requirements for vertical fenestration alterations (Table 301.5-A *[Table 141.0-A])* and will offer even more energy savings for alterations than the proposed changes for new construction. It follows that using new construction values for vertical fenestration alterations will be cost-effective.

The following sections describe the cost-effective methodology used for the proposed fenestration alteration values in Table 301.5-A(1) *[New Table].*

3.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on LSC, which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates,

forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

3.4.1.1 Climate-Zone Weighted Cost-Effectiveness Results

For climate-zone-specific cost-effectiveness summaries presented in this report, the incremental costs and benefits shown are weighted average values and do not represent different assumed fenestration product costs by climate zone. The underlying incremental measure costs are developed at the prototype level; however, climate-zone-level cost-effectiveness results vary because each climate zone has a different mix of building types affected by alterations. To develop climate-zone-specific results, the Statewide CASE Team converted prototype-level incremental costs and 30-year present-valued benefits into a single weighted average value for each climate zone based on affected prototype floor space within that climate zone. For each climate zone, both costs and benefits were calculated using the following weighted-average equation:

$$CZ\ Value = \frac{\sum_b \left(Value_b * Floorspace_{b,CZ}\right)}{\sum_b Floorspace_{b,CZ}}$$

where $Value_b$is either the prototype incremental cost per square foot or the prototype 30-year present-value benefit per square foot for prototype b, and $Floorspace_{b,CZ}$is the projected affected floor space associated with prototype b in climate zone CZ.

This approach ensures climate-zone results reflect the actual building stock composition contributing to statewide impacts. Climate zones with a greater share of high-window-to-wall-ratio prototypes may show higher weighted incremental costs and benefits per square foot, while climate zones dominated by lower-window-to-wall-ratio prototypes may show lower weighted values. Variation across climate zones therefore reflects differences in prototype composition, not differences in assumed measure costs by climate zone.

3.4.2 Fixed Windows—Energy and Energy Cost Savings Results

Energy savings and impacts for fixed window alterations are presented in Table 31 through Table 34 for the evaluated nonresidential building prototypes across California Climate Zones 1 through 5 and 10 through 16, which are the climate zones in which the measure was found to be cost-effective.

Although the overall savings patterns are directionally similar to those observed for new construction fixed windows, alteration results reflect distinct baseline conditions and

measure scope. Unlike the new construction measure, these results represent improvements relative to existing code requirements for altered fenestration and include a broader set of applicable climate zones. As a result, savings magnitudes and cost-effectiveness outcomes differ, even where the dominant physical driver—reduced conductive heat loss through lower-U-factor glazing—is similar.

As shown in Table 31, first-year electricity savings per square foot are generally small and vary by prototype and climate zone. Reported values range from small negative to small positive values, approximately -0.01 to 0.16 kWh/sf, with most results clustering near zero. Negative electricity savings occur in some prototypes and climate zones due to reduced solar gains or minor shifts in heating and cooling balance, while modest positive electricity savings appear in selected electrically heated or mixed-fuel cases. Peak demand impacts are negligible across all evaluated prototypes and climate zones, with modeled values effectively zero on a per-square-foot basis. As a result, the fixed window alterations measure should not be characterized as a peak demand reduction measure.

As with the new construction analysis, heating-related savings remain the dominant driver of impacts, though magnitudes for the alteration measure differ due to altered baseline assumptions and climate zone applicability. The proposed reduction in fixed-window U-factor lowers heating loads across most building types and applicable climate zones. For prototypes with natural gas heating systems, these reductions appear as natural gas savings, ranging from **small negative values to approximately 1.06 kBtu/sf**, with the largest savings occurring in colder or more heating-intensive cases such as schools, offices, assembly buildings, and restaurants, as shown in Table 32. Prototypes without substantial heating loads, or those without gas heating in the prototype, show limited or no natural gas savings.

Source energy results generally mirror the natural gas trends and are positive in most cases, as shown in Table 33. First-year source energy savings range from small negative values in a limited number of cases up to approximately 0.95 kBtu/sf, with the largest reductions occurring in heating-dominated prototypes and colder climate zones. Most prototypes show favorable source energy impacts, while the small negative values reflect cases where minor electricity increases outweigh limited heating savings. Overall, source energy impacts remain modest but positive across the large majority of modeled scenarios.

Table 34 presents total long-term system cost (LSC) savings over a 30-year period, expressed in 2029 present value dollars per square foot. LSC results are predominantly positive and range from small negative values in a limited number of prototype and climate zone combinations (approximately -$0.09/sf) up to approximately $1.46/sf. Heating-intensive building types, such as schools, offices, hospitals, assembly buildings, and restaurants, show the most consistent lifecycle benefits. Although some

prototypes show negative LSC values in selected climate zones, the majority of results remain positive, indicating that the fixed window alterations measure provides favorable long-term value for the majority of modeled alteration scenarios.

Table 31: First-Year Electricity Savings (kWh) Per Square Foot—Fixed Window Alterations

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.00	0.00	0.10	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.01	-0.01
Hospital	0.00	0.00	0.06	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Laboratory	0.03	0.03	0.11	0.03	0.11	0.03	0.04	0.02	0.03	0.01	0.01	0.02
Large Office	0.00	0.01	0.07	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Large Retail	0.00	0.00	0.02	0.00	0.03	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00
Large School	0.01	0.00	0.04	0.01	0.06	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Medium Office	0.03	0.02	0.14	0.02	0.16	0.00	0.02	0.02	0.01	0.02	0.01	0.07
Medium Retail	0.00	0.00	0.01	0.00	0.03	0.03	-0.01	-0.01	0.00	0.03	0.01	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.00	0.00	0.05	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Small Office	0.01	0.00	0.07	0.00	0.07	0.00	0.01	0.00	0.00	0.01	0.01	0.00
Small School	0.02	0.02	0.09	0.01	0.11	0.00	0.03	0.02	0.01	0.02	0.02	0.01
Strip Mall	0.00	0.01	0.02	0.01	0.04	0.00	0.01	0.01	0.01	0.01	0.00	-0.01

Table 32: First-Year Natural Gas Savings (kBtu) Per Square Foot—Fixed Window Alterations

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.34	0.27	0.05	0.24	0.00	0.09	0.27	0.22	0.16	0.26	0.07	0.51
Hospital	0.12	0.11	0.94	0.10	1.06	0.06	0.11	0.10	0.08	0.09	0.06	0.15
Laboratory	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.15
Large Office	0.22	0.17	0.33	0.16	0.33	0.08	0.16	0.14	0.10	0.17	0.06	0.31
Large Retail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Large School	0.31	0.24	-0.13	0.21	-0.20	0.11	0.22	0.20	0.15	0.21	0.07	0.40
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium Retail	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Non-refrigerated Warehouse	0.01	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.28	0.20	-0.26	0.17	-0.33	0.06	0.19	0.16	0.10	0.17	0.03	0.42
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27
Small School	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Strip Mall	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20

Table 33: First-Year Source Energy Savings (kBtu) Per Square Foot—Fixed Window Alterations

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.31	0.25	0.11	0.23	0.06	0.09	0.26	0.21	0.15	0.25	0.07	0.47
Hospital	0.10	0.10	0.84	0.09	0.95	0.05	0.09	0.08	0.07	0.08	0.06	0.13
Laboratory	0.13	0.11	0.13	0.10	0.10	0.10	0.20	0.08	0.15	-0.02	0.08	0.15
Large Office	0.19	0.15	0.32	0.14	0.33	0.07	0.15	0.13	0.09	0.15	0.06	0.27
Large Retail	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.07
Large School	0.29	0.23	-0.07	0.21	-0.13	0.10	0.21	0.19	0.15	0.21	0.07	0.38
Medium Office	0.13	0.11	0.15	0.11	0.15	0.03	0.10	0.09	0.07	0.11	0.04	0.19
Medium Retail	0.04	0.01	0.00	0.01	0.00	0.04	-0.01	-0.01	0.01	0.02	0.00	0.09
Non-refrigerated Warehouse	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.24	0.17	-0.18	0.14	-0.25	0.05	0.16	0.14	0.09	0.15	0.03	0.36
Small Office	0.03	0.04	0.05	0.03	0.04	0.01	0.04	0.03	0.03	0.05	0.02	0.25
Small School	0.14	0.07	0.05	0.07	0.04	0.03	0.08	0.07	0.06	0.11	0.05	0.53
Strip Mall	0.08	0.02	-0.02	0.02	-0.02	0.00	0.02	0.02	0.01	0.02	-0.02	0.18

Table 34: Total 30-Year LSC Savings (2029 PV$) Per Square Foot—Fixed Window Alterations

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.32	0.25	0.73	0.25	0.86	0.10	0.33	0.27	0.21	0.29	0.21	0.47
Hospital	0.08	0.09	1.23	0.09	1.46	0.06	0.11	0.09	0.09	0.09	0.09	0.13
Laboratory	0.38	0.40	0.85	0.35	0.69	0.26	0.75	0.27	0.68	-0.12	0.17	0.25
Large Office	0.17	0.13	0.77	0.13	0.87	0.06	0.15	0.12	0.11	0.16	0.13	0.27
Large Retail	0.02	0.03	0.12	0.03	0.18	0.04	-0.03	0.00	-0.04	0.01	0.11	0.04
Large School	0.33	0.26	0.22	0.26	0.23	0.13	0.29	0.23	0.21	0.28	0.16	0.47
Medium Office	0.43	0.30	1.05	0.29	1.17	0.04	0.28	0.23	0.18	0.26	0.16	0.61
Medium Retail	0.05	0.03	0.06	0.00	0.17	0.32	-0.09	-0.06	-0.01	0.23	0.08	0.08
Non-refrigerated Warehouse	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01
Restaurant	0.25	0.16	0.17	0.15	0.19	0.04	0.18	0.14	0.13	0.16	0.11	0.36
Small Office	0.09	0.08	0.47	0.07	0.51	0.01	0.10	0.05	0.08	0.12	0.11	0.30
Small School	0.28	0.24	0.62	0.19	0.73	0.03	0.28	0.20	0.17	0.28	0.27	0.67
Strip Mall	0.10	0.07	0.01	0.10	0.20	0.02	0.14	0.08	0.09	0.07	-0.06	0.13

3.4.3 Operable Windows—Energy and Energy Cost Savings Results

Energy savings and impacts for operable window alterations were evaluated for the applicable California climate zones using the nonresidential prototype buildings. Although several individual prototypes demonstrated positive energy and lifecycle cost savings, the weighted statewide cost-effectiveness analysis indicated that the measure is not cost effective in any climate zone after applying the revised fenestration subtype weighting methodology.

The weighting methodology reflects the estimated prevalence of operable windows across building types and places greater emphasis on prototypes with higher assumed operable window shares. As a result, no changes to the existing operable window alteration requirements are proposed for the 2028 Energy Code.

Because the measure is not proposed for adoption, there are no statewide savings, lifecycle cost, or greenhouse gas reductions.

3.4.4 Storefront—Energy and Energy Cost Savings Results

Energy savings and impacts for storefront window alterations are presented in Table 35 through Table 38 for the evaluated nonresidential building prototypes across all California climate zones.

