



Window Efficiency Requirements Upon Window Replacement

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Overview

Requirements for energy efficient replacement windows represent a major opportunity for energy and demand savings. Approximately half of the windows sold in California are replacement products representing a significant opportunity even though many replacements are already made with high performance windows.

Under current §152 standards language, replacement fenestration products (windows, glass doors and skylights) are exempt from U-factor and solar heat gain coefficient (SHGC) requirements. This proposal requires that residential fenestration replacement products meet the U-factor and SHGC levels found in the prescriptive package requirements.

The California Energy Commission has included replacement fenestration¹ as one of its key topic areas for the 2005 proceedings.

Description

The proposed language removes the exemption for replacement fenestration products and clarifies that they are covered as alterations.. Under modified language for alterations, replacement fenestration products would then have to meet labeling and prescriptive package requirements. The proposed language is clearly within the existing scope of the standards and consistent with the definition of an alteration that includes changes to the building's envelope:

ALTERATION is any change to a building's water-heating system, space-conditioning system, lighting system, or envelope that is not an addition.

An important consideration is defining replacement fenestration products as opposed to the repair of fenestration products. The current standards define a repair as:

REPAIR is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance. **Note:** Repairs to low-rise residential buildings are not within the scope of these standards.

It is the intent of this proposal to cover all types of replacement products under the standards except repairs. The proposed language for replacement fenestration is:

REPLACEMENT FENESTRATION is an alteration to the building envelope where all the glazing in an existing fenestration opening is replaced with a new manufactured fenestration product. **Note:** Glass replaced in an existing sash and frame, or replacement of a single sash in a multi-sash fenestration product are considered repairs.

This definition has been crafted to capture “retrofit” windows. “Retrofit” windows are used in the case where the existing frame is left in place, the existing sash and/or glass is removed, and a replacement window is installed over the existing frame. This is a very popular method of replacing windows because labor is minimized and it limits changes or damage to existing exterior finishes like stucco.

Two additional changes for fenestration products used in additions and alterations are also proposed. First, fenestration products used in additions of any size or in alterations would be required to meet the prescriptive package requirements. Existing language allows the use of fenestration in these cases with a U-factor up to 0.75. Secondly, in cases where fenestration area is being increased, language is proposed that limits the total fenestration area to the percentage specified in the prescriptive packages. This closes a longstanding loophole where it is possible to add any amount of fenestration area without regard for its energy impact as long as it was done as part of an alteration.

¹ Notice of Staff Workshop, October 22

For cases where meeting the package requirements is not desirable, the “existing plus alteration” performance approach may be used. It is also important to note that the package requirements (section 151(f)4) allow alternatives such as exterior shading devices to meet the solar heat gain coefficient requirement. Repairs remain exempt under this proposal.

If each of these changes are adopted, then the standards will uniformly require that the package requirements or performance alternatives be met no matter what type of construction—new, additions, alterations, or replacement fenestration—is proposed.

Benefits

There are many benefits to incorporating replacement windows and correcting outdated language for additions and alterations:

- Ensures that fenestration replacements in cooling climates (2,4,7-15) are required to have low solar gain, one of the most cost effective features studied in the AB970 process.
- Captures the energy and demand saving opportunity that might otherwise be missed on replacement fenestration and due to the U-factor exemption on additions and alterations.
- Makes it clear that fenestration replacements are covered under the standards and that they are required to be rated, certified, and labeled in accordance with §110 and §116 using either default or NFRC rated values.
- Allows the use of the Existing plus Alteration performance approach in §152(b)2B in cases where nonconforming fenestration products are desired.
- Makes the standards apply uniformly to window products no matter what type of construction is involved—new, additions, alterations or replacement.
- Reduces a loophole in the standards where a fenestration product can be replaced during an alteration with a poorer performing product.
- Reduces a loophole where fenestration can be added to a new home after final inspection without meeting at least the prescriptive package level of performance.

