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2019 California Building Energy Efficiency Standards

Residential High Performance Windows and Doors – Final Report

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EXECUTIVE SUMMARY

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for the use of various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison, and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

Measure Description

This measure improves the performance of fenestration products – windows and doors – in low-rise residential buildings by lowering the required U-factors for both products, and for windows by adjusting the solar heat gain coefficients (SHGC) by Climate Zone to further reduce energy use.

For windows, the proposal lowers the U-factor in all Climate Zones from 0.32 to 0.30 Btu/hr-ft^2-°F. In Climate Zones 2, 4, and 6-15 that have significant cooling demands, the proposal lowers the SHGC from 0.25 to 0.23. This level of performance is already in wide use and is typical of products with low conductance frame materials and dual pane glazing with an extra low solar heat gain low emissivity coating, argon gas fill, and an improved spacer.

This proposal also changes the requirements in Climate Zone 16 to have "no requirement" for SHGC like Climate Zones 1, 3 and 5 that have limited cooling and are dominated by heating. For the compliance software, the "no requirement" for the Standard Design is currently modeled with a 0.50 SHGC that is representative of dual glazing with a high solar gain low emissivity coating.

Some stakeholders have commented on a situation that exists under the performance approach where compliance is harder when the most widely available extra low solar heat gain low emissivity coatings are specified in the heating Climate Zones 1, 3, 5 and now 16. To address this concern, this proposal includes a recommendation that is not included in the energy analysis for changing the "no requirement" to 0.35 SHGC. This will allow credit when higher SHGC products are used, but will still show some penalty for the lower SHGC products. Overall, this will make compliance easier with widely used fenestration products while encouraging the use of more appropriate higher SHGC products. Comments were submitted with alternatives to this recommendation and are discussed in Section 3.2.2.

For swinging doors, such as those at the front entry and between the conditioned space and the garage, the proposal lowers the U-factor in all Climate Zones to 0.20 Btu/hr-ft^2-°F. This level of performance is typical of an insulated door and is widely available. The definition of doors has been lowered from 50

percent (½ lite) to 25 percent (¼ lite) of glass or less. Doors with more than 25 percent (¼ lite) are called glazed doors under the standards and are treated as windows under this proposal. It is anticipated that this will result in an increase in the use of rated and labeled doors. An exemption is provided for fire protection doors between the garage and residence based on stakeholder comments.

Under the current standards, the fenestration performance requirements for new construction also apply to additions, alterations, and replacement windows except for the case of performance compliance path alterations. This approach is unchanged for these cases so the performance levels made in this proposal will apply. No changes are proposed for performance alterations that have different requirements.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents that will be modified as a result of the proposed change.

Table 1: Scope of Code Change Proposal

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Will Compliance Software Be Modified	Modified Compliance Document(s)
Doors	Definitions – Door, Glazed Door, Fenestration Area	100.1(b) - Revise definitions to change glazed area to 25% and define residential area to include windows, skylights and glazed doors	None	No	No
Doors	Definitions – Door Area	100.1(b) - Add definition of door area that does not include glazed doors	None	No	No
Doors	Prescriptive	150.1(c)5 - Add section covering doors	None	Yes	Yes
Windows and Doors	Prescriptive	Table 150.1-A - Revise Fenestration U-factor and SGHC values. Add a row with door U-factors	None	Yes	Yes
Windows and Doors	Prescriptive	150.2(a)1B and 150.2(b)1B – revise to remove SHGC requirement from Climate Zone 16	None	Yes	Yes

Market Analysis and Regulatory Impact Assessment

For windows, the proposed change is an incremental improvement over the prescriptive requirements under the 2016 Title 24, Part 6 Standards. Many of the windows installed under the current standards already meet these proposed performance levels.

The window industry is well versed in understanding what it takes to meet these proposed values – a low conductance frame, dual glazing that includes a low emissivity coating, argon gas fill, and an improved spacer system. In Climate Zones 2, 4 and 6-15, the low emissivity coating needs to have a low solar gain. In Climate Zones 1, 3, 5 and now 16, the low emissivity coating needs to have a high solar

heat gain. For builders and installers, there is no difference in the specification or installation of this product other than ensuring it meets the new performance levels that are widely available.

For doors with less than 25 percent glazed area, typical of front entry doors and doors between the house and garage, the proposed change targets the use of insulated door products. Insulated door products (which typically have insulation sandwiched between either steel or fiberglass panels) are already in wide use.

For doors with 25 percent or more glazed area, typical of sliding glass and French doors, the proposal requires that these products meet the same requirement as window products. Under the 2016 Title 24, Part 6 Standards, the threshold is for doors with 50 percent or more glazed area. Most of these products are provided by window manufacturers and can meet the proposed 25 percent criteria using the same components as windows commonly utilize.

Overall this proposal increases the wealth of the State of California. California consumers will save more money on energy than they do for financing the efficiency measure.

The proposed changes to Title 24, Part 6 Standards have a negligible impact on the complexity of the standards or the cost of enforcement. When developing this code change proposal, the Statewide CASE Team interviewed building officials, Title 24 energy analysts and others involved in the code compliance process to simplify and streamline the compliance and enforcement of this proposal.

Cost-Effectiveness

The proposed code change was found to be cost-effective statewide with benefit-to-cost (B/C) ratios over five for single family and multifamily new construction. Measures that have a B/C ratio of 1.0 or greater are cost-effective. The larger the B/C ratio, the faster the measure pays for itself from energy savings.

There is one case – single family in Climate Zone 7 – where the B/C ratio is 0.6, with the present value of the savings being $81 and the incremental cost being $147. This proposal recommends that in this one case, with the relatively modest added measure cost, that the proposed U-factors and SHGC values be applied to Climate Zone 7, so that there are uniform requirements statewide. This will help to simplify the standards, and make enforcement and product specification less complex.

Cost-effectiveness varies significantly between single family and multifamily building prototypes used in Title 24, Part 6 Standards evaluations suggesting different requirements by climate zone for the two building types. The calculation of B/C ratio compares the 30-year lifecycle benefits (cost savings) to the lifecycle costs over the same time period. See Section 5 for a detailed description of the cost-effectiveness analysis.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the proposed code change. See Section 4 for more details.

Table 2: Estimated Statewide First-Year[a] Energy and Water Savings

Measure	First-Year Electricity Savings (GWh/yr)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Water Savings (million gallons/yr)	First-Year Natural Gas Savings (million therms/yr)
New Construction	5.660	8.174	0	0.915
Additions	1.217	1.757	0	0.197
Alterations	1.217	1.757	0	0.197
TOTAL	**8.093**	**11.689**	**0**	**1.308**

a. First year savings from all buildings completed statewide in 2020.

Compliance and Enforcement

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process will have on various market actors. The compliance process is described in Section 2.5. The impacts the proposed measure will have on various market actors is described in Section 3.3 and 0. The key issues related to compliance and enforcement are summarized below:

- For windows, the proposed change is an incremental modification to the products already in use. Other than checking for the new U-factors and SHGC performance levels, the impacts on compliance and enforcement are negligible.
- For doors, the proposal will likely result in an increase in the use of National Fenestration Rating System (NFRC) rated and labeled doors rather than default values.

Although a needs analysis has been conducted with the affected market actors while developing the code change proposal, the code requirements may change between the time the final CASE Report is submitted and the time the 2019 Standards are adopted. The recommended compliance process and compliance documentation may also evolve with the code language. To effectively implement the adopted code requirements, a plan should be developed that identifies potential barriers to compliance when rolling-out the code change and approaches that should be deployed to minimize the barriers.

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

The overall goal of this CASE Report is to propose a high performance windows and doors code change proposal. The report contains pertinent information supporting the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with a number of industry stakeholders including building officials, manufacturers, builders, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during two public stakeholder workshops that the Statewide CASE Team held on September 14, 2016 and March 14, 2017.

Section 2 of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this change is accomplished in the various sections and documents that make up the Title 24, Part 6.

Section 3 presents the market analysis, including a review of the current market structure. Section 3.2 describes the feasibility issues associated with the code change, such as whether the proposed measure overlaps or conflicts with other portions of the building standards such as fire, seismic, and other safety standards and whether technical, compliance, or enforceability challenges exist.

Section 4 presents the per unit energy, demand, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate energy, demand, and energy cost savings.

Section 5 presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of additional materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs. That is, equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.

Section 6 presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2019 Standards take effect. This includes the amount of energy that will be saved by California building owners and tenants, and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also considered.

Section 7 concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, Compliance Manual, and compliance documents.

2. MEASURE DESCRIPTION

2.1 Measure Overview

This measure improves the performance of fenestration products—windows and doors—in the low-rise residential buildings by lowering the required U-factors for both products, and for windows by adjusting the solar heat gain coefficients (SHGC) by Climate Zone to further reduce energy use. Improving the performance of fenestration products will reduce the heating, ventilation, and air conditioning (HVAC) loads. This measure also has significant impact on peak cooling loads by reducing the solar heat gain transmitted through the windows, which is a significant part of the cooling loads.

For windows, the proposed measure:

- Reduces the prescriptive window U-factor from 0.32 to 0.30 in all Climate Zones.
- Reduces the prescriptive window SHGC from 0.25 to 0.23 in Climate Zones 2, 4, and 6 through 15.
- Changes Climate Zone 16 to a higher SHGC specification, similar to Climate Zones 1, 3 and 5 that also have more heating load than cooling.
- Recommends an alternative for the high SHGC Climate Zones to consider establishing a minimum 0.35 SHGC requirement.

For doors, the proposed measure:

- Introduces a prescriptive swinging entry door U-factor requirement of 0.20 in all Climate Zones.
- Provides an exemption for swinging doors that are required to have fire protection by other parts of the Title 24 building code.
- Requires verification using a National Fenestration Rating System (NFRC) label, like the prescriptive window requirements.
- Changes the definition of glazed doors that are treated the same as windows from 50 percent to 25 percent glazed area.