As shown in Table 35, first-year electricity savings per square foot are generally positive across most prototypes and climate zones, reflecting the combined impact of reduced U-factor and lower SHGC values. Electricity savings generally range from approximately -0.02 to 0.23 kWh/sf, with the largest savings observed in medium office, assembly, and school prototypes. These savings are driven primarily by reduced solar heat gains, which lower cooling energy use across a wide range of building types and climate conditions. Peak demand impacts are negligible across all evaluated prototypes and climate zones, with modeled values effectively zero on a per-square-foot basis. As a result, the storefront alterations measure should not be characterized as a peak demand reduction measure.

Heating-related impacts vary by prototype and climate zone. As shown in Table 36, natural gas savings range from negative values of approximately -0.73 kBtu/sf to positive values exceeding 1.3 kBtu/sf. Positive heating savings are observed in building types such as hospitals and some office prototypes, while negative heating impacts occur in others, including assembly, schools, and restaurants in several climate zones. These negative values reflect increased heating energy use resulting from reduced solar heat gains associated with lower SHGC values. Prototypes without significant heating loads or without gas heating systems show limited or no natural gas impacts.

Source energy results reflect the combined effects of reduced cooling loads and, in some cases, increased heating loads. As shown in Table 37, first-year source energy savings range from approximately -0.58 to 1.22 kBtu/sf. Positive source energy savings are observed in many prototypes, particularly hospitals, offices, and schools, while negative impacts occur in selected building types and climate zones where increased heating energy outweighs cooling savings. Overall, source energy impacts are mixed but generally favorable across a majority of prototypes, with stronger benefits in cooling-dominated or mixed climates.

Table 38 presents total long-term system cost (LSC) savings over a 30-year period, expressed in 2029 present value dollars per square foot. LSC results are strongly positive across most prototypes and climate zones, ranging from approximately -$0.31/sf in limited cases up to approximately $1.98/sf. The largest lifecycle benefits are observed in hospitals, medium office, and school prototypes, where the combination of cooling energy savings and overall energy reductions provides substantial long-term value. Some negative LSC values occur in specific prototypes and climate zones where increased heating energy offsets cooling benefits; however, these cases are limited in scope. Overall, the storefront alterations measure demonstrates strong cost-effectiveness across a wide range of building types and all climate zones.

Table 35: First-Year Electricity Savings (kWh) Per Square Foot—Storefront Window Alterations

Prototype	CZ 3	CZ 4	CZ 5	CZ 6	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.16	0.06	0.19	0.07	0.08	0.08	0.09	0.09	0.08	0.10	0.09	0.16	-0.01
Hospital	0.10	0.04	0.12	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.06	0.00
Laboratory	0.13	0.09	0.14	0.08	0.14	0.11	0.12	0.06	-0.02	0.08	0.12	0.17	0.11
Large Office	0.12	0.05	0.14	0.06	0.06	0.05	0.06	0.05	0.05	0.04	0.04	0.06	0.00
Large Retail	0.02	0.01	0.04	0.02	0.02	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.00
Large School	0.02	0.05	0.03	0.04	0.06	0.06	0.07	0.06	0.05	0.07	0.06	0.10	0.01
Medium Office	0.18	0.09	0.23	0.10	0.12	0.11	0.12	0.09	0.09	0.09	0.08	0.13	0.07
Medium Retail	0.02	0.01	0.04	0.04	-0.02	0.00	0.02	-0.01	-0.02	0.01	0.02	0.02	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.08	0.05	0.10	0.05	0.07	0.07	0.07	0.06	0.05	0.07	0.07	0.12	0.00
Small Office	0.10	0.05	0.10	0.05	0.06	0.06	0.06	0.05	0.05	0.06	0.05	0.10	0.00
Small School	0.12	0.07	0.15	0.07	0.11	0.11	0.11	0.10	0.08	0.12	0.09	0.21	0.01
Strip Mall	0.03	0.02	0.05	0.02	0.04	0.03	0.04	0.01	0.01	0.05	0.03	0.03	-0.01

Table 36: First-Year Natural Gas Savings (kBtu) Per Square Foot—Storefront Window Alterations

Prototype	CZ 3	CZ 4	CZ 5	CZ 6	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	-0.33	-0.25	-0.36	-0.18	-0.35	-0.23	-0.19	-0.17	-0.18	-0.16	-0.26	-0.20	0.51
Hospital	1.15	0.56	1.36	0.39	0.53	0.57	0.59	0.56	0.52	0.58	0.61	0.70	0.15
Laboratory	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.19	0.15
Large Office	0.23	0.05	0.23	0.03	0.03	0.03	0.03	0.08	0.06	0.04	0.06	0.03	0.31
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Large School	0.27	-0.24	0.21	-0.24	-0.19	-0.18	-0.18	-0.15	-0.21	-0.17	-0.21	-0.11	0.41
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Non-refrigerated Warehouse	-0.01	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	-0.65	-0.26	-0.73	-0.15	-0.13	-0.14	-0.14	-0.16	-0.21	-0.16	-0.25	-0.07	0.42
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20

Table 37: First-Year Source Energy Savings (kBtu) Per Square Foot—Storefront Window Alterations

Prototype	CZ 3	CZ 4	CZ 5	CZ 6	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	-0.20	-0.18	-0.23	-0.12	-0.27	-0.15	-0.13	-0.10	-0.11	-0.08	-0.18	-0.07	0.47
Hospital	1.04	0.50	1.22	0.35	0.48	0.51	0.52	0.50	0.47	0.53	0.54	0.63	0.13
Laboratory	0.08	0.11	0.04	0.05	0.09	0.04	0.06	-0.05	-0.04	0.06	0.02	-0.06	0.31
Large Office	0.26	0.07	0.26	0.05	0.05	0.06	0.06	0.09	0.07	0.06	0.08	0.06	0.27
Large Retail	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.07
Large School	0.28	-0.19	0.22	-0.20	-0.14	-0.13	-0.13	-0.11	-0.16	-0.11	-0.16	-0.04	0.38
Medium Office	0.10	0.04	0.10	0.04	0.05	0.05	0.05	0.07	0.05	0.05	0.04	0.09	0.19
Medium Retail	-0.01	0.00	-0.01	0.02	-0.04	-0.01	0.01	-0.06	-0.02	-0.01	-0.05	0.00	0.09
Non-refrigerated Warehouse	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
Restaurant	-0.50	-0.19	-0.58	-0.09	-0.05	-0.07	-0.06	-0.09	-0.14	-0.08	-0.17	0.03	0.36
Small Office	0.05	0.01	0.03	0.04	0.03	0.03	0.03	0.03	0.02	0.04	0.01	0.08	0.33
Small School	0.00	0.00	-0.01	0.01	0.04	0.04	0.06	0.04	0.02	0.06	0.01	0.18	0.53
Strip Mall	-0.04	-0.03	-0.05	-0.01	0.00	-0.02	0.03	0.01	-0.02	0.00	-0.03	0.01	0.18

Table 38: Total 30-Year LSC Savings (2029 PV$) Per Square Foot—Storefront Window Alterations

Prototype	CZ 3	CZ 4	CZ 5	CZ 6	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Assembly	0.76	0.24	1.06	0.29	0.23	0.41	0.46	0.57	0.52	0.60	0.39	1.04	0.47
Hospital	1.63	0.74	1.98	0.63	0.79	0.85	0.83	0.75	0.75	0.81	0.76	0.98	0.13
Laboratory	0.93	0.82	0.81	0.51	1.08	0.75	0.88	0.19	-0.08	0.67	0.79	1.05	1.29
Large Office	0.97	0.37	1.14	0.38	0.42	0.41	0.43	0.40	0.38	0.32	0.30	0.47	0.27
Large Retail	0.11	0.09	0.28	0.11	0.18	0.02	0.08	0.07	0.10	0.02	0.05	0.17	0.05
Large School	0.44	0.09	0.40	0.02	0.23	0.25	0.26	0.25	0.14	0.31	0.18	0.61	0.47
Medium Office	1.20	0.61	1.48	0.62	0.78	0.73	0.77	0.67	0.63	0.67	0.55	0.95	0.60
Medium Retail	0.09	0.10	0.29	0.24	-0.18	-0.02	0.17	-0.31	-0.22	0.08	-0.06	0.16	0.08
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.01	0.00	-0.02	0.01	-0.01	0.00
Restaurant	0.05	0.17	0.12	0.25	0.43	0.43	0.44	0.36	0.25	0.43	0.28	0.80	0.36
Small Office	0.63	0.32	0.70	0.35	0.42	0.45	0.44	0.39	0.36	0.46	0.34	0.76	0.38
Small School	0.69	0.44	0.91	0.45	0.78	0.82	0.83	0.71	0.57	0.85	0.63	1.68	0.66
Strip Mall	0.08	0.10	0.25	0.06	0.20	0.13	0.26	0.17	0.05	0.30	0.11	0.29	0.13

3.4.5 Glazed Doors—Energy and Energy Cost Savings Results

Energy savings and impacts for glazed door alterations are presented in Table 39 for the evaluated nonresidential building prototypes across California Climate Zones 3 and 5, as these were the only two climate zones where the proposed U and SHGC factors were cost effective.

The first-year electricity savings per square foot are small but variable, ranging from approximately -0.11 to 0.12 kWh/sf depending on prototype and climate zone. Many prototypes exhibit modest positive electricity savings, particularly in assembly, office, and retail buildings, while some building types, including small offices and schools, show negative electricity savings. These results reflect changes in solar gains and thermal performance associated with glazed door systems and their interaction with building heating and cooling loads. Peak demand impacts are negligible across all evaluated prototypes and climate zones, with modeled values effectively zero on a per-square-foot basis. As a result, the glazed door alterations measure should not be characterized as a peak demand reduction measure. Heating-related impacts are mixed and vary by building type. Natural gas savings range from approximately -0.43 to 0.98 kBtu/sf. Positive heating savings are observed in building types such as hospitals, large schools, and large offices, while negative impacts occur in others, including assembly buildings and restaurants. These negative values indicate cases where reductions in solar heat gain lead to increased heating energy use. Prototypes without significant heating loads or without gas heating systems show limited or no natural gas impacts.

Source energy results reflect this variability. First-year source energy savings range from approximately -0.38 to 0.87 kBtu/sf, with positive impacts observed in heating-dominated building types such as hospitals and large schools, and negative impacts observed in building types such as restaurants, small offices, and some retail cases. Overall, source energy impacts are modest and vary by prototype, with both positive and negative results depending on building characteristics and system interactions.

The total long-term system cost (LSC) savings over a 30-year period, expressed in 2029 present value dollars per square foot. LSC results range from approximately -$0.68/sf to $1.26/sf and vary significantly by prototype and climate zone. Strong positive lifecycle savings are observed in building types such as hospitals, assembly buildings, and large offices, while negative lifecycle outcomes are observed in small offices, small schools, and restaurants. These results indicate that the cost-effectiveness of glazed door alterations is highly dependent on building type and usage patterns.