According to national window manufacturer association data², about 27% of the window market is for replacement windows of which vinyl and wood framed windows account for 90% of the units sold. Ninety one percent of the products sold have dual glazing and 40% of the products have a low-emissivity (low-e) coating. California accounts for 8.9% of the national window market of approximately 61 million units. Assuming that California follows the national trends, the market size for replacement windows in California is about 1.5 million windows per year. This means that the equivalent of 100,000 homes a year have windows replaced with the assumption of 15 windows per home. This compares to the 109,000 new single family dwellings used in the AB970 analysis completed during 2001. The potential energy and peak savings from encouraging the use of more efficient windows is significant.

Statewide energy savings for one year’s worth of replacement windows, reduced to account for energy efficient window replacements that would have occurred without this proposed change, is 250,000 therms, 10,125 MWh and 4,750 kW.

² *Study of the U.S. and Canadian Market for Windows and Doors*, AAMA/WDMA, April 2000

Environmental Impact

The lower U-factor and SHGC products required by this proposed change will reduce emissions by saving significant heating and cooling energy. Peak demand and its associated emissions will also be reduced. The products likely to be manufactured and installed as a result of this code change are already in wide use in construction in California. Additional environmental impacts due to manufacturing are believed to be negligible.

Type of Change

This proposal modifies the requirements for replacement fenestration, alterations and for additions less than 500 ft² to match prescriptive package requirements. As an alternative for cases where meeting the package requirements is not desired by the homeowner, the standards language supporting the use of “existing plus additions” and “existing plus alterations” performance approaches may be used under this proposal. A new definition for replacement fenestration is also proposed to distinguish the repair of a fenestration product from product replacement.

The standards already recognize alterations as a “change to a building’s...envelope that is not an addition”. This proposal modifies the standards to clarify that replacement fenestration is an alteration. However, the standards presently have a note providing an exemption for replacement fenestration in §152(b)2. This proposal deletes this note entirely (see Proposed Standards Language section below). The note in question was added to the 1992 standards when NFRC fenestration product ratings and lower U-factor products were not widely available. At this point, NFRC ratings and products like vinyl frames and low solar gain low-e windows that meet the prescriptive package requirements are widely available throughout California.

This proposal involves changes to the standards and to the *Residential Manual*. Replacement window manufacturers, replacement window contractors, window dealers, window retailers, building officials, and consumers will need information on this change.

Technology Measures

The lower U-factor and SHGC products likely to be manufactured and installed as a result of this code change are already in wide use and available throughout California. Virtually all fenestration manufacturers offer low solar gain products, and a large majority of manufacturers offer low U-factor products. All segments of the window industry—new home builders, remodelers and replacement window manufacturers—and all types of distribution models—builder direct, replacement contractors, building suppliers and retailers—regularly provide products that meet prescriptive package requirements to California’s building industry. Major retailers like Home Depot and Lowe’s now stock Energy Star window products that meet or beat prescriptive package fenestration performance levels.

Measure Availability and Cost

As part of the AB970 process, low solar gain low-e glass (low SHGC) and low conductance window frames (low U-factor) were analyzed for life cycle cost effectiveness at a range of prices from \$1.00 to \$3.00 per ft², with \$1.50 per ft² as the cost used for making package decisions. Both of these measures were some of the most cost effective studied.

Unique to the replacement situation is the fact that installation costs are typically higher than the product costs. As an example, a homeowner might pay \$500 per opening to have a replacement contractor remove the old window and replace it with a new window. The cost of the window may only be \$100 of the total installed cost. A replacement window that has low solar gain low-e glass might cost about \$20 more than clear glass. So on a percentage basis, the added cost of installing the more efficient product under this proposed change might be only 5 or 10% of the total window replacement cost.

In many cases homeowners are already making the choice to buy and install products that perform at or better than the prescriptive packages. Sources familiar with the replacement window industry believe that a large portion of the

replacement market already uses vinyl frames, and a growing share is using low solar gain low-e glass that meets the prescriptive requirements in the standards. This is partly because replacement products are often marketed directly to homeowners who can understand the benefits of a more efficient window and partly because salespeople know that selling a higher value product results in greater income. There are also replacements done by owners of rental houses, or people who are replacing windows to prepare a house for quick sale. These would be cases where the long term perspective, or the incentive to invest in better windows, is lacking. The proposed standard would make up for this deficiency in the market, by requiring better windows even when the owner wouldn't normally want to install them.