This code change is achieved by minor changes to existing code language, and the addition of a brief section to the prescriptive requirements to cover the new door criteria.

Under the current standards, the fenestration performance requirements for new construction also apply to additions, alterations, and replacement windows except for the case of performance alterations. This approach is unchanged for these cases so the performance levels made in this proposal will apply. No changes are proposed for performance alterations that have different requirements.

2.2 Measure History

Prescriptive window performance has increased dramatically since the 1998 standards with the shift to low conductance frames, low emissivity low solar gain glass coatings and argon gas filled cavities that are now widespread throughout California. Opaque door requirements have not changed for many code cycles, even though there is wide penetration of insulated door products available. The proposed change in U-factors and window SHGC are show in

Figure 1, as well as the historical values over time.

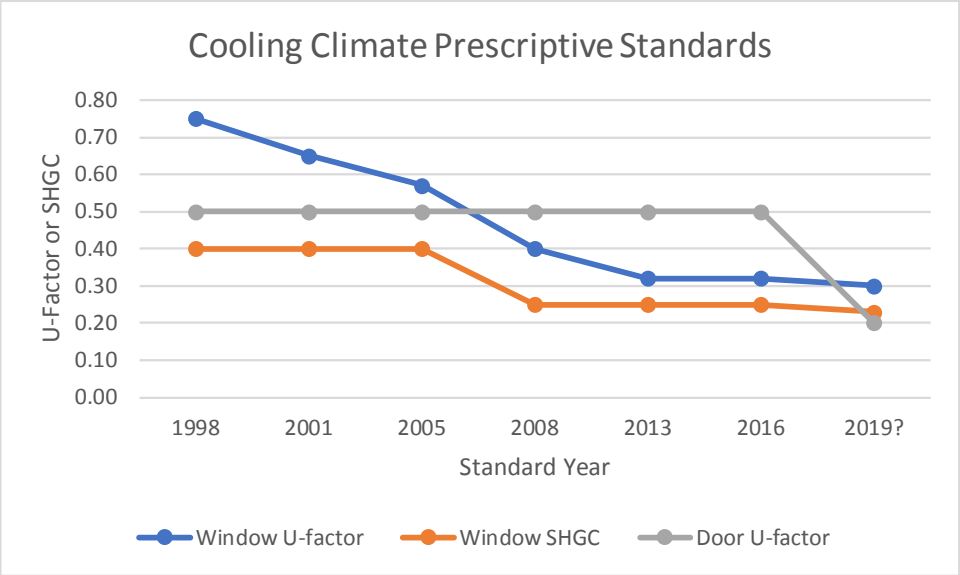

Figure 1: Cooling climate prescriptive standards over time

Historically, the building industry has been reluctant to support increased use of high performance glazing in part because of concerns about higher costs and product availability. In recent years, the window industry has continually advanced the performance of mainstream glazing products with technological advancements. The current prescriptive requirements of 0.32 U-factor and 0.25 SHGC (in cooling dominated Climate Zones) has been surpassed by many California builders, as evidenced by a recent data download from the CalCerts registry, which shows that about two-thirds of glazing installed in single family homes from January 2015 through April 2016 had a SHGC of 0.24 or less. With higher performance product available from all major manufacturers servicing the California market, it is important for the prescriptive requirements to remain current to avoid a reduction in the stringency of the standards. Glazing is an especially significant energy efficiency product in the California Time Dependent Valuation (TDV)-based compliance environment as peak cooling demand impacts related to west facing glazing are aligned with high TDV times of day.

2.3 Summary of Proposed Changes to Code Documents

The sections below provide a summary of how each Title 24, Part 6 documents will be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.3.1 Standards Change Summary

The proposed measure will require updating the definitions section 100.1(b), prescriptive section 150.1(c)5, Table 150.1-A, 150.2(a)1B and 150.2(b)1B.

2.3.2 Reference Appendices Change Summary

The proposed measure will require changes to the glossary and Table 4.5.1 door U-factors.

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

This proposed measure will require modification to the description of the Standard Design doors in section 2 of the Residential ACM Reference Manual. The windows already reference Standards Table 150.1-A, which will be updated as part of this proposal.

2.3.4 Compliance Manual Change Summary

The Residential Compliance Manual will need to be revised to match the proposed requirements and to describe the treating of doors and glazed doors.

2.3.5 Compliance Documents Change Summary

Add a field to the CF1R to state where the performance values are from – either NFRC values or defaults.

2.4 Regulatory Context

2.4.1 Existing Title 24, Part 6 Standards

The window performance requirements for low-rise residential buildings were last updated as part of the 2013 code cycle. The prescriptive U-factor for all Climate Zones was set at 0.32. The SHGC depends on the type of climate. In climates with cooling, Climate Zones 2, 4, and 6-16, the prescriptive SHGC is a maximum of 0.25. In the milder coastal climates that have mostly heating, Climate Zones 1, 3, and 5, there is no prescriptive SHGC requirement. The "no requirement" case is modeled in the compliance software with an assumed SHGC of 0.50. A Climate Zone map is shown in Figure 2.

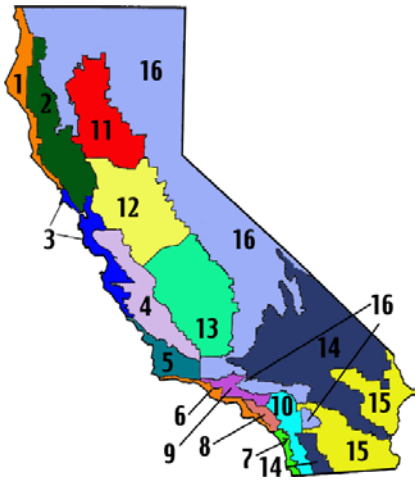

Figure 2: California climate zones

Source: (California Climate Zone Map, 2017)

2.4.2 Relationship to Other Title 24 Requirements

The impact of fenestration on energy performance is affected significantly by the Climate Zone, area, orientation, and shading in the building. The prescriptive standards limit fenestration to 20 percent of the floor area or less, and limit west facing glass to five percent of the floor area. Dwellings with glazing levels that exceed the 20 percent prescriptive limit (or five percent west facing limit) generally suffer a compliance penalty in the performance approach, however dwellings that install less glazing than the prescriptive requirements are not rewarded for reduced energy usage. There are no requirements for overhangs at this time.

2.4.3 Relationship to State or Federal Laws

Most other states follow the International Energy Conservation Code (IECC). The IECC code shares many similarities with Title 24, Part 6 requirements. The 2015 IECC has U-factors ranging from 0.32 to 0.40 and SHGC values as low as 0.25 in climates that are found in California. The 2018 IECC has 0.30 U-factors in some of the climates that are also found in California. Swinging doors are subject to the

same U-factor requirement as windows with an exception for 24 square foot (ft^2) of door. The IECC has eight Climate Zones and breaks the requirements down by county boundaries as shown in Figure 3.

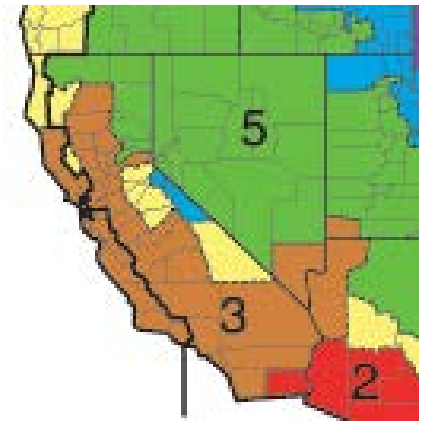

Figure 3: IECC climate zones

Source: (IECC Climate Zone Map, 2017)

2.4.4 Relationship to Industry Standards

There are two significant voluntary programs at the national level that have greatly affected fenestration performance over the last decade. They are both relevant to Title 24, Part 6 because the performance requirements particularly for U-factor are like those in this proposal including 0.30 U-factor windows and 0.17 U-factor opaque doors.

During the recession, the federal government offered a tax credit for energy efficiency improvements that included windows that met a 0.30 U-factor and 0.30 SHGC requirements nationwide. Many manufacturers modified their product to achieve these criteria in response. The 0.30 SHGC requirement was met by switching to a lower solar heat gain low emissivity coating like the ones required prescriptively in California. The 0.30 U-factor typically required manufacturers to adopt the same features described in Section 2.4.1.

ENERGY STAR® Windows and Doors have also had a significant impact on the fenestration industry where a large portion of the windows sold are ENERGY STAR labeled. ENERGY STAR has four Climate Zones nationally – two of which are in California as shown in Figure 4.

Figure 4: ENERGY STAR climate zones

Source: (Energy Star Program Requirements, 2016)

ENERGY STAR criteria includes 0.30 U-factors and 0.25 SHGC requirements for California Climate Zones as shown in Figure 4.