Table 39: First-Year Energy Savings and 30-Year Energy Cost Savings – Glazed Doors Alterations

Prototype	First-Year Electricity Savings (kWh/ft^2)		First-Year Natural Gas Savings (kBtu/ft^2)		First-Year Source Energy Savings (kBtu/ft^2)		Total 30-Year LSC Savings (2029 PV$/ft^2)	
Climate Zone	Climate Zone 3	Climate Zone 5	Climate Zone 3	Climate Zone 5	Climate Zone 3	Climate Zone 5	Climate Zone 3	Climate Zone 5
Assembly	0.10	0.12	-0.14	-0.17	-0.08	-0.11	0.52	0.69
Hospital	0.05	0.06	0.86	0.98	0.76	0.87	1.03	1.26
Laboratory	-0.04	-0.05	0.00	0.00	0.02	-0.03	-0.15	-0.42
Large Office	0.02	0.03	0.20	0.21	0.18	0.18	0.31	0.40
Large Retail	0.01	0.03	0.00	0.00	0.00	0.00	0.07	0.17
Large School	-0.06	-0.07	0.65	0.62	0.56	0.53	0.19	0.13
Medium Office	0.04	0.06	0.00	0.00	0.04	0.04	0.29	0.43
Medium Retail	0.01	0.03	0.00	0.00	-0.01	0.00	0.04	0.22
Non-refrigerated Warehouse	0.00	0.00	0.00	-0.01	0.00	-0.01	-0.02	-0.02
Restaurant	0.01	0.03	-0.36	-0.43	-0.31	-0.38	-0.22	-0.19
Small Office	-0.11	-0.11	0.00	0.00	-0.04	-0.06	-0.67	-0.68
Small School	-0.06	-0.04	0.00	0.00	-0.05	-0.06	-0.41	-0.28
Strip Mall	0.02	0.04	0.00	0.00	-0.03	-0.03	0.06	0.19

3.4.6 Orientation Sensitivity Analysis

To better understand the impact of partial façade upgrades, the Statewide CASE Team conducted a façade orientation sensitivity analysis using the Large Office prototype, since it has the highest window-to-wall ratio among the commercial prototypes and is therefore expected to show the largest impacts from fenestration upgrades. This analysis evaluates the energy impacts of replacing fenestration on a single façade (north, south, east, or west) while the remaining façades remain unchanged.

Although the primary analysis assumes full building fenestration replacement by type, this sensitivity analysis reflects a common real-world alterations scenario in which only a portion of the building envelope is upgraded. The analysis is intended to provide context on how energy impacts vary with façade orientation and solar exposure.

Table 40 presents total energy savings, expressed as percent reduction relative to baseline conditions, for each orientation across California climate zones.

Table 40: Orientation Sensitivity Analysis—Total Energy Savings (%) by Climate Zone (Large Office Prototype)

Climate Zone	North (0°)	East (90°)	South (180°)	West (270°)
CZ01	1.01%	0.83%	0.52%	0.82%
CZ02	1.20%	1.11%	1.01%	1.36%
CZ03	1.68%	1.51%	1.40%	1.78%
CZ04	1.15%	0.96%	1.01%	1.34%
CZ05	1.70%	1.63%	1.51%	1.88%
CZ06	0.69%	0.68%	0.80%	0.78%
CZ07	0.64%	0.63%	0.72%	0.81%
CZ08	0.69%	0.61%	0.79%	0.82%
CZ09	0.73%	0.55%	0.78%	0.86%
CZ10	0.74%	0.61%	0.83%	0.88%
CZ11	1.12%	0.74%	0.86%	0.97%
CZ12	1.02%	0.67%	0.80%	1.01%
CZ13	0.84%	0.43%	0.65%	0.75%
CZ14	1.12%	0.71%	0.74%	1.09%
CZ15	0.71%	0.45%	0.78%	0.62%
CZ16	1.31%	0.74%	0.51%	1.02%
Average	1.02%	0.80%	0.86%	1.05%

Results indicate that total energy savings are relatively consistent across orientations, generally ranging from approximately 0.5 to 1.9 percent depending on climate zone. While west-facing façades tend to exhibit slightly higher savings in some climate zones due to increased solar exposure, differences across orientations are small overall and do not significantly alter the magnitude of savings.

Across all orientations, energy savings are driven primarily by reductions in space heating energy use resulting from improved fenestration thermal performance (lower U-factor). As a result, even north-facing façades, which receive minimal direct solar radiation, demonstrate meaningful energy savings due to reduced conductive heat loss through the building envelope.

These results show that energy savings are relatively consistent across orientations and follow similar trends to the full-building alterations results. This indicates that partial façade upgrades can still deliver meaningful energy savings in a typical retrofit scenario.

3.4.7 Incremental First Cost

Incremental first costs or incremental costs reflect the difference in material and labor costs of installing window units with properties meeting the proposed measure as compared to those with properties meeting existing code requirements.

The Statewide CASE Team conducted interviews and surveys with manufacturers, trade associations, builders, national laboratories, and other stakeholders to estimate incremental costs associated with improved fenestration performance. Based on these discussions and available industry data, the Statewide CASE Team developed separate incremental cost assumptions by fenestration type.

Most labor costs associated with window installation will remain unchanged from the current requirements of the code. One possible impact raised by stakeholders is the additional weight and associated costs if triple-paned windows start to displace double-paned windows, but this proposal does not require heavier triple-paned windows. The Statewide CASE Team does not anticipate any increase in labor for the windows with U-factors proposed in this measure, as these U-factors can be readily achieved with one additional efficiency feature such as an improved thermal break, nonmetal pressure plate, argon gas-fill, second low-e coating, or warm edge spacer.

Incremental costs are assumed to be $0.58 per square foot of window for fixed windows, $0.90 per square foot of window for operable windows and glazed doors, and $1.25 per square foot of window for curtain wall or storefront systems. (Incremental costs obtained in March 2026.)

These cost differences reflect variation in system complexity, framing requirements, and glazing performance characteristics across fenestration types. Storefront systems have

the highest incremental cost due to more complex framing assemblies and larger glazed areas, while fixed windows have the lowest incremental cost due to simpler construction. Operable windows and glazed doors fall between these two cases.

Table 41 through Table 43 present the resulting incremental costs normalized to building floor area for each prototype. These values are derived by applying the incremental cost per square foot of window area to the total fenestration area in each prototype and dividing by total building floor area.

Across the evaluated prototypes, incremental costs per square foot of building area vary depending on fenestration area and building type. Incremental costs scale with fenestration area, resulting in higher per-square-foot building costs for prototypes with larger window-to-wall ratios. Fixed window alterations (Table 41) generally result in costs ranging from approximately $0.00 to $0.12/sf. Operable window and glazed door alterations (Table 42) result in moderately higher costs, typically ranging from approximately $0.00 to $0.18/sf. Storefront alterations (Table 43) have the highest costs, ranging from approximately $0.00 to $0.25/sf, with the largest values observed in building types with higher glazing ratios, such as assembly and school prototypes.

These incremental cost values are used in the cost-effectiveness analysis presented in Section 3.4.8.

3.4.8 Incremental Maintenance and Replacement Costs

In general, fenestration is only replaced on an as-needed basis, like in the case of accidental damage. Maintenance and replacement are typically associated with moisture-related damage for condensation issues in the frame assembly.

Items requiring maintenance include inspections for adjacent building elements that provide water drainage at the building such as window head flashing, roof drains, scuppers, transition flashing, and gutters. Sealant joints are typically employed to transition between different cladding and fenestration types within the building envelope. These sealant joints are often a critical component in the durability of a building envelope and also merit annual inspection. While regular inspections are best practice for the opaque envelope, it is also true that the vast majority of building owners do not inspect their property to ensure drainage. In cases such as these, wholesale replacement of sections of vertical fenestration is often required. The timing, frequency, and magnitude of these costs are not quantified for this CASE Report.

If building drainage elements are inspected as noted above, the only common replacement cost for windows is exterior sealant joints exposed to the weather and solar UV radiation. The frequency of replacement would depend on the type of sealants used as some are more resistant to the elements than others, but for the purposes of this

report the Statewide CASE Team assumes a period of ten years between sealant joint replacement.

Incremental maintenance cost is the incremental cost of replacing windows, as well as periodic maintenance and repair required to keep windows operating relative to current practices over the 30-year period of analysis. The present value of window maintenance cost or savings was calculated using a three percent discount rate, which is consistent with the discount rate used when developing the 2028 LSC hourly factors.

Description of the incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report.

Table 41 Fixed Window Alterations—Cost per Square Foot of Building Area

Building Prototype	Net Window Area (sf)	Incremental Cost per Square Foot of Window	Total Cost	Building Area (sf)	Total Cost per Square Foot of Building Area ($/sf)
Large Office	48,134	$0.58	$27,918	498,589	$0.06
Medium Office	7,027	$0.58	$4,076	53,628	$0.08
Small Office	642	$0.58	$372	5,502	$0.07
Large Retail	5,881	$0.58	$3,411	240,000	$0.01
Large School	22,162	$0.58	$12,854	210,866	$0.06
Small School	4,964	$0.58	$2,879	24,413	$0.12
Assembly	60,207	$0.58	$34,920	315,339	$0.11
Hospital	9,133	$0.58	$5,297	249,985	$0.02
Laboratory	7,027	$0.58	$4,076	53,628	$0.08
Small Restaurant	280	$0.58	$162	2,501	$0.06
Medium Retail	904	$0.58	$524	24,563	$0.02
Retail Strip Mall	558	$0.58	$324	9,375	$0.03
Warehouse	190	$0.58	$110	52,050	$0.00

Table 42 Operable Windows and Glazed Door Alterations—Cost per Square Foot of Building Area

Building Prototype	Net Window Area (sf)	Incremental Cost per Square Foot of Window	Total Cost	Building Area (sf)	Total Cost per Square Foot of Building Area ($/sf)
Large Office	48,134	$0.90	$43,321	498,589	$0.09
Medium Office	7,027	$0.90	$6,324	53,628	$0.12
Small Office	642	$0.90	$578	5,502	$0.11
Large Retail	5,881	$0.90	$5,293	240,000	$0.02
Large School	22,162	$0.90	$19,946	210,866	$0.09
Small School	4,964	$0.90	$4,468	24,413	$0.18
Assembly	60,207	$0.90	$54,186	315,339	$0.17
Hospital	9,133	$0.90	$8,220	249,985	$0.03
Laboratory	7,027	$0.90	$6,324	53,628	$0.12
Small Restaurant	280	$0.90	$252	2,501	$0.10
Medium Retail	904	$0.90	$814	24,563	$0.03
Retail Strip Mall	558	$0.90	$502	9,375	$0.05
Warehouse	190	$0.90	$171	52,050	$0.00

Table 43 Curtain Wall or Storefront Alterations—Cost per Square Foot of Building Area

Building Prototype	Net Window Area (sf)	Incremental Cost per Square Foot of Window	Total Cost	Building Area (sf)	Total Cost per Square Foot of Building Area ($/sf)
Large Office	48,134	$1.25	$60,168	498,589	$0.12
Medium Office	7,027	$1.25	$8,784	53,628	$0.16
Small Office	642	$1.25	$803	5,502	$0.15
Large Retail	5,881	$1.25	$7,351	240,000	$0.03
Large School	22,162	$1.25	$27,703	210,866	$0.13
Small School	4,964	$1.25	$6,205	24,413	$0.25
Assembly	60,207	$1.25	$75,259	315,339	$0.24
Hospital	9,133	$1.25	$11,416	249,985	$0.05
Laboratory	7,027	$1.25	$8,784	53,628	$0.16
Small Restaurant	280	$1.25	$350	2,501	$0.14
Medium Retail	904	$1.25	$1,130	24,563	$0.05
Retail Strip Mall	558	$1.25	$698	9,375	$0.07
Warehouse	190	$1.25	$238	52,050	$0.00

3.4.9 Cost Effectiveness

Results of the per-unit cost-effectiveness analyses for window alterations are presented in Table 44 through Table 47. Results are shown separately by fenestration type to reflect differences in performance, applicable climate zones, and incremental cost assumptions.