Useful Life, Persistence and Maintenance

The products installed under this code change will have approximately the same useful life, persistence and maintenance costs as the less efficient products that would have been installed without the influence of the standards.

Performance Verification

When a permit is obtained, a subsequent inspection may be required. In that case, a building inspector could verify the requirements by checking the window label.

Cost Effectiveness

The life cycle cost effectiveness of low solar gain glass on all orientations in the hotter climates (2,4,7-15) was established for new construction during the AB970 process and then assumed to apply to additions and alterations. Vinyl frames were also shown to be very cost effective in the AB970 analysis, but were not included in the prescriptive packages due to other factors. There is no reason to expect that the life cycle cost on window replacements would be different than the life cycle costs on additions and alterations.

Estimating the energy savings for replacement windows depends on many factors such as the existing windows, location, age, insulation levels, air leakage levels, site conditions like shading and many other factors. Detailed data about where replacement windows are sold, what type of windows are replaced and what replacement product is used is not readily available. In light of the lack of data, a simple estimate is appropriate.

The 2001 Database for Energy Efficiency Resources (DEER) Update Study³ has a statewide average use of 164 therms for heating, 1619 kWh for cooling and a cooling demand of 1.9 kW. If the window replacement saves 10%⁴ of the heating energy, 20% of the cooling energy and 10%⁵ of the cooling demand on the average, then the savings per home would be an average of 16 therms, 324 kWh and 0.19 kW.

To estimate life cycle cost effectiveness, consider the case of a 1500 ft² home with 223 ft² of window area (15% of floor area). The added cost for the low solar gain low-e glass at \$1.50 per ft² is \$335. Using the 30-year present worth multipliers⁶ of \$14.21 per therm and \$2.06 per kWh, the present value of the energy savings is (14.21 \$/therm

³ 2001 DEER Update Study, Xenergy for the California Energy Commission, August 2001

⁴ Based on the average results using Micropas for the 1761 ft² prototype with before 1978 building features found in Table 7-6 of the *Residential Manual*.

⁵ In a paper titled "Energy Savings and Pollution Prevention Benefits of Solar Heat Gain Standards in the International Energy Conservation Code", 2002, authors Arasteh (LBNL) and Prindle (ASE) found simulated demand savings ranging from 0.39 to 0.65 kW and field measured savings of 0.2kW to 1kW. The 10% figure is approximately the 0.52 kW simulated average divided by 4.8 kW typical of a 4 ton air conditioner.

⁶ Utility Cost Forecasts, Years 2005 through 2035, Eley Associates, February 2002

x 16 therms) + (2.06 \$/kWh x 324 kWh) = \$895. Since the added \$335 cost of replacement windows with low solar gain low-e glass is much less than the present value of the energy savings, the more efficient replacement windows are clearly cost effective and would remain cost effective more than double the cost.

If the same home is assumed to upgrade to both vinyl frames and low solar gain low-e, the initial cost estimate doubles to \$670. Even at this higher cost the replacement windows are clearly cost effective.

Statewide, assuming that 25% of the 100,000 homes (see discussion in Benefits section above) receiving replacement windows each year are influenced by this proposed change, the savings would be 250,000 therms, 10,125 MWh and 4,750 kW. A ten-year estimate can be obtained by multiplying the energy by 45⁷ and the demand by 9 assuming the savings begin at the end of the year. The ten-year estimates would be 11.25 million therms, 455,625 MWh and 42,750 MW.

Analysis Tools

In most cases, analysis tools will not be needed for compliance with the proposed prescriptive requirements. In cases where meeting the prescriptive requirements is not desirable, the existing plus alteration performance approach that is already part of the standards is referenced. No new analysis tools are required.