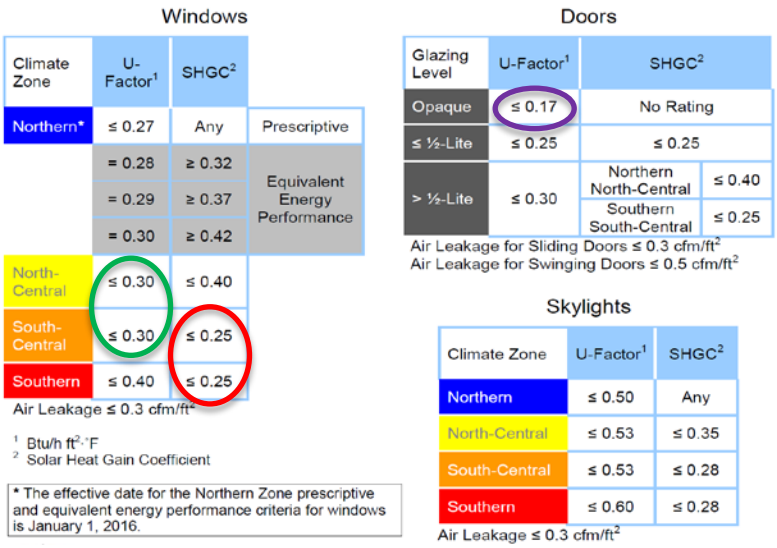

Figure 5: ENERGY STAR criteria

Source: (Energy Star Program Requirements, 2016)

2.5 Compliance and Enforcement

The Statewide CASE Team collected input during the stakeholder outreach process on what compliance and enforcement issues may be associated with these measures. This section summarizes how the proposed code change will modify the code compliance process. 0 presents a detailed description of how the proposed code changes could impact various market actors. When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced.

This code change proposal will affect new construction buildings, additions, and alterations. The key steps and changes to the compliance process are summarized below. There are training programs currently underway, such as the Energy Code Ace Title 24, Part 6 Essentials courses, that should be leveraged to provide support to the industry in preparation for the 2019 Title 24, Part 6 Standards. See Section 3 for details on training programs.

- **Design Phase**: The proposed window measure does not change the current construction design process. For doors, designers that are specifying an NFRC rated door will need to indicate this on the plans.
- **Permit Application Phase**: There are no anticipated changes to the existing permit application phase process as the 2019 proposal is incremental in nature.
- **Construction Phase**: This measure does not change the existing construction phase process.
- **Inspection Phase**: The window measure does not impact the existing inspection process. For doors, if an NFRC rated door is installed the NFRC label should be left on the door until it can be inspected by the building inspector and any other third party inspectors. This inspection would occur at the same time as the final inspection and would not add complexity. The incremental time for inspection is marginal.

There are no significant challenges to compliance and enforcement in any of the phases identified above. There is not a significant burden placed on any market actor as it relates to compliance and enforcement.

If this code change proposal is adopted, the Statewide CASE Team recommends that information presented in this section, Section 3 and 0 be used to develop a plan that identifies a process to develop compliance documentation and how to minimize barriers to compliance.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market actors. The Statewide CASE Team gathered information 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, Energy Commission staff, and a wide range of industry players who were invited to participate in utility-sponsored stakeholder meetings held on September 14, 2016 and March 14, 2017.

3.1 Market Structure

There are numerous fenestration and door manufacturers of all sizes selling product in California, and many are already offering product that meets the proposed performance levels.

For windows and glazed doors, the proposed requirements represent an incremental improvement to efficiency that captures the energy savings of products already widely installed, it is anticipated that this proposal does not change the current market structure for windows and glazed doors.

For swinging doors, insulated doors are already in wide use that have the characteristics needed to meet the proposed 0.20 U-factor. The proposed performance requirement will shift more swinging door products to be insulated, and will increase the use of NFRC labeled door products.

3.2 Technical Feasibility, Market Availability, and Current Practices

3.2.1 Windows

Windows have some unique characteristics among energy efficiency measures. One is that homes typically have 15-25 windows and can have many different configurations, such as fixed, horizontal sliding, vertical sliding, casement, and sliding and swinging patio doors. Each of the configurations potentially has slightly different performance ratings due mostly to differences in the frame to glass ratio. This means that a typical home can have four or five sets of performance numbers and choosing a single set of values that can all be met prescriptively can pose challenges.

The impact of windows on the building energy performance is also very dependent on the orientation. But in most cases, typical practice is to use the same low emissivity glass coatings on all orientations to maintain the same appearance. Inherently, this requires that the coatings selected must balance both a lower U-factor and an appropriate SHGC for the building, climate, and window orientations. Lower SHGC helps reduce cooling energy use, particularly with the use of TDV energy, but can increase heating. Fenestration products also provide daylight, ventilation, and egress, and have an important impact on the appearance of the building.

The current prescriptive requirements for windows in low-rise residential new construction include a maximum 0.32 U-factor and a maximum 0.25 SHGC in Climate Zones with significant cooling including 2, 4, and 6-16. There is no requirement for SHGC in the heating dominated Climate Zones 1, 3, and 5. The current criteria were established in 2013 and were not changed for the 2016 Standards.

The window industry is well versed in what it takes to meet these requirements. The most common product includes:

- Low conductance frame most commonly made with PVC vinyl, wood, fiberglass
- Dual pane insulating glass
- Low emissivity glass coating
- Argon gas fill in the cavity
- Thermally improved spacer

The type and placement of the low emissivity coatings is critical. Figure 6 shows the nomenclature for a dual pane insulated glass unit. Normally, low SHGC coatings are applied on surface 2 and high SHGC coatings are on surface 3.

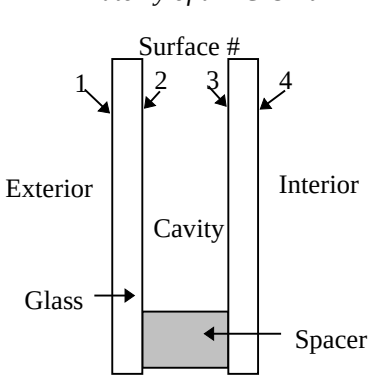

Figure 6: Dual pane insulating glass unit

Source: (California Window Initiative, 1998)

When the 2013 Standards were developed, the maximum fenestration U-factors and SHGC values were reduced, but they were not reduced to the most stringent (cost-effective) level, in part because of the problem of multiple operator types, but also due to lack of experience with the product. Now that these same requirements have been in place during two code cycles, it is apparent that these values can be tightened to increase energy efficiency while most often requiring the same product described above or one with modest changes. As a result, this proposal has been crafted to capture the extra energy savings by lowering the U-factor requirement to 0.30 for all Climate Zones, and the SHGC to 0.23 in cooling climates, using windows products that are already in wide use.

Other technologies that could improve the performance were considered. Triple glazing is not widely available and would often require costly redesign and retooling of the window frames. Another technology, low emissivity coatings facing the conditioned space are available, but have not caught on in the marketplace. Chromogenic glass that has variable SHGC is expensive, requires controls, and is rarely used in low-rise residential construction. There are some lower SHGC coatings available, but they have a tinted appearance that make them less appealing for most low-rise residential construction.

3.2.2 Windows in Heating Climates

Climate Zone 16 is a special compliance case. Under the current Title 24, Part 6 Standards, it shares a requirement for the 0.25 SHGC with other climates that have more significant cooling loads. However, Climate Zone 16, with updated 2019 TDV values, is now showing that there are more energy savings available with a high SHGC product than a low SHGC product, similar to other heating dominated climates. Based on this observation, the Statewide CASE Team recommends switching Climate Zone 16 to share the same “no requirement” for SHGC as Climate Zones 1, 3 and 5.

There is a second issue on windows in heating climates. Some stakeholders have commented that under the performance approach compliance is harder when the most widely available extra low solar heat gain low emissivity coatings commonly used in cooling Climate Zones are specified in the heating Climate Zones 1, 3, 5 and now 16. These products would be allowed prescriptively without penalty, because SHGC is normally treated as a maximum value. Because the 0.50 SHGC used for the "no requirement" case is very favorable in these Climate Zones, the change in modeling rules increases energy use on paper. In practice, though, because the "no requirement" status of SHGC in these Climate Zones, the SHGC values are often ignored in these Climate Zones.

One idea that strikes a balance would be to change the "no requirement" Climate Zones to a minimum 0.35 SHGC typical of a mid-solar gain low emissivity coating that was the basis of the 2008 Standards and is a product offering available from multiple manufacturers. This will allow credit when higher SHGC products are used, but will still show some penalty for the lower SHGC products. Overall, this will make compliance easier with widely used fenestration products while encouraging the use of more appropriate higher SHGC products. The Statewide CASE Team recommends that the Energy Commission consider this recommendation, but recognize that it will not show energy savings using the traditional assumptions used for standards development.

One commenter had several suggestions that could also improve upon the current modeling of "no requirement" climate zones. One suggestion is to make a change only affecting the ACM modeling by setting the standard design to the same 0.23 proposed in cooling dominated climates. This proposal will raise the heating energy use higher than the suggested 0.35 SHGC value, but does have the advantage that it maintains the use of "no requirement" in the prescriptive packages that has been in use for many years. The message to the energy consultants and builders that lower SHGC can increase energy use in the affected mild heating climates is diminished with this approach. A second suggestion was to consider using 0.30 SHGC to replace the "no requirement" with the note that this is a better dividing line between mid and low SHGC products. The 0.35 recommendation was made to encourage a higher SHGC and utilizes a type of glass coating that is widely available in the market

3.2.3 Doors

Currently, the standards have two door definitions – door and glazed door. The door definition applies to swinging and other types of doors with less than 50 percent glazed area. This type of swinging door is commonly assigned a default U-factor of 0.50, but there is some use of insulated doors with lower U-factors. Glazed doors are then doors with 50 percent or greater glazed area. Glazed doors are normally treated the same as fenestration, such as windows and sliding or swinging glass doors.

The 2016 Title 24, Part 6 Standard does not have prescriptive requirements for swinging entry doors, such as a front entry door or the door between the conditioned space and an attached garage. Yet insulated doors are widely available and commonly used in California dwellings. This proposal recommends that swinging doors have a maximum 0.20 U-factor requirement that would typically be met with an insulated door, most of which consist of either fiberglass or steel outer skins with an insulating foam core.

Traditionally doors between the conditioned space and attached garages were required to meet fire protection requirements typically with solid wood core doors or products otherwise identified as having 20 minute ratings. However, other parts of Title 24 have recently adopted fire sprinkler requirements that often result in fire sprinklers in the garage negating the need for fire protection doors. However, in responding to feedback from some stakeholders, this proposal has added language that exempts fire protection doors from having to meet the proposed U-factor requirements.