Across the evaluated fenestration types, cost-effectiveness varies by fenestration type and climate zone. The tables below include results for all climate zones for completeness, including climate zones with benefit-to-cost ratios (BCR) below 1.0 that are not included in the proposed code changes. For clarity, the Statewide CASE Team has included the results for all climate zones, including those for which the proposed changes are not cost-effective (BCR<1.0). The code change proposal does not include those climate zones. Cost-effectiveness is driven primarily by reductions in heating and, in some cases, cooling energy use, with variation across building types and climate zones.

As shown in Table 44, fixed window alterations are consistently cost-effective across all applicable climate zones, with BCR values ranging from approximately 1.35 to 10.98 in the climate zones included in the proposed code change. The highest cost-effectiveness is observed in colder climate zones, particularly Climate Zones 3 and 16, where heating energy savings are greatest. Even in milder climates, fixed window alterations remain cost-effective due to relatively low incremental costs and consistent energy savings.

Table 45 shows that operable window alterations are not cost effective in any evaluated climate zone. Benefit-to-cost ratios are below 1.0 across all climate zones and are negative in most cases, indicating that lifecycle costs exceed projected benefits. As a result, operable window alterations are not included in the proposed code changes.

Storefront (curtain wall) alterations demonstrate the strongest cost-effectiveness among the fenestration types, as shown in Table 46. BCR values range from approximately 1.31 to 4.19 across the climate zones included in the proposed code change. The highest BCR values are observed in Climate Zones 3, 5, and 15, where large reductions in solar heat gain and cooling energy use drive substantial lifecycle savings. Despite higher incremental costs relative to other fenestration types, the magnitude of energy savings, particularly electricity savings, results in strong overall cost-effectiveness across all climate zones.

As shown in Table 47, glazed door alterations are cost effective in Climate Zones 3 and 5, with BCR values of approximately 2.19 to 2.61. Results for other climate zones are included for completeness but have BCR values below 1.0 and are not reflected in the proposed code changes. These results closely align with those observed for operable windows due to similar performance characteristics and incremental cost assumptions.

Overall, the results indicate that the proposed window alteration measures provide cost-effective energy savings in the climate zones included in the proposal. Fixed window alterations demonstrate strong and consistent cost-effectiveness across the applicable climate zones, while storefront and curtain wall alterations provide favorable cost-effectiveness in the climate zones where they are proposed. Glazed door alterations are also cost effective in the applicable climate zones, whereas operable window alterations were not found to be cost effective and are therefore not included in the proposal.

Table 44: 30-Year Cost-Effectiveness Summary Per Square Foot—Fixed Window Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	$0.19	$0.06	3.23
2	$0.16	$0.06	2.65
3	$0.57	$0.05	10.82
4	$0.16	$0.05	3.11
5	$0.62	$0.06	10.98
6	$0.03	$0.05	0.53
7	$0.00	$0.06	0.00
8	$0.04	$0.05	0.85
9	$0.05	$0.05	0.95
10	$0.07	$0.05	1.35
11	$0.14	$0.04	3.11
12	$0.11	$0.05	2.10
13	$0.11	$0.05	2.17
14	$0.13	$0.05	2.64
15	$0.10	$0.04	2.28
16	$0.24	$0.05	4.91

Table 45: 30-Year Cost-Effectiveness Summary Per Square Foot—Operable Window Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	-$0.53	$0.09	-5.82
2	-$0.75	$0.10	-7.80
3	-$0.03	$0.08	-0.40
4	-$0.71	$0.08	-9.14
5	-$0.07	$0.09	-0.77
6	-$0.71	$0.08	-9.04
7	-$0.76	$0.09	-8.77
8	-$0.76	$0.08	-9.48
9	-$0.79	$0.08	-9.93
10	-$0.80	$0.08	-10.30
11	-$0.80	$0.07	-11.75
12	-$0.79	$0.08	-9.86
13	-$0.88	$0.08	-11.55
14	-$0.77	$0.08	-9.84
15	-$0.93	$0.07	-14.07
16	-$0.61	$0.08	-7.86

Table 46: 30-Year Cost-Effectiveness Summary Per Square Foot—Storefront and Curtain Wall Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	$0.12	$0.13	0.97
2	$0.09	$0.13	0.71
3	$0.33	$0.11	2.91
4	$0.20	$0.11	1.85
5	$0.46	$0.12	3.77
6	$0.19	$0.11	1.74
7	$0.10	$0.12	0.84
8	$0.24	$0.11	2.11
9	$0.21	$0.11	1.88
10	$0.28	$0.11	2.56
11	$0.18	$0.09	1.90
12	$0.14	$0.11	1.31
13	$0.26	$0.11	2.48
14	$0.15	$0.11	1.40
15	$0.38	$0.09	4.19
16	$0.18	$0.11	1.67

Table 47: 30-Year Cost-Effectiveness Summary Per Square Foot—Glazed Door Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$/square foot)	Costs Total Incremental PV Costs (2029 PV$/square foot)	Benefit-to-Cost Ratio
1	-$0.21	$0.09	-2.25
2	-$0.32	$0.10	-3.36
3	$0.18	$0.08	2.19
4	-$0.29	$0.08	-3.72
5	$0.23	$0.09	2.61
6	-$0.24	$0.08	-3.08
7	-$0.28	$0.09	-3.21
8	-$0.26	$0.08	-3.21
9	-$0.27	$0.08	-3.37
10	-$0.24	$0.08	-3.12
11	-$0.30	$0.07	-4.44
12	-$0.29	$0.08	-3.66
13	-$0.32	$0.08	-4.24
14	-$0.24	$0.08	-3.01
15	-$0.27	$0.07	-4.17
16	-$0.20	$0.08	-2.64

3.5 Vertical Fenestration Alterations—Statewide Impacts

3.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact. For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The alteration savings presented here are based on per-unit results that represent major fenestration replacement events—full replacement of the modeled vertical fenestration area—and a three percent annual replacement rate, consistent with an assumed 30-year fenestration life. The code trigger of 100 percent of a fenestration type (windows, curtain wall, storefront, or glazed doors) does not change this underlying representation of major replacement projects, but more clearly aligns the code trigger

with the modeled case in which an entire fenestration system is upgraded during an alteration project.

Statewide results are presented separately by fenestration type in Table 48 through, Table 50 with corresponding summary totals shown in Table 51. The statewide estimates reflect weighted allocations of affected floorspace across fixed windows, storefront and curtain wall systems, and glazed doors. Total statewide impacts represent the combined savings associated with the applicable fenestration types included in the proposal.

Fixed window alterations (Table 48) result in the largest statewide impacts among the evaluated alterations measures, including approximately 1.26 GWh of first-year electricity savings, 0.24 MW of peak demand reduction, and 0.05 million therms of natural gas savings. These impacts correspond to approximately 6.62 million kBtu of first-year source energy savings and $15.74 million in 30-year present-valued LSC savings. Savings are driven by a combination of reduced heating and cooling loads across a broad range of building types and climate zones.

Storefront and curtain wall alterations (Table 49) result in approximately 1.32 GWh of first-year electricity savings and 0.02 MW of peak demand reduction, with negligible natural gas savings. These impacts correspond to approximately 0.36 million kBtu of source energy savings and $8.67 million in 30-year present-valued LSC savings. Savings are driven primarily by reduced cooling energy use associated with reduced RSHGC and occur across a wide range of building types and climate zones where storefront and curtain wall systems are prevalent.

Glazed door alterations (Table 49) produce more modest statewide impacts due to their limited affected floorspace and applicability only in Climate Zones 3 and 5. First-year electricity savings total approximately 0.02 GWh, with negligible peak demand and natural gas impacts. These savings correspond to approximately 0.09 million kBtu of source energy savings and $0.23 million in 30-year present-valued LSC savings.

Table 48: Statewide Energy and LSC Impacts—Fixed Window Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2028 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	441,225	0.00	0.00	0.00	0.06	$0.08
2	2,805,041	0.02	0.01	0.00	0.25	$0.46
3	15,077,664	0.93	0.09	0.02	2.60	$8.54
4	7,970,040	0.04	0.03	0.01	0.77	$1.25
5	1,218,252	0.09	0.01	0.00	0.17	$0.76
10	15,999,636	0.05	0.02	0.00	0.56	$1.08
11	2,815,952	0.02	0.01	0.00	0.21	$0.38
12	15,270,231	0.04	0.04	0.01	1.15	$1.65
13	5,459,772	0.02	0.02	0.00	0.29	$0.58
14	3,579,500	0.02	0.01	0.00	0.28	$0.48
15	2,157,121	0.02	0.00	0.00	0.05	$0.21
16	1,100,829	0.01	0.00	0.00	0.22	$0.27
Total	73,895,263	1.26	0.24	0.05	6.62	$15.74

Table 49: Statewide Energy and LSC Impacts—Storefront and Curtain Wall Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2028(Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
3	4,184,280	0.22	0.00	0.00	0.10	$1.37
4	2,070,873	0.06	0.00	0.00	0.01	$0.41
5	398,414	0.03	0.00	0.00	0.00	$0.18
6	3,397,290	0.11	0.00	0.00	0.00	$0.65
8	4,851,390	0.18	0.00	0.00	0.01	$1.14
9	7,351,350	0.24	0.00	0.00	0.03	$1.53
10	5,342,130	0.22	0.01	0.00	0.10	$1.47
11	940,305	0.02	0.00	0.00	0.01	$0.17
12	4,666,470	0.10	0.00	0.00	0.00	$0.68
13	1,958,871	0.07	0.00	0.00	0.03	$0.51
14	1,181,147	0.04	0.00	0.00	-0.03	$0.18
15	750,321	0.03	0.00	0.00	0.03	$0.29
16	357,709	0.00	0.00	0.00	0.07	$0.06
Total	37,450,549	1.32	0.02	0.00	0.36	$8.67

Table 50: Statewide Energy and LSC Impacts—Glazed Door Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2028(Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
3	1,154,706	0.02	0.00	0.00	0.09	$0.21
5	121,664	0.00	0.00	0.00	0.01	$0.03
Total	1,276,370	0.02	0.00	0.00	0.09	$0.23

Table 51: Statewide Energy and LSC Impacts—Alterations

Measure	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
Fixed Window Alterations	1.26	0.24	0.05	6.62	15.74
Operable Window Alterations	0.00	0.00	0.00	0.00	0.00
Storefront and Curtain Wall Alterations	1.32	0.02	0.00	0.36	8.67
Glazed Door Alterations	0.02	0.00	0.00	0.09	0.23
Total	2.6	0.26	0.05	7.07	24.64

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Overall, these results indicate that the statewide GHG benefits of the alterations measures are driven primarily by fixed window replacements, which provide the largest reductions in both electricity and natural gas consumption. Storefront and curtain wall measures provide smaller but measurable emissions reductions through reduced electricity use, while glazed door measures contribute modest additional GHG benefits in the climate zones where they apply.