Relationship to Other Measures

One possible change to the 2005 standards is the lowering of the U-factor. If such a change is made, a likely target for U-factors is 0.50 in climate zones with no SHGC requirement and 0.40 in climate zones with the 0.40 SHGC requirement. These values are typical of low conductance products like vinyl, wood or fiberglass with either clear glass (0.50 case) or low solar gain low-e glass (0.40 case). The prescriptive package requirements in the current (2001) standards are as follows:

Climate Zone	U-factor	SHGC	Climate Zone	U-factor	SHGC
1	0.65	Any	9	0.75	0.40
2	0.65	0.40	10	0.65	0.40
3	0.75	Any	11	0.65	0.40
4	0.75	0.40	12	0.65	0.40
5	0.75	Any	13	0.65	0.40
6	0.75	Any	14	0.65	0.40
7	0.75	0.40	15	0.65	0.40
8	0.75	0.40	16	0.60	Any

As the proposed language changes rely on the performance levels found in the prescriptive packages, lower U-factors would apply to replacement fenestration products as well.

Methodology

The exemption for replacement windows has been recognized as an area for improvement for several building code cycles and was listed by the California Energy Commission as a topic for this proceeding during the AB970 effort. Research consisted of reviewing the standards language to identify a strategy to incorporate replacement fenestration

⁷ The homes replaced in the first year accrue savings for 9 years; the second year homes accrue 8 years and so forth

in the standard. Because a large portion of the residential window market is already consistent with the prescriptive standards, no research into product availability is necessary

Recommendations

The Commission should modify the standards to make it clear that replacement products are an alteration covered by the standards and must meet prescriptive package requirements. Additionally, additions of all sizes and alterations that increase fenestration area should be required to meet prescriptive package requirements. In cases where additional fenestration area is added, the added area should be limited so that the total fenestration area does not exceed the prescriptive package limits.

Proposed Standards Language

The following changes are proposed:

1. Add definition for “REPLACEMENT FENESTRATION” to §101(b) as follows: “**REPLACEMENT FENESTRATION** is an alteration to the building envelope where all the glazing in an existing fenestration opening is replaced with a new manufactured fenestration product. **Note:** Glass replaced in an existing sash and frame, or replacement of a single sash in a multi-sash fenestration product are considered repairs.”
2. Revise 152(a) exception 2 to read “**EXCEPTION 2 to Section 152 (a):** Any dual-glazed greenhouse window and dual-glazed skylight installed in an addition complies with the U-factor requirements in Section 151(f)3A.”
3. Revise 152(a)1A to read “Additions up to 100 square feet shall not exceed 50 square feet of glazing, and shall not exceed the ~~glazing~~ U-factor ~~shall not exceed 0.75~~, and the ~~glazing~~ Solar Heat Gain Coefficient requirements of sections 151(f)3A and 151(f)4 as ~~shall not exceed the value~~ specified in Alternative Component Package D (Tables 1-Z1 through 1-Z16); or”
4. Delete the exception in 152(a)1B “~~**EXCEPTION to Section 152 (a) 1 B:** If an addition is less than 500 square feet, glazing may have a U factor not to exceed 0.75 in lieu of any lower U factor required by the package.~~”
5. Revise 152(b) to read “**Alterations.** Alterations to existing residential buildings or alterations in conjunction with a change in building occupancy to a low-rise residential occupancy shall meet either Item 1 or 2 below. Replacement fenestration is an alteration.”
6. Delete note to 152(b)2 “~~**Note:** Fenestration products repaired or replaced, not as part of an alteration, need not comply with the U factor and Solar Heat Gain Coefficient requirements applicable to alterations.~~”
7. Revise 152(b)1A to read “Alterations that add fenestration area ~~to a building shall be limited to a maximum 0.75~~ not exceed the total glazing area. U-factor and ~~the~~ Solar Heat Gain Coefficient requirements of sections 151(f)3 and 151(f)4 2A ~~for new fenestration products~~ as specified in Alternative Component Package D (Tables 1-Z1 through 1-Z16).”
8. Insert a new 152(b)1B to read “Replacement fenestration shall not exceed the U-factor and Solar Heat Gain Coefficient requirements of sections 151(f)3A and 151(f)4 as specified in Alternative Component Package D (Tables 1-Z1 through 1-Z16).”
9. Revise exception in 152(b) to read “**EXCEPTION to Section 152 (b) 1 A:** Any dual-glazed greenhouse window and dual-glazed skylight installed as part of an alteration complies with the U-factor requirements in section 151(f)3A applicable to prescriptive alterations.”