The standards recognize two methods for determining U-factors. One is to use default tables, and the second is to use NFRC certified and labeled products. Like the situation with windows, the default values do not meet prescriptive proposed requirements, so most window products have NFRC labels.

This means that swinging doors meeting the new requirement will need NFRC labels. Fortunately, these labels are already in wide use for insulated door products. ENERGY STAR data indicates that millions of door products are sold each year with NFRC labels in recent years.

This proposal also recommends that the definition of a glazed door be reduced from 50 percent to 25 percent of the door area. The origin of the 50 percent threshold dates to the beginning of the Title 24, Part 6 Standards long before there was the industry recognized NFRC that emerged in the 1990s. At this point in time, the NFRC rating system is mature and in wide use and should be used for most fenestration products to ensure accurate ratings for the many energy efficient features that current door products incorporate.

3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

It is expected that builders will not be impacted significantly by any one proposed code change or the collective effect of all of the proposed changes to Title 24, Part 6. Builders could be impacted for change in demand for new buildings and by construction costs. Demand for new buildings is driven more by factors such as the overall health of the economy and population growth than the cost of construction. The cost of complying with Title 24, Part 6 requirements represents a very small portion of the total building value. Increasing the building cost by a fraction of a percent is not expected to have a significant impact on demand for new buildings or the builders' profits. Even as shown in Figure 7, California home prices have increased by about $300,000 in the last 20 years. In the six years between the peak of the market bubble in 2006 and the bottom of the crash in 2012, the median home price dropped by $250,000. The current median price is about $500,000 per single family home. The combination of all single family measures for the 2016 Title 24, Part 6 Standards was around $2,700 (California Energy Commission, 2015). This is a cost impact of approximately half of one percent of the home value. The cost impact is negligible as compared to other variables that impact the home value.

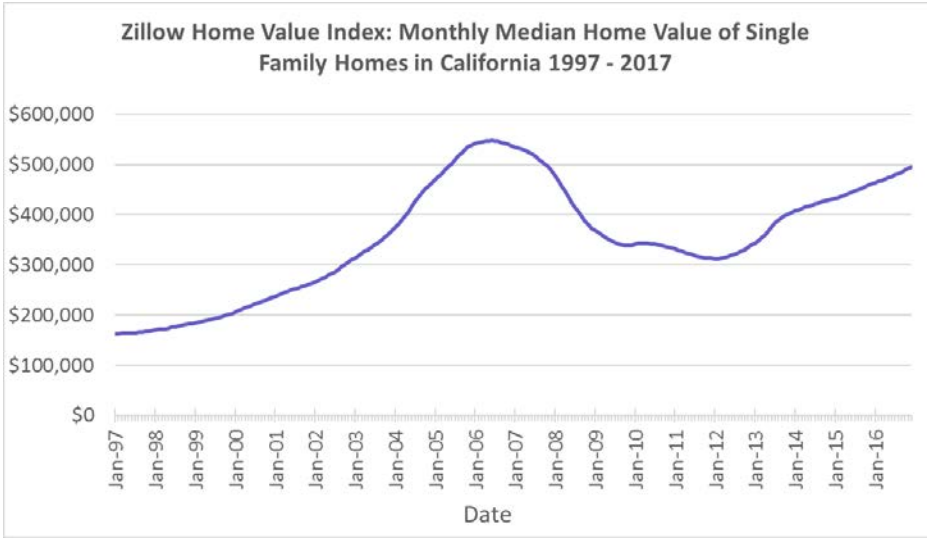

Figure 7: California median home values 1997 to 2017

Source: (Zilllow, 2017)

Market actors will need to invest in training and education to ensure the workforce, including designers and those working in construction trades, know how to comply with the proposed requirements. Workforce training is not unique to the building industry, and is common in many fields associated with the production of goods and services. Costs associated with workforce training are typically accounted

for in long-term financial planning and spread out across the unit price of many units as to avoid price spikes when changes in designs and/or processes are implemented.

The builder is responsible for understanding the design requirements, ensuring that all subcontractors are aware of these requirements, and ultimately ensuring that all requirements are implemented per the design intent. Additional time may be required for these processes but it is not expected to have a significant impact on project schedule.

Refer to 0 for a description of how the compliance process will impact builders.

3.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including the California Building code and model national building codes published by the International Code Council, the International Association of Plumbing and Mechanical Officials and ASHRAE 90.1) are typically updated on a three-year revision cycles. As discussed in Section 3.3.1, all market actors, including building designers and energy consultants, should (and do) plan for training and education that may be required to adjusting design practices to accommodate compliance with new building codes. As a whole, the measures the Statewide CASE Team is proposing for the 2019 code cycle aim to provide designers and energy consultants with opportunities to comply with code requirements in multiple ways, thereby providing flexibility in requirements can be met.

Energy consultants will not be significantly impacted by this measure. They will continue to serve as the primary resource for designers and builders for Title 24, Part 6 compliance information. With their detailed knowledge of the Title 24, Part 6 compliance software, the energy consultant will work closely with the builder in determining the most cost-effective approach for demonstrating compliance based on builder design, project location, and construction team comfort level with alternative methods.

Refer to Appendix B for a description of how the compliance process will impact building designers and energy consultants.

3.3.3 Impact on Occupational Safety and Health

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. All existing health and safety rules will 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.

3.3.4 Impact on Building Owners and Occupants (Including Homeowners and Potential First-Time Homeowners)

Building owners and occupants will benefit from lower energy bills. For example, the Energy Commission estimates that on average the 2016 Title 24, Part 6 Standards will increase the construction cost by $2,700 per single family home, but the standards will also result in a savings of $7,400 in energy and maintenance cost savings over 30 years. This is roughly equivalent to an $11 per month increase in payments for a 30-year mortgage and a monthly energy cost savings of $31 per month. Overall, the 2016 Title 24, Part 6 Standards are expected to save homeowners about $240 per year relative to homeowners whose single family homes are minimally compliant with the 2013 Title 24, Part 6 requirements (California Energy Commission, 2015). As discussed in Section 3.4.1, when homeowners or building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. Energy cost savings can be particularly beneficial to low income homeowners who typically spend a higher portion of their income on energy bills, often have trouble paying energy bills and sometimes go without food or medical care to save money for energy bills (Association, National Energy Assistance Directors, 2011).

Additional benefits to the builder owner and occupants will include increased interior comfort for the occupant due to reduced summer heat gains and winter heat loss resulting in greater thermal envelope integrity.

3.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The proposed measure is expected to have a minimal impact on the window industry as product availability is already moving towards the proposed 2019 specification. Demand for window products should not be impacted by this measure.

The opaque door industry will be impacted as product will now have to be NFRC labeled to meet the prescriptive requirements. Windows are in a similar situation where the only way to meet the prescriptive criteria is to have NFRC labeled product, as the default labeled product does not meet prescriptive requirements. Millions of door products sold each year that have NFRC labels and meet the 0.20 U-factor requirement. ENERGY STAR reports that more than 70 percent of hinged products nationally are ENERGY STAR qualified in recent years.

Refer to 0 for a description of how the compliance process will impact building designers and energy consultants.

3.3.6 Impact on Building Inspectors

Building inspectors will not be significantly impacted by this measure.

3.3.7 Impact on Statewide Employment

Section 3.4.1 discusses statewide job creation from the energy efficiency sector in general, including updates to Title 24, Part 6.

3.4 Economic Impacts

3.4.1 Creation or Elimination of Jobs

In 2015, California's building energy efficiency industry employed more than 321,000 workers who worked at least part time or a fraction of their time on activities related to building efficiency. Employment in the building energy efficiency industry grew six percent between 2014 and 2015 while the overall statewide employment grew three percent (BW Research Partnership, 2016). Lawrence Berkeley National Laboratory's report *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth* (2010) provides a detail on the types of jobs in the energy efficiency sector that are likely to be supported by revisions to building codes.

Building codes that reduce energy consumption provide jobs through *direct employment*, *indirect employment*, and *induced employment*.[1] Title 24, Part 6 creates jobs in all three categories with a significant amount from induced employment, which accounts for the expenditure-induced effects in the

[1] The definitions of direct, indirect, and induced jobs vary widely by study. Wei et al (2010) describes the definitions and usage of these categories as follows: "*Direct employment* includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration. *Indirect employment* refers to the ''supplier effect'' of upstream and downstream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an indirect job. *Induced employment* accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees, e.g.,i.e. non industry jobs created such as teachers, grocery store clerks, and postal workers."

general economy due to the economic activity and spending of direct and indirect employees (e.g., nonindustry jobs created such as teachers, grocery store clerks, and postal workers). A large portion of the induced jobs from energy efficiency are the jobs created by the energy cost savings due to the energy efficiency measures. For example, as mentioned in Section 3.3.4, the 2016 Standards are expected to save single family homeowners about $240 per year. Money saved from hundreds of thousands of homeowners over the entire life of the building will be reinvested in local businesses. Wei, Patadia, and Kammen (2010) estimate that energy efficiency creates 0.17 to 0.59 net job-years[2] per GWh saved. By comparison, they estimate that the coal and natural gas industries create 0.11 net job-years per GWh produced. Using the mid-point for the energy efficiency range (0.38 net job-years per GWh saved), the estimates that this proposed code change will result in a statewide first-year savings of 8.09 GWh, this measure will result in approximately 3.1 jobs created in the first year. See Section 6.1 for statewide savings estimates.

3.4.2 Creation or Elimination of Businesses in California

There are approximately 43,000 businesses that play a role in California's advanced energy economy (BW Research Partnership, 2016). California's clean economy grew ten times more than the total state economy between 2002 and 2012 (20 percent compared to 2 percent). The energy efficiency industry, which is driven in part by recurrent updates to the building code, is the largest component of the core clean economy (Ettenson & Heavey, 2015). Adopting cost-effective code changes for the 2019 Title 24, Part 6 code cycle will help maintain the energy efficiency industry.