Table 52 presents the estimated first-year statewide reduction in greenhouse gas (GHG) emissions resulting from the proposed vertical fenestration alterations measures, disaggregated by fenestration type. The statewide estimates reflect the affected floorspace assumptions, fenestration subtype distributions, and climate zone applicability assumptions described in Appendix C. Results are presented separately by fenestration type to illustrate the relative contribution of each measure category to overall statewide GHG reductions. The total values shown in Overall, these results indicate that the statewide GHG benefits of the alterations measures are driven primarily by fixed window replacements, which provide the largest reductions in both electricity and natural gas consumption. Storefront and curtain wall measures provide smaller but measurable emissions reductions through reduced electricity use, while glazed door measures contribute modest additional GHG benefits in the climate zones where they apply.

Table 52 represent the combined statewide impacts across all applicable fenestration types included in the proposal.

Fixed window alterations result in approximately 386 metric tons of CO_2e emissions reductions in the first year of compliance, with an associated monetary value of approximately $47,543. These reductions include approximately 109 metric tons CO_2e associated with electricity savings and 277 metric tons CO_2e associated with natural gas savings. Fixed windows account for the majority of the statewide GHG reductions associated with the alterations measures.

Storefront and curtain wall alterations result in approximately 19 metric tons of CO_2e emissions reductions, corresponding to an estimated value of approximately $2,390. Most of these reductions are attributable to electricity savings (18 metric tons CO_2e), with a relatively small contribution from natural gas savings (1 metric ton CO_2e), reflecting the strong impact of reduced solar heat gain (lower SHGC) on cooling energy use.

Glazed door alterations result in approximately 6 metric tons of CO_2e emissions reductions, with an associated value of approximately $688. These reductions are driven primarily by natural gas savings (5 metric tons CO_2e), with negligible electricity-related emissions impacts.

GHG emissions reductions and their associated monetary value were calculated using hourly emissions factors published alongside the LSC and source energy hourly factors in the research versions of CBECC, in combination with data from the CEC's 2028 Metrics Report. Additional methodological details are provided in the 2028 CASE Methodology Report.

Overall, these results indicate that the statewide GHG benefits of the alterations measures are driven primarily by fixed window replacements, which provide the largest reductions in both electricity and natural gas consumption. Storefront and curtain wall measures provide smaller but measurable emissions reductions through reduced electricity use, while glazed door measures contribute modest additional GHG benefits in the climate zones where they apply.

Table 52: First-Year Statewide GHG Emissions Impacts—Alterations

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO_2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO_2e)	Total Reduced GHG Emissions (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions ($)
Fixed Windows	109	277	386	47,543
Operable Windows	0	0	0	0
Storefront and Curtain Wall Windows	18	1	19	2,390
Glazed Doors	0	5	6	688
Total	**127**	**283**	**411**	**50,621**

3.5.3 Statewide Water Use Impacts

The proposed code change will not result in water use impacts.

3.5.4 Statewide Material Impacts

The Statewide CASE Team expects little to no changes to material impacts because the proposed code change is only changing existing U-factors and SHGC values which should not necessarily translate to more or different materials being used.

For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

3.5.5 Environmental Impacts

This proposal would result in significant energy savings and GHG emissions reduction. This requirement ensures less thermal energy is exchanged through windows, increasing the heating and cooling efficiency within spaces.

There are no identified indirect adverse environmental impacts nor indirect environmental benefits from this code change proposal.

3.5.6 Other Non-Energy Impacts

Improved insulation from better performing windows would provide tighter building envelopes, thus improving occupant comfort by better regulating indoor temperature, reducing noise, and contributing to indoor air quality.

3.6 Vertical Fenestration Alterations—Proposed Code Language

3.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions). New to the 2028 energy code is to italicize defined terms when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included with greyed highlight and italics.

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation. New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, “Section 601.1 [Section 130.0(a)] General” contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from the requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

3.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

3.6.3 Reference Appendices

There are no proposed changes to the Reference Appendices.

3.6.4 Energy Code (Title 24, Part 6)

SECTION 301.5.2 *[Section 141.0(b)]* Alterations.

301.5.2.2.1 *[Section 141.0(b)2A]* Fenestration. For hotel/motel buildings and nonresidential buildings with Group R Occupancies and their common or public use areas, *fenestration ~~Fenestration~~ alterations* other than *repairs* shall meet the following requirements:

301.5.2.2.1.1. *Vertical fenestration alterations* shall meet the requirements in Table 301.5-A.1 *[Table 141.0-A].*

Exception to 301.5.2.2.1.1: In an *alteration,* where 150 square feet or less of the *entire building's vertical fenestration* is replaced, *RSHGC* and *VT* requirements of Table 301.5-A.1 *[Table141.0-A]* shall not apply.

301.5.2.2.1.2. Added *vertical fenestration* shall meet the requirements in Table 301.3-C.2, D or E in Section 301.3.9 9 *[Table 140.3-B, C or D].*

Exception to 301.5.2.2.1.2: In an *alteration*, where 50 square feet or less of *vertical fenestration* is added, *RSHGC* and *VT* requirements of Table 301.3-C.2, D or E in Section 301.3.9 *[Table 140.3-B, C or D]* shall not apply.

301.5.2.2.1.3. All altered or newly installed *skylights* shall meet the requirements of Table 301.3-C.2, D or E in Section 301.3.9 *[Table 140.3-B, C or D].*

Exception to 301.5.2.2.1.3. In an *alteration*, where 50 square feet or less of *skylight* is added, *SHGC* and *VT* requirements of Table 301.3-C.2, D or E in Section 301.3.9 *[Table 140.3-B, C or D]* shall not apply.

301.5.2.2.2 *[New Section].* Nonresidential Vertical Fenestration. For *nonresidential buildings* not including hotel/motel buildings and nonresidential buildings with California Building Code Group R Occupancies and their common or public use areas, *vertical fenestration alterations* other than *repairs* shall meet the following requirements:

301.5.2.2.2.1. *Vertical fenestration alterations* replacing one hundred percent of any single *fenestration* type (*windows, storefront, curtainwall*, *glazed doors)* shall meet the requirements of Sections 301.3.4.2 through 301.3.4.4 *[Sections 140.3(a)5B through 140.3(a)5D].*

301.5.2.2.2.2 All other *vertical fenestration alterations* shall meet the requirements in Table 301.5-A.2 *[New Table].*

Exception to Section 301.5.2.2.2.2: In an *alteration,* where 150 square feet or less of the *entire building's vertical fenestration* is replaced, *RSHGC* and *VT* requirements of Table 301.5-A.2 *[New Table]* shall not apply.

301.5.2.2.2.3. Added *vertical fenestration* shall meet the requirements of Table 301.3-C.3 *[New Table]* in Section 301.3.9.

Exception to Section 301.5.2.2.2.3: In an *alteration,* where 50 square feet or less of *vertical fenestration* is added, *RSHGC* and *VT* requirements of Table 301.3-C.3 *[New Table]* shall not apply.

301.5.2.2.2.4. All altered or newly installed *skylights* shall meet the requirements of Table 301.3-C.2, D or E in Section 301.3.9 *[Table 140.3-B, C or D]* **Exception to Section 301.5.2.2.2.4:** In an *alteration*, where 50 square feet or less of *skylight* is added, *SHGC* and *VT* requirements of Table 301.3-C.2, D or E in Section 301.3.9 *[Table 140.3-B, C or D]* shall not apply.

NOTE: Glass replaced in an existing sash and frame, or sashes replaced in an existing frame are considered *repairs*. In these cases, Section 100.4.4.1 *[Section 141.0(c)]* requires that the replacement be at least equivalent to the original in performance.

Table 301.5-A.1 *[Table 141.0-A]* Altered Vertical Fenestration Maximum U-Factor and Maximum RSHGC— Hotel/Motel Buildings and Nonresidential Buildings with Group R Occupancies

Requirement	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
U-factor	0.47	0.47	0.58	0.47	0.58	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
RSHGC	0.41	0.31	0.41	0.31	0.41	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.41

NOTE: The required values for *VT* are located in Table 301.3-C.2, D or E in Section 301.3.9 for all *Climate Zones*

Table 301.5-A.2 *[New Table]* Altered Vertical Fenestration Maximum U-Factor and Maximum RSHG— Nonresidential Buildings (Including Relocatable Public School Buildings Where Manufacturers Certify Use Only in Specific Climate Zone, Not Including Nonresidential Buildings with Group R Occupancies)

Requirement	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Fixed Window (Max U-factor)	0.43	0.43	0.43	0.43	0.43	0.47	0.47	0.47	0.47	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Fixed Window (Max RSHGC)	0.41	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.41
Fixed Window (Min VT)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Curtain Wall or Storefront (Max U-factor)	0.47	0.47	0.43	0.43	0.43	0.43	0.47	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Curtain Wall or Storefront (Max RSHGC)	0.41	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.41
Curtain Wall or Storefront (Min VT)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

Operable Window (Max U-factor)	0.47	0.47	0.58	0.47	0.58	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Operable Window (Max RSHGC)	0.41	0.31	0.41	0.31	0.41	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.41
Operable Window (Min VT)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Glazed Doors (Max U-factor)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Glazed Doors (Max RSHGC)	0.41	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.41
Glazed Doors (Min VT)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

3.6.5 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

3.6.6 ACM Reference Manual

The ACM Reference Manual will need to be modified to accommodate the new requirement when one hundred percent of any one type of vertical fenestration is replaced.

3.6.7 Compliance Forms

As discussed in Section 3.1.4.5, the nonresidential compliance forms will require changes to accommodate documentation of the one hundred percent replacement trigger, as well as the different scoping required by AB 130. Additionally, the schema logic supporting compliance within the prescriptive forms will need to be updated to reflect these reduced U-factor requirements.

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Appendix A: Assumptions for Cost-Effectiveness Analysis

Nonresidential Fenestration—New Construction

Assumptions for Energy Savings Analysis

Appendix AThe Statewide CASE Team simulated the energy impacts in all climate zones and applied the climate-zone LSC hourly factors when calculating energy and energy cost impacts.

Appendix BThe base case (standard design) used 2025 Title 24, Part 6 prescriptive fenestration U-factor and SHGC requirements (Table 301.3-C).

Appendix CThe proposed case applied more stringent U-factor values (0.34 for fixed windows in CZ 1, 2, 4 and 16; 0.43 for operable windows in CZ 1-5, 9, and 11-16). SHGC values were unchanged between base and proposed cases.

Appendix DPrototypes modeled were limited to high-WWR building types, chosen to maximize sensitivity to fenestration performance changes. This assumption makes results conservative for low-WWR buildings.

Appendix EFenestration assemblies were modeled as NFRC-rated, double-pane units consistent with typical market-available products. No specific technology or manufacturer was assumed.

Appendix FStakeholder engagement confirmed that the scope of the new construction measure is limited to U-factor tightening only, with SHGC values unchanged. Stakeholders reviewed and did not request revisions to these assumptions.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 53 lists the eight prototype buildings used in this analysis. These prototypes are drawn from existing CBECC prototype sets and reflect building characteristics typical of California's commercial building stock.