Proposed ACM Language

Not applicable.

Bibliography and Other Research

Replacement windows are recognized in the 2000 *International Energy Conservation Code* (IECC, §502.2.5) and the 2000 *International Residential Code* published by the International Code Council. Like the language proposed here, these codes are based on prescriptive criteria, but allow performance type calculations as an option. IECC requirements are summarized in the following table.

Climate Zone*	Heating Degree Days HDD	MAXIMUM		MINIMUM					
		Fenestration U-factor	Fenestration Solar Heat Gain Coefficient SHGC*	Ceiling R-value	Wall R-value	Floor R-value	Basement wall R-value	Slab perimeter R-value and depth	Crawl space wall R-value
1-4	0 - 1,999	0.75	0.40	R-26	R-13	R-11	R-5	R-0	R-5
5-7	2,000 - 3,499	0.50	0.40	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
8	3500 - 3999	0.50	Any	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
9-12	4,000 - 5,999	0.40	Any	R-38	R-18	R-21	R-10	R-9, 2 ft.	R-19

* Climate Zones above 12 dropped.

With the exceptions of climate zones 1 and 16, all California climate zones are below 3500 heating degree days. These requirements are very similar to California prescriptive package requirements.

Additional discussion of the benefits of including replacement windows in the standards have been provided to the written and oral records by Cardinal Glass Industries during the AB970 process (00-ADM-01) in fall of 2000 and spring of 2001. They also provided additional testimony during staff workshops for the 2005 standards proceedings.

Potential stakeholders in the window industry that we contacted as part of this effort include:

- Jim Sweeny – Milgard Manufacturing. Window manufacturer. Milgard supports the inclusion of replacement windows and labeling requirements in the standards. Noted that there will be enforcement issues as a large majority of window replacements are made without building permits.
- Russ Taylor – Jeld-Wen, Inc. Window manufacturer. Supports bringing replacement windows under standard.
- David Oddo – Superior Windows. Window manufacturer. Strongly supports concept of including replacement windows under the standard as a major manufacturer of replacement windows because is promotes the use of low solar gain low-e products. Recalls that during 1992 proceeding, replacement windows without a building permit not subject to Title 24. Suggested concept that if U-factors get lowered in next standard that perhaps they should be lowered to values typical of a thermally improved (thermal break) aluminum product, not a vinyl product as there are situations where aluminum makes sense.
- Phil Linquist – Windowmaster, Inc. Window manufacturer. Overall a good move as would drive more low-e sales. May cause confusion to homeowners purchasing replacement windows at retail as to what product they need to install.

- Dariush Arasteh – LBNL. Input on market situation.
- Garrett Stone – Cardinal Glass Industries. Provide IECC code change language on how to define a replacement window to make sure we capture the case where the existing sash and/or glass is cut out but the existing frame is left in place. This is referred to as a “retrofit window” in this proposal.
- Jim O’Bannon – Richard Heath and Associates (consultant on IOU Statewide Residential Contractor Program (RCP)). Input on market situation. Under RCP program, found that almost all replacement windows already had labels. Estimates that 80% of replacement windows use the retrofit (“flush fin”) replacement method where the existing frame is left in place.
- Paul Thompson – Cardinal CG. Cardinal would like to see 0.40 SHGC requirement on replacement windows. Commented that replacement window segment is a market where dealers are selling directly to consumers and they are able to show the value of improved products. Different from new construction where builder cost and codes is the driver. Estimated that some of the mostly replacement window manufacturers are at 90% low solar gain low-e already. Provided industry contacts.

Acknowledgments

PG&E sponsored this proposal under direction of Pat Eilert. The contractor for this project is the Heschong Mahone Group. This proposal was written by Ken Nittler of Enercomp, Inc., with assistance of Mark Modera of Modera Consulting. See bibliography section below for a list of people in the window industry and experts on the window industry that were contacted as part of this effort.

Appendices

Not applicable.