Table 3 lists industries that will likely benefit from the proposed code change by North American Industry Classification System (NAICS) Code. Builders, insulation contractors, and manufacturers will all be impacted, primary as it relates to the new construction residential industry. All of the insulation manufacturers mentioned in Section 3.1 conduct business within California and have the opportunity to increase sales revenue. The proposed code changes are not expected to have a significant impact on the retrofit market.

Table 3: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Residential Building Construction	2361
Window and Door Installation	23835
Manufacturing	32412
Engineering Services	541330

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

In 2014, California's electricity statewide costs were 1.7 percent of the state's gross domestic product (GDP) while electricity costs in the rest of the United States were 2.4 percent of GDP (Thornberg, Chong, & Fowler, 2016). As a result of spending a smaller portion of overall GDP on electricity relative to other states, Californians and California businesses save billions of dollars in energy costs per year relative to businesses located elsewhere. Money saved on energy costs can be otherwise invested, which provides California businesses with an advantage that will only be strengthened by the adoption of the proposed code changes that impact residential buildings.

3.4.4 Increase or Decrease of Investments in the State of California

The proposed changes to the building code are not expected to impact investments in California on a macroeconomic scale, nor are they expected to affect investments by individual firms. The allocation of

[2] One job-year (or ''full-time equivalent'' FTE job) is full time employment for one person for a duration of one year.

resources for the production of goods in California is not expected to change as a result of this code change proposal.

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

The proposed code changes are not expected to have a significant impact on the California's General Fund, any state special funds, or local government funds. Revenue to these funds comes from taxes levied. The most relevant taxes to consider for this proposed code change are: personal income taxes, corporation taxes, sales and use taxes, and property taxes. The proposed changes for the 2019 Title 24, Part 6 Standards are not expected to result in noteworthy changes to personal or corporate income, so the revenue from personal income taxes or corporate taxes is not expected to change. As discussed, reductions in energy expenditures are expected to increase discretionary income. State and local sales tax revenues may increase if homeowners spend their additional discretionary income on taxable items. Although logic indicates there may be changes to sales tax revenue, the impacts that are directly related to revisions to Title 24, Part 6 have not been quantified. Finally, revenue generated from property taxes is directly linked to the value of the property, which is usually linked to the purchase price of the property. The proposed changes will increase construction costs. As discussed in Section 3.3.1, however, there is no statistical evidence that Title 24, Part 6 drives construction costs or that construction costs have a significant impact on home price. Since compliance with Title 24, Part 6 does not have a clear impact on purchase price, it can follow that Title 24, Part 6 cannot be shown to impact revenues from property taxes.

3.4.5.1 Cost of Enforcement

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised standards, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals. The proposed residential changes will not impact state buildings.

Cost to Local Governments

All revisions to Title 24, Part 6 will result in changes to compliance determinations. Local governments will need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2019 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 2.5 and 0, 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.

3.4.6 Impacts on Specific Persons

The proposed changes to Title 24, Part 6 are not expected to have a differential impact on any groups relative to the state population as a whole, including migrant workers, commuters or persons by age, race or religion. Given construction costs are not well correlated with home prices, the proposed code changes are not expected to have an impact on financing costs for business or home-buyers. Some financial institutions have progressive policies that recognize the financial implications associated with

occupants of energy efficient homes saving on energy bills and therefore have more discretionary income.[3]

Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed-through from landlords. Renters who do not pay directly for energy costs may see some of the net savings depending on if and how landlords account for energy cost when determining rent prices.

On average, low-income families spend less on energy than higher income families, however lower income families spend a much larger portion of their incomes on energy (Association, National Energy Assistance Directors, 2011). Thus it seems reasonable that low-income families would disproportionately benefit from Title 24, Part 6 Standards that reduce residential energy costs.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

The energy savings analysis relied on the CBECC-Res software to estimate energy use for single family and multifamily prototype buildings by comparing the current requirements to the proposed requirements. Other than the windows and doors, all other modeled building energy features meet current prescriptive requirements. The latest 2019 TDV values were used, as updated on February 13, 2017.

4.2 Energy Savings Methodology

To assess the energy, demand, and energy cost impacts, the Statewide CASE Team compared current 2016 prescriptive design practices to design practices that would comply with the proposed requirements. While not included in this report, a number of other performance levels were analyzed including cases with triple glazing, low emissivity coatings on glazing surfaces facing conditioned space, overhangs, and reduced glazing area impacts.

The Energy Commission provided guidance on the type of prototype buildings that must be modeled. Residential single family energy savings are calculated using two prototypes (a 2,100 ft^2 single story and a 2,700 ft^2 two story) available with the CBECC-Res software tool. Residential results are weighted 45 percent for the 2,100 ft^2 prototype and 55 percent for the 2,700 ft^2 prototype. Multifamily savings are calculated based on a multifamily prototype (an 8-unit, 6,960 ft^2 two story building), also available in CBECC-Res. Details on the prototypes are available in the ACM Approval Manual (Energy Commission 2015).

Table 4 presents the details of the prototype buildings used in the analysis. Additional prototype details can be found in Appendix C.

[3] For example, see US EPA's ENERGY STAR® website for examples: http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=CA.

Table 4: Prototype Buildings used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype ID	Occupancy Type	Area (ft^2)	Number of Stories	Statewide Area (million ft^2)
New Construction Prototype 1	Residential single family	2,100	1	110.6
New Construction Prototype 2	Residential single family	2,700	2	173.8
New Construction Prototype 3	Residential low-rise multifamily	6,960	2	45.7

The energy savings from this measure vary by Climate Zone and between single family and multifamily building type. As a result, the energy impacts and cost-effectiveness were evaluated by Climate Zone and building type.

Energy savings, energy cost savings, and peak demand reductions were calculated using a TDV methodology. The latest 2019 TDV multipliers (updated February 2017) were applied.

4.3 Per-Unit Energy Impacts Results

All result tables in Sections 4 and 5 present results for both a composite single family dwelling unit (weighted by one-story, two-story ratio) and for the eight-unit multifamily prototype. Results are shown by climate zone, and aggregated both on a statewide construction "weighted" average basis, as well as on a straight numerical average basis.

Results reported in these sections are shown for the combined savings of the proposed windows and doors measure on the new construction prototypes. For Climate Zones 2, 4, and 6-15, this includes a 0.30 U-factor and 0.23 SHGC for the windows. For Climate Zones 1, 3, 5, and now 16, the proposal is for a 0.30 U-factor and no requirement for SHGC, which is modeled as a 0.50 SHGC. Opaque doors in all Climate Zones are modeled with a 0.20 U-factor.

The results for Climate Zone 16 show an increase in kWh and a decrease in therms because there are higher TDV savings with a higher SHGC than the current lower SHGC values, as described in Section 3.2.2. The decrease in U-factor to 0.30 has the highest impact in the Climate Zones 1, 3, 5 and 16 that have the highest proportion of heating loads.

Energy savings and peak demand reductions per unit for the blended single family prototype (45 percent one story, 55 percent two story) and the multifamily eight-unit prototype (new construction) are presented in Table 5 and Table 6, respectively. While there is some variance in kWh, kW and therm savings, the TDV energy impact is positive in all Climate Zones.

See Section 6 of this report for estimated statewide savings from additions and alterations. The per unit energy savings estimates do not take naturally occurring market adoption or compliance rates into account.

Table 5: First-Year Energy Impacts per Single Family Dwelling Unit – New Construction

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	17	0.00	21	4,788
2	10	0.04	3	2,576
3	8	0.00	11	2,605
4	14	0.06	1	3,164
5	9	0.00	12	2,770
6	9	0.03	-1	1,463
7	3	0.02	-1	505
8	26	0.07	0	3,500
9	44	0.08	0	3,426
10	57	0.10	0	4,135
11	96	0.11	3	6,120
12	47	0.12	3	5,041
13	97	0.11	4	6,143
14	88	0.11	2	5,748
15	198	0.14	0	8,623
16	-159	-0.71	139	18,442
Weighted Average	**47**	**0.06**	**6**	**4,713**
Average	**35**	**0.02**	**12**	**4,941**

Table 6: First-Year Energy Impacts per Multifamily Building (8-unit prototype) – New Construction

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	29	-0.03	60	13,363
2	72	0.15	23	11,832
3	-9	-0.02	26	4,802
4	89	0.24	18	12,041
5	-31	-0.08	24	2,854
6	57	0.09	6	6,542
7	34	0.12	1	4,594
8	107	0.16	4	9,326
9	160	0.30	7	13,850
10	202	0.33	8	15,590
11	317	0.35	26	23,386
12	198	0.29	25	18,653
13	331	0.38	23	23,594
14	297	0.34	22	21,924
15	701	0.54	1	31,390
16	-739	-1.39	288	28,814
Weighted Average	**105**	**0.16**	**21**	**12,389**
Average	**114**	**0.11**	**35**	**15,160**

5. LIFECYCLE COST AND COST-EFFECTIVENESS

5.1 Energy Cost Savings Methodology

Time Dependent Valuation (TDV) energy is a normalized format for comparing electricity and natural gas cost savings that takes into account the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 30 years. The TDV cost impacts are presented in 2020 present value (PV) dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBtu." Peak demand reductions are presented in peak power reductions (kW). The Energy Commission derived the 2020 TDV values that were used in the analyses for this report (Energy + Environmental Economics 2016).

In order to quantify energy savings and peak electricity demand reductions resulting from the proposed measure, the CBECC-Res software was used. Simulations were conducted using recent development versions of the software that incorporate the 2019 TDV values with minor updates described below to the Standard Design to better reflect existing conditions.