Energy savings were calculated by simulating each prototype under baseline (2025 Title 24, Part 6) prescriptive fenestration requirements and comparing results to the

proposed fenestration requirements for the 2028 code cycle. For new construction, this meant reducing U-factor values in all climate zones while holding SHGC constant. Simulations were run in CBECC 2025, with outputs converted to EnergyPlus and post-processed in MeasureSET to calculate electricity, natural gas, source energy, peak demand, and long-term-system costs impacts. High-WWR prototypes such as large office, hospital, and school buildings were included to ensure results captured the greatest sensitivity to fenestration performance.

Table 53: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Assembly	1	315,339	The main assembly prototype comprises five different assembly buildings, i.e., Dodge building types: Religious Worship, Sports & Recreation, Library, Exhibits & Events, and Transportation Terminals. The CBECC model is separated into individual building files before using the Standard Design. The CBECC Standard Design is modeled with SZVAVHP for Library, and all other assembly building types are modeled with SZVAVAC systems. Gas hot water system is used as the Standard Design SWH.
Hospital	5	241,501	5-story hospital plus basement. Source: DOE Standard 90.1 Hospital prototype and scorecard. The prototype contains Title 24, Part 6, minimally compliant envelope features and lighting. For HVAC systems, the AIA guidelines recommended using VAV systems wherever possible.
OfficeLarge	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%. Because CBECC will model single-zone heat pumps in the Large School prototype's Standard Design, results from measures applied to the prototype should be compared to the Proposed Design prototype model, not the Standard Design. For example, as with the Assembly prototype, if a U-factor measure is applied to the Large School windows, that measure should be applied to a copy of the original Proposed Design. The results from that analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
			should then be compared to the results of the original prototype's Proposed Design.
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%
OfficeSmall	1	5,502	1-story, 5-zone office building with pitched roof and unconditioned attic. WWR–24%
RetailLarge	1	240,000	Big-box type retail building with WWR–12% and SRR–0.82%
SchoolSmall	1	24,413	Elementary school with WWR–36%
SchoolLarge	2	210,866	High school with WWR–35% and SRR–1.4%
Warehouse	1	52,045	Single story high ceiling warehouse. Includes one office space. WWR–0.7% ,SRR–5%
RetailStripMall	1	9,375	Strip mall building with WWR–10%
RetailMedium	1	24,563	Similar to a Target or Walgreens, 7% WWR on the front façade, none on other sides. SRR–2.1%.
RestaurantFastFood	1	2,501	Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic.
OfficeMediumLab	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%

There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction and alterations, so the Standard Design is minimally compliant with the 2025 Title 24 requirements. For fenestration, this means meeting the prescriptive U-factor and SHGC values specified in Table 301.3-C of the standard. For this analysis, the Standard Design assumed a U-factor of 0.36 Btu/(h•ft²·•°F) for fixed windows and 0.46 Btu/(hr·ft²·°F) for operable windows. SHGC values were unchanged between Standard and Proposed Designs.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 54 presents the parameters modified and the values used in the Standard Design and Proposed Design. In all climate zones, the Proposed Design applied a U-factor of 0.34 for fixed windows, and 0.43 for operable windows, consistent across all prototypes.

Because SHGC requirements remain unchanged in the proposal, the measure is climate-dependent primarily in heating-dominated locations, where reductions in U-

factor yield measurable savings. For this reason, simulations were run only in CZ 1 (mild coastal) and CZ 16 (cold mountain), representing the edge cases of the potential statewide impact.

Table 54: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zones	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Hospital	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
OfficeMediumLab	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
OfficeLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
OfficeMedium	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
OfficeSmall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)

Prototype ID	Climate Zones	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
RestaurantFastFood	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
RetailLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
RetailMedium	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
RetailStripMall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
SchoolLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
SchoolSmall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)

Prototype ID	Climate Zones	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Warehouse	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)
Assembly	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-Factor	Fixed: 0.36 Btu/(h·ft²·°F) Operable: 0.46 Btu/(h·ft²·°F)	Fixed: 0.34 Btu/(h·ft²·°F) Operable: 0.43 Btu/(h·ft²·°F)

The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone LSC hourly factors when calculating energy and LSC impacts.

Nonresidential Fenestration—Alterations

Key Assumptions for Energy Savings Analysis

- The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone LSC hourly factors when calculating energy and energy cost impacts.
- The base case (Standard Design) was defined as minimally compliant with the 2025 Title 24, Part 6 prescriptive fenestration requirements (Table 301.5-A).
- The Proposed Design applied more stringent requirements for both U-factor and SHGC across all climate zones.
- Prototypes modeled were limited to eight high-WWR building types to capture the largest sensitivity to fenestration changes.
- Fenestration assemblies were modeled as NFRC-rated, double-pane systems representative of common market practice. No specific manufacturer or product technology was assumed.
- Stakeholder engagement confirmed that both U-factor and SHGC should be reduced in the alterations measure and that savings should be evaluated across

all 16 climate zones. Stakeholders reviewed these assumptions and agreed no additional revisions were necessary.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 55 resents the prototype buildings used in the analysis. These prototypes are consistent with those used for new construction but were simulated separately under alteration assumptions.

Energy savings were calculated by comparing results for the Standard Design (minimally compliant with 2025 Title 24, Part 6 fenestration U-factor and SHGC requirements) against the Proposed Design (more stringent U-factor and SHGC values across all climate zones). Prototypes were modeled in CBECC 2025 and EnergyPlus, with outputs processed in MeasureSET to calculate electricity, natural gas, source energy, peak demand, and long-term system cost impacts. Unlike the new construction analysis, which was limited to CZ 1 and 16, the alterations analysis evaluated all 16 climate zones to capture the full statewide impact of the proposed measure. High-WWR prototypes such as large office, hospital, and school buildings were included to ensure results captured the greatest sensitivity to fenestration performance.

Table 55: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Assembly	1	315,339	The main assembly prototype comprises five different assembly buildings, i.e., Dodge building types: Religious Worship, Sports & Recreation, Library, Exhibits & Events, and Transportation Terminals. The CBECC model is separated into individual building files before using Standard Design. The CBECC Standard Design is modeled with SZVAVHP for Library, and all other assembly building types are modeled with SZVAVAC systems. Gas hot water system is used as the Standard Design SWH.
Hospital	5	241,501	5-story hospital plus basement. Source: DOE Standard 90.1 Hospital prototype and scorecard. The prototype contains Title 24, Part 6, minimally compliant envelope features and lighting. For HVAC systems,

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
			the AIA guidelines recommended using VAV systems wherever possible.
OfficeLarge	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%. Because CBECC will model single-zone heat pumps in the Large School prototype's Standard Design, results from measures applied to the prototype should be compared to the Proposed Design prototype model, not the Standard Design. For example, as with the Assembly prototype, if a U-factor measure is applied to the Large School windows, that measure should be applied to a copy of the original Proposed Design. The results from that analysis should then be compared to the results of the original prototype's Proposed Design.
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%
OfficeSmall	1	5,502	1-story, 5-zone office building with pitched roof and unconditioned attic. WWR–24%
RetailLarge	1	240,000	Big-box type retail building with WWR–12% and SRR–0.82%
SchoolSmall	1	24,413	Elementary school with WWR–36%
SchoolLarge	2	210,866	High school with WWR–35% and SRR–1.4%
Warehouse	1	52,045	Single story high ceiling warehouse. Includes one office space. WWR–0.7% ,SRR–5%
RetailStripMall	1	9,375	Strip mall building with WWR–10%
RetailMedium	1	24,563	Similar to a Target or Walgreens, 7% WWR on the front façade, none on other sides. SRR–2.1%.
RestaurantFastFood	1	2,501	Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic.
OfficeMediumLab	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%

There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction/additions and alterations, so the Standard Design is minimally compliant with the 2025 Title 24 requirements. Under the

Standard Design, fenestration U-factors are 0.58 Btu/(hr·ft²·°F) in CZ 3 and 5 and 0.47 Btu/(hr·ft²·°F) in all other climate zones. SHGC values are 0.41 in CZs 1, 3, 5, and 16, and 0.31 in all other zones. These values are consistent with the prescriptive fenestration requirements in Table 301.5-A [Table 141.0-A] of the 2025 Standards.

The Proposed Design was identical to the Standard Design except for the revisions that represent the proposed changes to the code.

Table 56 presents the parameters modified and the values used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume reduced U-factor requirements to 0.32 in CZ 1, 0.34 in CZ 16, and 0.36 in all other climate zones. SHGC requirements were also reduced to 0.25 in CZs 1–8, 10, and 16, and 0.22 in CZs 9 and 11–15. These changes were applied consistently across all prototypes and climate zones.

Table 56 summarizes the modifications made to each prototype to represent the Proposed Design. Because both U-factor and SHGC requirements are climate-dependent, simulations were performed in all 16 climate zones. This ensured that results captured both the cooling-load benefits of lower SHGC in hot climates and the potential heating penalties in colder climates. The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

Table 56: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Hospital	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	U = 0.58 (CZs 3,5); U = 0.47 (others) | SHGC = 0.41 (CZs 1,3,5,16), 0.31 (others)	Fixed: U = 0.43; SHGC = same as baseline; VT = 0.42 | Storefront: U = 0.43; SHGC = 0.26 (most CZs), 0.41 (CZ1 and 16); VT = 0.46 | Operable: U = 0.47; SHGC = same as baseline; VT = 0.32 | Doors: U = 0.47; SHGC = same as baseline; VT = 0.17

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeMediumLab	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
OfficeLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
OfficeMedium	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
OfficeSmall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
RestaurantFastFood	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
RetailLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
RetailMedium	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
RetailStripMall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
SchoolLarge	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
SchoolSmall	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
Warehouse	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above
Assembly	CZ01-CZ16	WindowMaterial:SimpleGlazingSystem	U-factor, SHGC, VT	Same as above	Same as above

Appendix B: Purpose and Necessity of Proposed Code Changes

Introduction

The sections below provide the purpose and necessity of proposed changes to Title 24, Part 1; Title 24, Part 6; and the reference appendices. This section intends to provide the CEC with the information needed for the Initial Statement of Reasons.

See Sections 2.6 and 3.6 of this report for marked up code language.

Nonresidential Fenestration—New Construction

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

TABLE 301.3-C PRESCRIPTIVE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS

Purpose: The purpose of this change is to update the current U-factor requirement for fixed windows in Climate Zones 1- 4 and 16 from U- 0.36 to U- 0.34. The proposal would also change the U-factor requirement for operable windows in Climate Zones 1-5, and 9-16 from U-0.46 to U-0.43.

Necessity: This change is necessary to maintain modern industry fenestration standards for fixed and operable windows in all climate zones. The proposal also contributes to alignment between Title 24, Part 6 and the 2027 IECC and ASHRAE 90.1-2025 requirements, since this would be the first update to the prescriptive U-factors for all climate zones since the 2013 code cycle.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

Nonresidential Vertical Fenestration—Alterations

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

SECTION 301.5.2 Alterations

Purpose: The purpose of this change is to update U-Factor and RSHGC values for vertical fenestration replacement for consistency with the U-factor and RSHGC values for new construction; where more than one hundred percent of any type of fenestration (storefront, windows, spandrel, curtain wall, glazed doors) is being replaced.

This change also replaces existing Table 301.5-A with an expanded Table 301.5-A, indicating updated U-factor and RSHGC values for Fixed Windows and Curtain Wall or Storefront.

Necessity: The required U-factors for fenestration alterations have been unchanged since at least the 2013 code, so this change represents a substantial improvement in building envelope performance to maintain modern industry standards where window replacement occurs.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

Appendix C: Assumptions for Statewide Savings Estimates

New Construction/Additions—Windows

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts provided by the CEC. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates consider the current market share rate. The Statewide CASE Team estimated that the current market share rate for the proposed code change is zero percent for the new construction market. The current market share rate is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past Title 24 code cycles.

Table 57 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some (but not all) buildings.

Table 58 also presents the assumed distribution of fixed and operable window area by building type. These fenestration subtype shares were developed based on professional judgment regarding the prevalence of each fenestration type within the prototype buildings and were used to weight the statewide construction forecasts in the savings analysis. The applicable climate zones for new construction vary by fenestration type. Fixed window measures apply to Climate Zones 1, 2, 3, 4, and 16, while operable window measures apply to Climate Zones 1 through 5, and 9 through 16.

Table 58 reflects the combined set of climate zones across all new construction fenestration measures. In the statewide savings analysis, each measure is applied only to the climate zones relevant to that specific fenestration type. No other climate zones were modeled for new construction because the measure is not proposed there.

The Statewide CASE Team applied per-unit savings by prototype to the statewide construction forecasts shown in Table 56. Per-unit savings were weighted using the fenestration subtype shares shown in Table 58 and applied only to the climate zones relevant to each fenestration type, as shown in Table 59. This methodology yields the statewide first-year energy, demand, and cost savings reported in the main body of this report.

Table 57: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2028, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 9	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	2.69	1.31	0.00	4.65	0.00	3.22	0.00	0.22	0.04	0.03	12.16
Medium Office	0.09	0.68	1.25	0.97	0.38	2.56	0.39	0.38	0.54	0.32	0.25	0.13	7.94
Small Office	0.05	0.15	0.30	0.05	0.11	0.64	0.09	0.38	0.33	0.09	0.05	0.04	2.28
Large Retail	0.00	0.00	1.77	0.35	0.08	1.88	0.36	0.84	0.00	0.08	0.12	0.07	5.55
Medium Retail	0.10	0.56	0.81	0.67	0.10	2.04	0.24	2.22	1.23	0.42	0.31	0.14	8.84
Strip Mall	0.00	0.00	0.10	0.30	0.09	0.69	0.00	0.09	0.07	0.30	0.05	0.04	1.73
Large School	0.08	0.23	1.15	0.46	0.11	1.17	0.09	0.34	0.17	0.11	0.02	0.02	3.95
Small School	0.01	0.33	1.08	0.66	0.20	1.93	0.48	1.97	0.99	0.28	0.22	0.13	8.28
Non-refrigerated Warehouse	0.06	0.43	1.93	0.99	0.17	3.02	0.49	2.57	0.79	0.50	0.39	0.16	11.5
Assembly	0.11	0.43	0.48	0.71	0.05	2.09	0.21	1.26	0.35	0.11	0.21	0.07	6.08
Hospital	0.04	0.22	0.92	0.47	0.10	0.99	0.18	0.92	0.35	0.15	0.09	0.06	4.49
Laboratory	0.00	0.01	2.40	0.27	0.00	0.23	0.00	0.77	0.34	0.05	0.01	0.02	4.1
Restaurant	0.01	0.08	0.31	0.16	0.03	0.82	0.08	0.34	0.15	0.11	0.05	0.03	2.17
TOTAL	**0.55**	**3.12**	**15.19**	**7.37**	**1.42**	**22.71**	**2.61**	**15.3**	**5.31**	**2.74**	**1.81**	**0.94**	**79.07**

Table 58: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2028, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Fixed Window Share of Fenestration Area	Operable Window Share of Fenestration Area
Large Office	100%	88%	0%
Medium Office	100%	60%	30%
Small Office	100%	30%	50%
Large Retail	100%	10%	0%
Medium Retail	100%	60%	0%
Strip Mall	100%	5%	0%
Large School	100%	60%	30%
Small School	100%	50%	40%
Non-refrigerated Warehouse	100%	100%	0%
Assembly	100%	75%	5%
Hospital	100%	80%	5%
Laboratory	100%	93%	0%
Restaurant	100%	30%	10%

Table 59: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	New Construction Impacted Fixed Windows (Percent Square Footage)	New Construction Impacted Operable Windows (Percent Square Footage)
1	100%	100%
2	100%	100%
3	100%	100%
4	100%	100%
5	0%	100%
6	0%	0%
7	0%	0%
8	0%	0%
9	0%	100%
10	0%	100%
11	0%	100%
12	0%	100%

Climate Zone	New Construction Impacted Fixed Windows (Percent Square Footage)	New Construction Impacted Operable Windows (Percent Square Footage)
13	0%	100%
14	0%	100%
15	0%	100%
16	100%	100%

Vertical Fenestration Alterations

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide affected floorspace forecasts provided by the CEC. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates consider the current market share rate. The Statewide CASE Team estimated that the current market share rate for the proposed code change is zero percent for the retrofit market. The current market share rate is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past Title 24 code cycles.

Table 60 presents the projected existing nonresidential floorspace affected by the proposed code change in 2028. For alterations, affected floorspace is based on the estimated portion of existing building stock undergoing fenestration replacement in a given year.

The Statewide CASE Team assumed the proposed fenestration requirements apply to approximately three percent of existing floorspace annually, based on an assumed 30-year window useful life and corresponding annual turnover of one-thirtieth of the building stock. This approach reflects that fenestration retrofits occur gradually as windows reach the end of their useful life, rather than uniformly across all buildings.

Table 61 presents the assumed distribution of fixed windows, operable windows, storefront systems, and glazed doors by building type. These fenestration subtype shares were developed based on professional judgment regarding the prevalence of each fenestration type within the prototype buildings and were used to weight the statewide alterations savings analysis.

The fenestration subtype shares shown in Table 61 were applied to the three percent annual affected floorspace assumption to estimate the percentage of existing building stock impacted by each fenestration type. The resulting assumptions used in the statewide analysis are shown in Table 62.

The applicable climate zones for the alterations measures vary by fenestration type. Fixed window measures apply to Climate Zones 1–5 and 10–16, glazed door measures apply to Climate Zones 3 and 5, and storefront measures apply to Climate Zones 3–6 and 8–16. No operable window alterations measure was proposed; therefore, operable windows are shown for completeness in Table 61 and Table 62 but are not applied in the statewide analysis.

Table 63 presents the climate zone applicability assumptions used in the statewide analysis. The percentage of affected floorspace shown in Table 63 represents the full statewide building stock; however, these percentages are applied only to the climate zones relevant to each fenestration type when calculating statewide savings.

Table 60: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2028 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.06	2.81	132.12	66.18	1.68	106.03	74.4	170.77	301.78	62.35	2.76	88	8.66	20.67	4.13	4.48	1,047
Medium Office	2.82	29.28	71.22	39.58	12.68	49.01	44.83	61.07	83.34	69.54	17	95.23	24.95	13.37	10.34	4.11	628
Small Office	4.46	12.41	19.56	9.02	7.02	13.19	8.45	13.18	22.07	24.63	10.64	40.87	22.73	5.58	7.39	2.95	224
Large Retail	1.05	9.47	61.37	28.14	4.57	34.86	27.11	47.31	70.07	59.46	12.58	63.03	24.77	12	10.56	3.55	470
Medium Retail	1.23	13.28	45.94	25.98	5.38	47.41	35.9	71.11	111.65	73.07	10.69	63.99	26.05	16.86	9.83	5.66	564
Strip Mall	3.46	10.14	38.11	18.88	5.21	42.85	28.96	59.78	86.14	72.63	12.43	50.86	26.03	16.61	9.58	4.95	487
Large School	2.46	6.45	55.63	21.61	5.07	35.87	17.35	30.95	51.35	17.18	4.69	35.17	6.3	3.06	1.12	1.64	296
Small School	2.09	20.76	56.7	35.22	6.56	44.73	46.2	83.88	122.89	104.06	23.3	86.26	55.02	23.88	14.67	7.85	734
Non-refrigerated Warehouse	3.53	20.52	107.79	53.77	9.76	95.7	50.8	137.48	211.45	194.41	33.21	141.57	55.7	41.48	30.8	12.4	1,200
Assembly	3.2	14.71	62.75	26.13	4.95	48.15	29.72	76.39	101.41	79.83	14.48	60.6	25.82	16.56	10.82	5.49	581
Hospital	2	11.87	50.95	25.95	5.5	30.85	29.47	44.54	72.89	41.81	11.53	55.81	24.32	9.29	4.84	3.4	425
Laboratory	0.41	4.23	43.44	37.31	0.89	11.33	19.53	15.9	16.39	16.94	0.98	14.89	5.38	2.21	0.6	0.72	191
Restaurant	0.61	3.65	14.59	7.42	1.52	17	10.74	24.6	39.73	33.66	3.6	17.27	7.88	7.08	3.58	1.95	195
TOTAL	**27.38**	**159.58**	**760.17**	**395.19**	**70.79**	**576.98**	**423.46**	**836.96**	**1291.16**	**849.57**	**157.89**	**813.55**	**313.61**	**188.65**	**118.26**	**59.15**	**7,042**

Table 61: Assumed Fenestration Subtype Distribution by Building Type

Building Type	Fixed Windows	Operable Windows	Storefront/Curtainwall	Glazed Doors	Total
Large Office	88%	0%	10%	2%	100%
Medium Office	60%	30%	5%	5%	100%
Small Office	30%	50%	5%	5%	100%
Large Retail	10%	0%	80%	10%	100%
Medium Retail	60%	0%	30%	10%	100%
Strip Mall	5%	0%	85%	10%	100%
Large School	60%	30%	5%	5%	100%
Small School	50%	40%	5%	5%	100%
Non-refrigerated Warehouse	100%	0%	0%	0%	100%
Assembly	75%	5%	10%	10%	100%
Hospital	80%	5%	10%	5%	100%
Laboratory	93%	0%	5%	2%	100%
Restaurant	30%	10%	50%	10%	100%

Table 62: Existing Building Stock Impacted by Proposed Code Change in 2028, by Building Type and Fenestration Type

Building Type	Fixed Windows (Percent Square Footage)	Operable Windows (Percent Square Footage)	Storefront Windows (Percent Square Footage)	Glazed Doors (Percent Square Footage)
Large Office	2.64%	0.00%	0.30%	0.06%
Medium Office	1.80%	0.90%	0.15%	0.15%
Small Office	0.90%	1.50%	0.15%	0.15%
Large Retail	0.30%	0.00%	2.40%	0.30%
Medium Retail	1.80%	0.00%	0.90%	0.30%
Strip Mall	0.15%	0.00%	2.55%	0.30%
Large School	1.80%	0.90%	0.15%	0.15%
Small School	1.50%	1.20%	0.15%	0.15%
Non-refrigerated Warehouse	3.00%	0.00%	0.00%	0.00%
Assembly	2.25%	0.15%	0.30%	0.30%
Hospital	2.40%	0.15%	0.30%	0.15%
Laboratory	2.79%	0.00%	0.15%	0.06%
Restaurant	0.90%	0.30%	1.50%	0.30%

Table 63: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	Existing Building Stock (Alterations) Impacted Fixed Windows (Percent Square Footage)	Existing Building Stock (Alterations) Impacted Operable Windows (Percent Square Footage)	Existing Building Stock (Alterations) Impacted Storefront Windows (Percent Square Footage)	Existing Building Stock (Alterations) Impacted Glazed Doors (Percent Square Footage)
1	100%	0%	0%	0%
2	100%	0%	0%	0%
3	100%	0%	100%	100%
4	100%	0%	100%	0%
5	100%	0%	100%	100%
6	0%	0%	100%	0%
7	0%	0%	0%	0%
8	0%	0%	100%	0%
9	0%	0%	100%	0%
10	100%	0%	100%	0%
11	100%	0%	100%	0%
12	100%	0%	100%	0%
13	100%	0%	100%	0%
14	100%	0%	100%	0%
15	100%	0%	100%	0%
16	100%	0%	100%	0%

Appendix D: Environmental Analysis

New Construction/Additions—Windows

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2028 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed standards. A "significant effect on the environment" is "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." (Cal. Code Regs., tit. 14, § 15002(g).)