1. The Energy Commission expects to adopt the ANSI/ASHRAE Standard 62.2-2016 (ASHRAE, 2016), which requires higher mechanical ventilation airflows for single family homes than the 2010 version of the Standard (the 2010 Standard is the current requirement in California). The proposed 62.2-2016 airflows have been included in both the standard design and the proposed design for the single family analysis. There is no change in ventilation requirements for

multifamily; therefore, no adjustments were made for ventilation rates in the multifamily prototype.

2. The 2016 California Plumbing Code (CA BSC, 2016c) includes requirements that all hot water pipes be insulated. The next release of CBECC-Res is expected to incorporate this requirement, but the current release does not. The standard design and the proposed design have been adjusted to include pipe insulation for both the single family and the multifamily analyses.

3. The next release of CBECC-Res is expected to automatically degrade all R-19 insulation to an installed value of R-18, due to compression of the batt in a 2x6 wall cavity. This affects the standard design, because the 0.051 U-factor requirement is modeled as a wall with R-19 cavity insulation. The appropriate degradation to R-18 was applied to the standard design for the single family and multifamily analyses.

5.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings over the 30-year period of analysis are presented in Table 7 and Table 8 for single family and multifamily new construction, respectively. While there is some variance between the savings for electricity and gas, the total for each climate zone is positive, indicating that the proposed measures are cost-effective if the cost is less than the present value of the savings. Savings and costs represent the combined impact of the windows and doors measure.

Table 7: TDV Energy Cost Savings Over 30-Year Period of Analysis – per Single Family Dwelling Unit – New Construction

Climate Zone	30-Year TDV Electricity Cost Savings (2020 PV$)	30-Year TDV Natural Gas Cost Savings (2020 PV$)	Total 30-Year TDV Energy Cost Savings (2020 PV $)
1	$90	$741	$831
2	$339	$102	$441
3	$42	$413	$455
4	$485	$58	$543
5	$46	$438	$483
6	$272	-$21	$251
7	$119	-$37	$81
8	$598	$1	$599
9	$574	$15	$589
10	$701	$10	$711
11	$927	$132	$1,059
12	$732	$136	$868
13	$927	$136	$1,063
14	$921	$69	$990
15	$1,473	$14	$1,488
16	-$1,852	$5,091	$3,239
Weighted Average	**$576**	**$237**	**$814**
Average	**$400**	**$456**	**$856**

Table 8: TDV Energy Cost Savings Over 30-Year Period of Analysis – per 8-unit Multifamily – New Construction

Climate Zone	30-Year TDV Electricity Cost Savings (2020 PV$)	30-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 30-Year TDV Energy Cost Savings (2020 PV$)
1	$181	$2,191	$2,372
2	$1,132	$891	$2,023
3	-$84	$987	$903
4	$1,409	$662	$2,071
5	-$325	$915	$590
6	$891	$241	$1,132
7	$771	$24	$795
8	$1,457	$157	$1,613
9	$2,119	$265	$2,384
10	$2,372	$325	$2,697
11	$3,058	$987	$4,046
12	$2,276	$951	$3,227
13	$3,203	$879	$4,082
14	$2,938	$855	$3,793
15	$5,406	$36	$5,442
16	-$5,382	$10,668	$5,286
Weighted Average	**$1,386**	**$773**	**$2,159**
Average	**$1,339**	**$1,315**	**$2,653**

5.3 Incremental First Cost

The Statewide CASE Team estimated the current incremental construction cost, which represent the incremental cost of the measure if a building meeting the proposed standard were built today. Per the Energy Commission's guidance, design costs are not included in the incremental first cost. Incremental first costs are shown in Table 9.

On a per ft^2 basis, the incremental costs are the same for new construction, additions and alterations.

Table 9: Summary of Incremental Costs Applied in the Analysis

Product Type	Description	Material Cost/Unit	Additional Labor Cost/Unit[a]	Total Cost/Unit Including Markup[b]	Unit
Proposed Window	0.32 to 0.30 U-factor	$0.15	$0.00	$0.195	Per ft^2 Window
Proposed Door	Uninsulated to Insulated	$1.00	$0.00	$1.30	Per ft^2 Door

a. **Additional Labor Cost/Unit:** This cost only includes incremental labor relative to the base case.

b. **Total Cost/Unit Including Markup:** Total costs are presented as costs to the builder. A 30% overhead and profit markup was applied to all material costs presented.

Table 10 presents incremental costs for the proposed measure relative to this base case for the three residential prototypes. On a per building basis, incremental costs are larger for the multifamily prototype because the fenestration areas are larger as shown in Appendix C.

Table 10: Projected Incremental Costs for the Proposed High Performance Fenestration Measure

Measure	2,100 ft^2 Single Family Prototype	2,700 ft^2 Single Family Prototype	Averaged Single Family Prototypes (45% 2,100 ft^2, 55% 2,700 ft^2	8-unit, 6,960 ft^2 Multifamily Prototype
Proposed Windows and Doors	$134	$157	$147	$412

5.4 Lifetime Incremental Maintenance Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the period of analysis. The present value of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2019 TDV. The present value of maintenance costs that occurs in the nth year is calculated as follows:

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left[\frac{1}{1+\text{d}}\right]^{\text{n}}$$

The useful life of the proposed measure is expected to be the lifetime of the home or apartment. There are no anticipated incremental maintenance requirements for high performance fenestration products.

5.5 Lifecycle Cost-Effectiveness

This measure proposes a prescriptive requirement. As such, a lifecycle cost analysis is required to demonstrate that the measure is cost-effective over the 30-year period of analysis.

The Energy Commission establishes the procedures for calculating lifecycle cost-effectiveness. The Statewide CASE Team collaborated with Energy Commission staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. In this case, incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The TDV energy cost savings from electricity and natural gas savings were also included in the evaluation.

Design costs were not included nor was the incremental cost of code compliance verification.

According to the Energy Commission's definitions, a measure is cost-effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the total present lifecycle cost benefits by the present value of the total incremental costs.

Table 11 and Table 12 show the projected lifecycle cost-effectiveness for the combined high performance window and door measure.

Table 11: Lifecycle Cost-Effectiveness Summary per Single Family Dwelling Unit – New Construction

Climate Zone	Benefits TDV Energy Cost Savings + Other Present Value Savings[a] (2020 PV$)	Costs Total Incremental Present Valued Costs[b] (2020 PV$)	Benefit-to-Cost Ratio
1	$831	$147	5.7
2	$441	$147	3.0
3	$455	$147	3.1
4	$543	$147	3.7
5	$483	$147	3.3
6	$251	$147	1.7
7	$81	$147	0.6
8	$599	$147	4.1
9	$589	$147	4.0
10	$711	$147	4.8
11	$1,059	$147	7.2
12	$868	$147	5.9
13	$1,063	$147	7.2
14	$990	$147	6.7
15	$1,488	$147	10.1
16	$3,239	$147	22.1
Weighted Average	**$814**	**$147**	**5.5**
Average	**$856**	**$147**	**5.8**

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

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement and maintenance costs over the period of analysis. Costs are discounted at a real (inflation adjusted) 3 percent rate. Includes incremental first cost if proposed first cost is greater than current first cost. Includes present value of maintenance incremental cost if PV of proposed maintenance costs is greater than the PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

Table 12: Lifecycle Cost-Effectiveness Summary per 8-Unit Multifamily Building Type – New Construction

Climate Zone	Benefits TDV Energy Cost Savings + Other Present Value Savings[a] (2020 PV$)	Costs Total Incremental Present Valued Costs[b] (2020 PV$)	Benefit-to-Cost Ratio
1	$2,372	$412	5.8
2	$2,023	$412	4.9
3	$903	$412	2.2
4	$2,071	$412	5.0
5	$590	$412	1.4
6	$1,132	$412	2.7
7	$795	$412	1.9
8	$1,613	$412	3.9
9	$2,384	$412	5.8
10	$2,697	$412	6.6
11	$4,046	$412	9.8
12	$3,227	$412	7.8
13	$4,082	$412	9.9
14	$3,793	$412	9.2
15	$5,442	$412	13.2
16	$5,286	$412	12.8
Weighted Average	**$2,159**	**$412**	**5.2**
Average	**$2,653**	**$412**	**6.4**

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

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement and maintenance costs over the period of analysis. Costs are discounted at a real (inflation adjusted) 3 percent rate. Includes incremental first cost if proposed first cost is greater than current first cost. Includes present value of maintenance incremental cost if PV of proposed maintenance costs is greater than the PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

6. FIRST-YEAR STATEWIDE IMPACTS

6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction by multiplying the per-unit savings, which are presented in Section 4.3, by the statewide new construction forecast for 2020, which is presented in more detail in Appendix A. The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2020, for all Climate Zones. The lifecycle energy cost savings represents the energy cost savings over the entire 30-year analysis period. Results are presented in Table 13 for new construction.

Table 13: Statewide Energy and Energy Cost Impacts (Combined Single Family and Multifamily) – New Construction

Climate Zone	Statewide Construction in 2020 (units)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	Lifecycle[b] Present Valued Energy Cost Savings (PV $ million)
1	576	0.008	0.000	0.010	$0.41
2	4,672	0.047	0.148	0.013	$1.80
3	19,928	0.082	-0.036	0.169	$6.74
4	11,283	0.149	0.574	0.020	$5.17
5	2,191	0.009	-0.009	0.019	$0.76
6	9,829	0.124	0.302	0.003	$2.88
7	9,718	0.039	0.190	-0.006	$0.92
8	15,100	0.434	0.935	0.006	$8.53
9	22,642	1.030	1.916	0.025	$14.45
10	22,590	1.202	2.030	0.011	$15.16
11	4,695	0.405	0.459	0.015	$4.53
12	25,438	1.032	2.524	0.081	$18.80
13	8,409	0.725	0.791	0.027	$7.98
14	4,240	0.351	0.426	0.009	$4.01
15	3,657	0.703	0.511	0.001	$5.30
16	4,629	-0.681	-2.584	0.509	$11.56
TOTAL	**169,597**	**5.660**	**8.174**	**0.915**	**$109.01**

a. First-year savings from all buildings completed statewide in 2020.

b. Energy cost savings from all buildings completed statewide in 2020 accrued during 30-year period of analysis.