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including—but not limited to—an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal would not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

There are moderate energy savings and GHG emissions reduction from this proposal because of increased vertical fenestration efficiency in Climate Zones 1-5, and 9-16. For more information on energy savings, see Section 2.5.1. For more information on the GHG emission reductions, see Section 3.5.2.

Direct Adverse Environmental Impacts

There are no identified direct environmental impacts from this code change proposal.

Indirect Environmental Impacts

There are no indirect environmental impacts associated with this code change proposal.

Indirect Environmental Benefits

There are no indirect environmental benefits associated with this code change proposal.

Indirect Adverse Environmental Impacts

There are no indirect adverse environmental impacts associated with this code change proposal.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental,

legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team determined that this measure would not result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

If an EIR is developed, CEQA requires a lead agency to evaluate reasonable alternatives to proposals that would have a significant adverse effect on the environment, including a "no project" alternative. (Cal. Code Regs. Tit. 14, §§ 15002(h)(4) and 15126.6.)

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use from the proposed code change.

Nonresidential Fenestration—Alterations

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2028 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed standards. A "significant effect on the environment" is "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." (Cal. Code Regs., tit. 14, § 15002(g).)

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including—but not limited to—an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal would not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

There are significant energy savings and GHG emission reductions from this proposal as a result of aligning the U-factor requirements of Window Alterations with those of New Construction, when one hundred percent of any single type of fenestration is replaced, and updating the U-factor and RSHGC requirements for Fixed Windows and Curtain Wall or Storefront when less than one hundred percent is replaced. For more information on the energy savings, see Section 3.5.1. For more information on the GHG emission reductions, see Section 3.5.2.

Direct Adverse Environmental Impacts

There are no identified direct adverse environmental impacts from this code change proposal.

Indirect Environmental Impacts

Indirect Environmental Benefits

There are no indirect environmental benefits associated with this code change proposal.

Indirect Adverse Environmental Impacts

There are no indirect adverse environmental impacts associated with this code change proposal.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team determined that this measure would not result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

If an EIR is developed, CEQA requires a lead agency to evaluate reasonable alternatives to proposals that would have a significant adverse effect on the environment, including a "no project" alternative. (Cal. Code Regs. Tit. 14, §§ 15002(h)(4) and 15126.6.)

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use from the proposed code change.

Appendix E: Summary of Stakeholder Engagement

Introduction to Stakeholder Engagement

Collaborating with stakeholders who may be affected by proposed code changes is a core component of the Statewide CASE Team's process. The Statewide CASE Team engages interested parties to identify and address issues related to the proposals, with the goal of submitting recommendations to the CEC in this CASE Report that reflect broad support. Public stakeholders provide valuable feedback on analyses and help identify and address adoption challenges, including cost effectiveness, market and technical barriers, compliance and enforcement, and potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations.

Nonresidential Fenestration—New Construction, Additions and Alterations

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on:

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

The Statewide CASE Team hosted two stakeholder meetings for Nonresidential Fenestration New Construction/Additions Windows via webinar, as described in Table 64. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with

code language, and meeting notes, are included in the bibliography section of this report.

Table 64: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Nonresidential Covered Processes, Envelope Utility-Sponsored Stakeholder Meeting	Tuesday, September 30, 2025.	Solar Pool Heating Envelope—Fenestration Improvements Traction Elevators Data Center Improvements
Second Round of Nonresidential Covered Processes, Envelope Utility-Sponsored Stakeholder Meeting	Tuesday, March 17, 2026.	Nonresidential Fenestration Data Centers Healthcare Exceptions

The first round of utility-sponsored stakeholder meetings began in September 2025 and served as an early forum to promote transparency and gather stakeholder feedback on measures under consideration by the Statewide CASE Team.

The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred in March 2026 and provided updated details on proposed code changes. These meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the full Title 24 Stakeholders listserv, which includes over 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from diverse industries and trades, such as manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was announced on the Title 24 Stakeholders LinkedIn page and cross-promoted on the CEC LinkedIn page approximately two weeks in advance to engage individuals, organizations, and broader channels outside beyond the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted

in to the listserv. Exported webinar meeting data captured attendance numbers, individual comments, and results from live attendee polls to help evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 65.

Table 65: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Thomas Culp, PhD/Birch Point Consulting	Industry Representative	N/A
Helen Sanders/Technoform N.A.	Industry Representative	N/A
Katherine Cort/PNNL	National Laboratory	N/A
Robert Hart/LBL	National Laboratory	N/A
Christian Valoria, PNNL	National Laboratory	N/A
Allegra Steenson/PNNL	National Laboratory	N/A
Walt Zalis/Energetics	PAWS	N/A
Tom Herron/NFRC	Industry	N/A
Jennifer Hatfield/J. Hatfield and Associates	Industry Representative	N/A
Brad Begin/Alpen	Industry	N/A
James Fitzsimmons/Arcadia	Industry	N/A
Lothar Erkens/Winco	Industry	N/A
Eric Shadd/NORESCO	Consultant	N/A
Craig Drumheller/WDMA	Industry Representative	N/A

Appendix F: Code Language Markup (Non-restructured)

The language below is from the Draft CASE Report and in the non-restructured 2025 Title 24 Part 6 Code Language.

SECTION 2—New Construction/Additions Fenestration

SECTION 140.3(a)5B
Vertical windows in exterior walls shall have an area-weighted average U-factor no greater than the applicable value in Table 140.3-B, (B1), C, or D.

SECTION 140.3(a)5C
Vertical windows in exterior walls shall have an area-weighted average relative solar heat gain coefficient, RSHGC, excluding the effects of interior shading, no greater than the applicable value in Table 140.3-B, (B1), C, or D.

SECTION 140.3(a)5D
Vertical windows in exterior walls shall have an area-weighted average Visible Transmittance (VT) no less than the applicable value in Tables 140.3-B, B(1), C, or D.

TABLE 140.3-B. PRESCRIPTIVE ENVELOPE CRITERIA FOR ~~NONRESIDENTIAL BUILDINGS (INCLUDING~~ RELOCATABLE PUBLIC SCHOOL BUILDINGS WHERE MANUFACTURER CERTIFIES USE ONLY IN SPECIFIC CLIMATE ZONE, AND ~~GUEST ROOMS OF HOTEL/MOTEL BUILDINGS)~~ CALIFORNIA BUILDING CODE GROUP R OCCUPANCIES AND THEIR COMMON OR PUBLIC USE AREAS

TABLE 140.3-B(1) PRESCRIPTIVE FENESTRATION CRITERIA FOR NONRESIDENTIAL BUILDINGS (NOT INCLUDING RELOCATABLE PUBLIC SCHOOL BUILDINGS AND CALIFORNIA BUILDING CODE GROUP R OCCUPANCIES AND THEIR COMMON OR PUBLIC USE AREAS

Fenestration—Vertical (All Climate Zones) (Area-Weighted Performance Rating)	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Fixed Window (Max U-factor)	~~0.36~~ 0.34	~~0.36~~ 0.34	0.36	~~0.36~~ 0.34	0.36	0.36	0.36	0.36	0.34	0.36	0.34	0.34	0.34	0.34	0.34	~~0.36~~ 0.34
Fixed Window (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
Fixed Window (Min VT)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Curtain Wall 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
Curtain Wall or Storefront (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
Curtain Wall or Storefront (Min VT)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Operable Window (Max U-factor)	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	0.46	0.46	0.46	~~0.46~~ 0.43	0.46	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43	~~0.46~~ 0.43
Operable Window (Max RSHGC)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Operable Window (Min VT)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Glazed Doors (Max U-factor)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

Glazed Doors (Max RSHGC)	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Glazed Doors (Min VT)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Fenestration (Max WWR%)	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%

SECTION 3—Vertical Fenestration Alterations

SECTION 141.0(b) Alterations.

141.0(b)2A Fenestration. For relocatable public school buildings and nonresidential buildings with Group R Occupancies and their common or public use areas, fenestration ~~Fenestration~~ alterations other than repair shall meet the requirements below:

i. Vertical fenestration alterations shall meet the requirements in Table 141.0-A.

ii. Added vertical fenestration shall meet the requirements of Table 141.0-B, C, or D.

iii. All altered or newly installed skylights shall meet the requirements of Table 140.3-B, C, or D.

Exception to Section 141.0(b)2Ai: In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 141.0-A shall not apply.

Exception to Section 141.0(b)2Aii: In an alteration, where 50 square feet or less of vertical fenestration is added, RSHGC and VT requirements of Table 140.3-B, C, or D shall not apply.

Exception to Section 141.0(b)2Aiii: In an alteration, where 50 square feet or less of skylight is added, SHGC and VT requirements of Table 140.0-B, C, or D shall not apply.

141.0(b)2A.1. Nonresidential Vertical Fenestration. For nonresidential buildings not including relocatable public school buildings and California Building Code Group R Occupancies and their common or public use areas, vertical fenestration alterations other than repairs shall meet the following requirements:

i. Vertical fenestration alterations replacing one hundred percent of any single fenestration type (windows, storefront, curtainwall, glazed doors) shall meet the requirements of Sections 140.3(a)5B through 140.3(a)5D.

ii. All other vertical fenestration alterations shall meet the requirements in Table 141.0-A(1).

iii. Added vertical fenestration shall meet the requirements of Table 140.3-B(1).

iv. All altered or newly installed skylights shall meet the requirements of Table 140.3-B, C, or D.

Exception to Section 141.0(b)2A.1ii: In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 141.0-A(1) shall not apply.

Exception to Section 141.0(b)2A.1iii: In an alteration, where 50 square feet or less of vertical fenestration is added, RSHGC and VT requirements of Table 140.3-B(1) shall not apply.

Exception to Section 141.0(b)2A.1iv: In an alteration, where 50 square feet or less of skylight is added, SHGC and VT requirements of Table 140.0-B, C, or D shall not apply.

NOTE: Glass replaced in an existing sash and frame, or sashes replaced in an existing frame are considered *repairs*. In these cases, Section 141.0(c) requires that the replacement be at least equivalent to the original in performance.