The approach to estimate energy savings for additions and alterations is based on the methodology applied in the impact analysis report for the 2016 Title 24, Part 6 updates. In the impact analysis, the projected savings for new construction buildings were increased by 43 percent to account for additions and alterations. The 43 percent factor was based on the dollars spent on new construction compared to that spent on additions and alterations according to 2011 data from the Construction Industry Research Board. In the absence of better information, it is assumed that additions represent half of the total dollars spent on additions and alterations. Table 14 shows the impacts for additions and alterations.

Table 14: Statewide Energy and Energy Cost Impacts (Combined Single Family and Multifamily) – Additions and Alterations

Building Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	Lifecycle Present Valued Energy Cost Savings (PV $ million)
Additions	1.217	1.757	0.197	$23.44
Alterations	1.217	1.757	0.197	$23.44
TOTAL	**2.434**	**3.515**	**0.393**	**$46.87**

6.2 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.3 Statewide Material Impacts

The proposed code change will not result in impacts to toxic materials or materials which require significant energy inputs.

6.4 Other Non-Energy Impacts

Non-energy benefits of the proposed measures include improved occupancy comfort and increased property valuation.

7. PROPOSED REVISIONS TO CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

7.1 Standards

The proposed measure will require updating the definitions section 100.1(b), prescriptive section 150.1(c)5 and Table 150.1-A.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

(b) **Definitions**

CHANGE #1- Revise definitions as follows in 100.1(b):

DOOR is an operable opening in the building envelope, including swinging and roll-up doors, fire doors, pet doors and access hatches with less than ~~50~~ 25-percent glazed area. When that operable opening has ~~50~~ 25 percent or more glazed area it is a glazed door. See Fenestration: Glazed Door.

GLAZED DOOR is an exterior door having a glazed area of ~~50~~ 25 percent or greater of the area of the door. Glazed doors shall meet fenestration product requirements. See: Door.

FENESTRATION AREA for windows in nonresidential buildings is the total window rough opening area which includes the fenestration, fenestration frame components in the exterior walls and roofs. Fenestration area in low-rise residential buildings is the total window, skylight and glazed door rough opening area which includes the fenestration, fenestration frame components in the exterior walls and roofs.

CHANGE #2- Add the following definition as follows after door definition in 150.1(b):

DOOR AREA for doors other than glazed doors is the total door rough opening area which includes the door fenestration, door fenestration frame components in the exterior walls and roofs.

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCEAPPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS

(c) **Prescriptive Standards/Component Package**

CHANGE #3- Revise 150.1(c)3 to:

3. **Fenestration.**
A. Installed fenestration products, including glazed doors, shall have an area weighted average U-factor and SHGC ~~no greater than the~~ meeting the maximum or minimum applicable fenestration value in TABLE 150.1-A and shall be determined in accordance with Sections 110.6(a)2 and 110.6(a)3.

CHANGE #4- Revise the currently reserved 150.1(c)5 to:

5. **~~RESERVED~~ Doors.**
A. Installed swinging door products separating conditioned space from outside or adjacent unconditioned space, but not including glazed door products, shall have an area weighted average U-factor no greater than the applicable door value in TABLE 150.1-A and shall be determined in accordance with Sections 110.6(a)2. Glazed door products are treated as fenestration products in 150.1(c)3 and 150.1(c)4.

EXCEPTION 1 to Section 150.1(c)5: Swinging doors between the garage and conditioned space that are required to have fire protection are not required to meet the applicable door value in TABLE 150.1-A.

CHANGE #5- Revise Table 150.1-A to have the new fenestration and door requirements:

TABLE 150.1-A COMPONENT PACKAGE-A STANDARD BUILDING DESIGN

		Climate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Building Envelope	Fenestration	Maximum U-factor	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~
		Maximum SHGC	NR	0.23 ~~5~~	NR	0.23 ~~5~~	NR	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	0.23 ~~5~~	~~0.25~~ NR
		Maximum Total Area	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
		Maximum West Facing Area	NR	5%	NR	5%	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	~~5%~~ NR
	Door	Maximum U-factor	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

ALTERNATIVE CHANGE #5a instead of CHANGE #5 - Revise Table 150.1-A to have the new fenestration and door requirements and to add minimum SHGC in Climate Zones 1, 3, 5, and 16:

TABLE 150.1-A COMPONENT PACKAGE-A STANDARD BUILDING DESIGN

		Climate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Building Envelope	Fenestration	Maximum U-factor	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~	0.30 ~~2~~
		Maximum or Minimum SHGC	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.35 Min ~~0.25~~
		Maximum Total Area	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
		Maximum West Facing Area	NR	5%	NR	5%	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	~~5%~~ NR
	Door	Maximum U-factor	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

SECTION 150.2 – ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS TO EXISTING LOW-RISE RESIDENTIAL

BUILDINGS

(a) **Additions.**

1. **Prescriptive approach**

B. Additions that are 700 square feet or less shall meet all the requirements of Section 150.1(c) except:

iii. In Climate Zones 2, 4 and 6-1~~6~~5; the maximum allowed west-facing fenestration area shall not be greater than 60 square feet; and shall also comply with either a or b below:

(b) **Alterations.**

1. **Prescriptive approach.**

B. **Replacement Fenestration.**

EXCEPTION 1 to Section 150.2(b)1B: Replacement of vertical fenestration no greater than 75 square feet with a U-factor no greater than 0.40 in Climate Zones 1-16, and a SHGC value no greater than 0.35 in Climate Zones 2, 4, and 6-1~~6~~5.

7.2 Reference Appendices

The proposed measure will require changes to the glossary and Table 4.5.1 door U-factors.

Appendix JA1 – Glossary

Change #1 – Add definition of door to match Standards 100.1(b):

DOOR is an operable opening in the building envelope, including swinging and roll-up doors, fire doors, pet doors and access hatches with less than ~~50~~ 25 percent glazed area. When that operable opening has ~~50~~ 25 percent or more glazed area it is a glazed door. See Fenestration: Glazed Door.

Change #2 – Revise glazed door and fenestration area to match Standards 100.1(b):

GLAZED DOOR is an exterior door having a glazed area of ~~50~~ 25 percent or greater of the area of the door. Glazed doors shall meet fenestration product requirements. See: Door.

FENESTRATION AREA for windows in nonresidential buildings is the total window rough opening area which includes the fenestration, fenestration frame components in the exterior walls and roofs. Fenestration area in low-rise residential buildings is the total window, skylight and glazed door rough opening area which includes the fenestration, fenestration frame components in the exterior walls, and roofs.

JA4.5 Miscellaneous Construction

Table 4.5.1 – Doors

Change #3 – Strike row 7 as NFRC ratings are required for any value lower than 0.5 Btu/hr-ft2-F.

Description		U-factor (Btu/°F-ft^2)
		A
~~Insulated single layer metal *sectional doors*, minimum insulation nominal thickness of 1-3/8 inch; expanded polystyrene (R-4 per inch).~~	~~7~~	~~0.179~~

7.3 ACM Reference Manual

This proposed measure will require modification to the description of the Standard Design doors in section 2 of the Residential ACM Reference Manual. The windows already reference Standards Table 150.1-A which will be updated as part of this proposal.

SECTION 2 – The Proposed Design and Standard Design

2.5.6.5 *Doors*

PROPOSED DESIGN

The compliance software shall allow users to enter doors specifying the U-factor, area, and orientation. Doors to the exterior or to unconditioned zones are modeled as part of the conditioned zone. For doors with less than ~~50~~25 percent glass area, the U-factor shall come from *JA4, Table 4.5.1* (default U-factor 0.50), or from NFRC certification data for the entire door. For unrated doors, the glass area of the door, calculated as the sum of all glass surfaces plus two inches on all sides of the glass (to account for a frame), is modeled under the rules for fenestrations; the opaque area of the door is considered the total door area minus this calculated glass area. Doors with ~~50~~25 percent or more glass area are modeled under the rules for fenestrations using the total area of the door. When modeling a garage zone, large garage doors (metal roll-up or wood) are modeled with a 1.0 U-factor.

STANDARD DESIGN

The standard design has the same door area for each dwelling unit as the proposed design. The standard design door area is distributed equally between the four main compass points—north, east, south and west. ~~All doors are assumed to have a U-factor of 0.50.~~ The U-factors for the standard design are taken from Section 150.1(c) and Table 150.1-A. The net opaque wall area is reduced by the door area in the standard design.

7.4 Compliance Manuals

The Residential Compliance Manual will need to be revised to match the proposed requirements and to describe the treating of doors and glazed doors.

7.5 Compliance Documents

Add a field to the CF1R to state where the performance values are from – either NFRC values or defaults.

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Appendix A: Statewide Savings Methodology

The projected new residential construction forecast that will be impacted by the proposed code change in 2020 is presented in Table 15.

The Statewide CASE Team estimated statewide impacts for the first year that new single family and multifamily buildings comply with the 2019 Title 24, Part 6 Standards by multiplying per-unit savings estimates by statewide construction forecasts that the California Energy Commission Demand Analysis Office provided. The construction forecast from the Energy Commission presented annual new construction estimates for single family and multifamily dwelling units by forecast climate zones (FCZ). The Statewide CASE Team converted estimates from FCZ, which are not used for Title 24, Part 6, to building standards climate zones (BSCZ) using a conversion factors that the Energy Commission provided. The conversion factors, which are presented in Table 16, represent the percentage of dwelling units in a FCZ that are also in a BSCZ. For example, looking at the first column of conversion factors in Table 16, 22.5 percent of the homes in FCZ 1 are also in BSCZ 1 and 0.1 percent of homes in FCZ 4 are in BSCZ 1. To convert from FCZ to BSCZ, the total forecasted construction in each FCZ was multiplied by the conversion factors for BSCZ 1, then all homes from all FCZs that are found to be in BSCZ 1 are summed to arrive at the total construction in BSCZ 1. This process was repeated for every climate zone. See Table 17 for an example calculation to convert from FCZ to BSCZ. In this example, BSCZ 1 is made up of homes from FCZs 1, 4, and 14.

After converting the statewide construction forecast to BSCZs, the Statewide CASE Team made assumptions about the percentage of buildings in each climate zone that will be impacted by the proposed code change. Assumptions are presented in Table 15.

Table 15: Projected New Residential Construction Completed in 2020 by Climate Zone[a]

Building Climate Zone	Single Family Buildings					Multifamily Dwelling Units[b]				
	Total Buildings Completed in 2020	Percent of Total Construction in Climate Zone	Percent of New Buildings Impacted by Proposal	Buildings Impacted by Proposal	Percent of Total Impacted by Proposal in Climate Zone	Total Dwelling Units Completed in 2020	Percent of Total Construction in Climate Zone	Percent of New Dwelling Units Impacted by Proposal	Dwelling Units Impacted by Proposal	Percent of Total Impacted by Proposal in Climate Zone
1	465	0.4%	100%	465	0.4%	111	0.2%	100%	111	0.2%
2	3,090	2.6%	100%	3,090	2.6%	1,582	3.0%	100%	1,582	3.0%
3	11,496	9.8%	100%	11,496	9.8%	8,432	16.1%	100%	8,432	16.1%
4	7,435	6.4%	100%	7,435	6.4%	3,848	7.3%	100%	3,848	7.3%
5	1,444	1.2%	100%	1,444	1.2%	747	1.4%	100%	747	1.4%
6	6,450	5.5%	100%	6,450	5.5%	3,379	6.4%	100%	3,379	6.4%
7	5,779	4.9%	100%	5,779	4.9%	3,939	7.5%	100%	3,939	7.5%
8	9,948	8.5%	100%	9,948	8.5%	5,153	9.8%	100%	5,153	9.8%
9	12,293	10.5%	100%	12,293	10.5%	10,350	19.7%	100%	10,350	19.7%
10	18,399	15.7%	100%	18,399	15.7%	4,191	8.0%	100%	4,191	8.0%
11	3,947	3.4%	100%	3,947	3.4%	747	1.4%	100%	747	1.4%
12	19,414	16.6%	100%	19,414	16.6%	6,023	11.5%	100%	6,023	11.5%
13	7,034	6.0%	100%	7,034	6.0%	1,375	2.6%	100%	1,375	2.6%
14	3,484	3.0%	100%	3,484	3.0%	756	1.4%	100%	756	1.4%
15	3,203	2.7%	100%	3,203	2.7%	454	0.9%	100%	454	0.9%
16	3,188	2.7%	100%	3,188	2.7%	1,441	2.7%	100%	1,441	2.7%
Total	**117,069**	**100%**		**117,069**	**100%**	**52,528**	**100%**		**52,528**	**100%**

Source: Energy Commission Demand Analysis Office

a. Statewide savings estimates do not include savings from mobile homes.

b. Includes high-rise and low-rise multifamily construction.

Table 16: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ)

		Building Standards Climate Zone (BSCZ)																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Forecast Climate Zone (FCZ)	**1**	22.5%	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	33.1%	0.2%	0.0%	0.0%	13.8%	100%
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.0%	75.7%	0.0%	0.0%	0.0%	2.3%	100%
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.9%	22.8%	54.5%	0.0%	0.0%	1.8%	100%
	4	0.1%	13.7%	8.4%	46.0%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	100%
	5	0.0%	4.2%	89.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	0.0%	100%
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	75.8%	7.1%	0.0%	17.1%	100%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	40.1%	0.0%	50.8%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	100%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	0.0%	26.9%	54.8%	0.0%	0.0%	0.0%	0.0%	6.1%	0.0%	5.8%	100%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.9%	0.0%	0.0%	0.0%	12.3%	7.9%	4.9%	100%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	27.0%	0.0%	30.6%	42.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	4.2%	95.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	100%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	69.6%	0.0%	0.0%	28.8%	0.0%	0.0%	0.0%	1.6%	0.1%	0.0%	100%
	14	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	100%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	100%
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Table 17: Converting from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ) – Example Calculation

Climate Zone	Total Statewide Single Family Homes by FCZ [A]	Conversion Factor FCZ to BSCZ 1 [B]	Single Family Homes in BSCZ 1 [C] = A x B
1	1,898	22.5%	427
2	8,148	0.0%	0
3	9,396	0.0%	0
4	16,153	0.1%	23
5	11,385	0.0%	0
6	6,040	0.0%	0
7	2,520	0.0%	0
8	12,132	0.0%	0
9	9,045	0.0%	0
10	21,372	0.0%	0
11	3,741	0.0%	0
12	4,746	0.0%	0
13	8,309	0.0%	0
14	518	2.9%	15
15	1,509	0.0%	0
16	159	0.0%	0
Total	117,069		**465**

Appendix B: DISCUSSION OF IMPACTS OF COMPLIANCE PROCESS ON MARKET ACTORS

This section discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. The Statewide CASE Team asked stakeholders for feedback on how the measure would impact various market actors during public stakeholder meetings that were held on September 14, 2016 and March 14, 2017 (Statewide CASE Team 2016). The key results from feedback received during stakeholder meetings and other target outreach efforts are detailed below.

Table 18 identifies the market actors who will play a role in complying with the proposed change, the tasks for which they will be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing work flow, and ways negative impacts could be mitigated.

The proposed measure does not present any significant challenges to compliance and enforcement. The compliance process generally fits within the current work flow of market actors, although some new tasks will be required (see Table 18). Market actors will continue to coordinate and collaborate with the same actors with whom they currently engage. There will not be any new documentation practices required, such as new compliance documents.

Table 18: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Builder	• Coordinate with design team & trades, such as the window and door contractors • Ensure construction superintendents know all the requirements • Schedule inspections & post forms onsite	• Meet project budgets & schedule • Minimal inspection failures • Minimal paperwork required • Owner satisfied • No warranty issues	• Improved windows and door may require the specification of a slightly different product	• Enhanced training materials Energy Code Ace content to streamline process
Architect/ Designer	• Identify any application issues (i.e., climate) related to improved windows and doors, as well as relevant requirements • Verify proposed windows and doors specification meets all code requirements • Develop required construction details for proposed windows and doors implementation approach • Coordinate with key subs, as needed, for example, window and door contractor • Provide correction comments if necessary	• Balances form/function to satisfy owner desires • Plans completed to concisely specify window and door requirements and installation details • Meet project budgets • Quickly and easily determine requirements based on scope • Quickly and easily determine if plans/specs match forms • Quickly and easily provide correction comments to resolve any issues	• Need to verify new calculations are compliant and match plans	• Enhanced training materials Energy Code Ace content to streamline process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Title 24 Consultant	• Confirm data on plans is compliant • Perform required calculations to confirm compliance • Provide feedback on the energy impact of improved windows and doors on compliance • Ensure builder is aware of code requirements	• Project team is clearly aware of requirements • Energy goals are met • Minimal plan check comments • Modeling can be completed in a straightforward and consistent manner (no code ambiguity)	• Note need for NFRC door labels when insulated doors are specified	• Consider adding field to CBECC-Res to specify the source of the U-factors and SHGC values as NFRC or default
Subcontractors	• Install product/components to meet requirements • Coordinate, as needed with other trades to ensure work does not negatively impact others	• Meet builder's schedule • Coordinate work activities with other subs to optimize implementation • Minimal inspection failures & callbacks • Minimal paperwork required • Finish within budget	• Install door products with NFRC labels	• Enhanced training materials/Energy Code Ace content to streamline process
Building Inspector/Plans Examiner	• Understand code requirements and verify they are met • Verify that CF-1R is consistent with building plans and meets compliance criteria for local jurisdiction • Verify that all paperwork is in order and CF-2R and CF-3Rs are signed off and certified • Sign occupancy permit	• Minimal paperwork • No additional time needed to demonstrate compliance	• Need to verify NFRC door labels	• None

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
HERS Rater	• Review CF2Rs • Make sure parties are aware of requirements • Verify QII is being met • Communicate any inspection issues • Submit CF-3R's	• Project meets QII requirements • Minimal inspection failures & callbacks • Minimal paperwork needed • Maintain positive relationships with team	• Help to refine installation details based on improved HERS inspection criteria	• Revise compliance document to streamline HERS verification step

Appendix C: PROTOTYPE DETAILS

Table 19 shows details on the residential prototypes applied in this analysis.

Table 19: Prototype Multiplier Details

Item	Description	Unit	Single Family New construction prototype 1	Single Family New construction prototype 2	Multifamily New construction prototype 3
1	Number of Dwelling Units		1	1	8
2	Floor Area	Square feet	2,100	2,700	6,960
3	Slab Perimeter	Linear feet	162	128	292
4	Wall Area	Square feet	1,018	2,130	3,760
5	Wall Area Between House and Garage	Square feet	250	250	0
6	Wall Area Between House and Attic	Square feet	0	42	0
7	Window Area	Square feet	420	540	1,044
8	Window Perimeter	Linear feet	351	457	1,114
9	Door Area	Square feet	20	20	160
10	Door Area Between House and Garage	Square feet	20	20	0
11	Door Perimeter	Linear feet	19	19	155