Pacific Gas and Electric Company

CASE Study for Residential Windows

2008 California Building Energy Efficiency Standards

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Purpose

The intent of this CASE study is to evaluate possible changes to the prescriptive U-factor and Solar Heat Gain Coefficient (SHGC) for residential fenestration products, to consider various measures and their energy and economic impacts, and to propose appropriate values for incorporation into the 2008 Energy Standards.

Overview

Description	This study proposes modifications to the fenestration U-factor and SHGC values in the reference Residential Alternative Component Package D. The new values are shown to be cost-effective, as required by the Warren-Alquist act. A new alternative component Package S is proposed for fenestration products with higher U-factors but with enhanced structural characteristics; the new package is shown to have energy equivalency to the proposed Package D. Industry standard structural rating systems were reviewed and a minimum structural criteria was set as a requirement for use of this package. Also recommended is the elimination of the currently footnoted Package D options that allow compliance without HERS verification.
Type of Change	The proposed changes consist of modification of the fenestration values in the reference Package D and addition of a new Package S. No changes are proposed to the Mandatory Measures or to the performance compliance methodology. Performance calculation results will be impacted by the new Package D U-factor and SHGC values used in calculating the Standard Design energy budget. The Standards and Residential Manual will be modified to include the proposed changes to Package D and inclusion of new Package S.
Energy Benefits	The revisions to reference Package D will yield energy savings in all climate zones when compared to current practice, reduce heating energy in most climate zones and reduce cooling energy in all zones. The cooling energy savings will reduce peak demand due to reduction of air conditioning loads due to use of more efficient fenestration products.
Non-Energy Benefits	None identified.
Environmental Impact	No adverse environmental impacts are known.

Technology Measures	The proposed Package D fenestration values are readily available in products from a large majority of window manufacturers. These values are currently met by the most commonly installed products in new California homes, and in the replacement window market. Vinyl, wood, fiberglass or other non-metal frame windows with low-E glass can achieve the Package D prescriptive fenestration values. Many metal frame windows using high performance low-E glass will be able to meet the new Package S prescriptive fenestration values, with the possible exception of climate zones 1 and 16. For these two zones, an alternative to the package S U-factor is allowed in combination with installation of a higher efficiency space heater. No useful life, maintenance or persistence issues are known.
Performance Verification	The currently required NFRC labels will continue to serve well as a performance verification tool. Builders and enforcement personnel are already trained to rely on the NFRC label to verify installation of the correct product.
Cost Effectiveness	Low-E glass, necessary to achieve most of the proposed fenestration values, was determined to be cost-effective in warmer climate zones at a $1.50 price differential during the AB970 proceedings. The price of low-E has come down dramatically since that time and is now cost-effective in several additional zones. The remaining specialty aluminum window manufacturers in California build primarily high-end products that are more costly than vinyl. In the production home market (the majority of homes built in the state) vinyl windows are also considered to be less costly than aluminum. The proposed prescriptive Package D fenestration values are shown to be cost effective in all climate zones. Net present value (NPV) of TDV savings exceeds the cost of upgrading to the proposed U-factor and SHGC values.
Analysis Tools	Current energy software tools are used to quantify energy savings and peak reduction for the proposed measures. No enhancements are required, other than the normal program updates to reflect other 2008 Standards measures.
Relationship to Other Measures	Currently, U-factors in prescriptive package D are higher than the values achieved by the most commonly installed window products. This differential between what is prescribed and what is typically installed allows builders to increase their compliance margin by increasing glass area or alternatively, to eliminate other conservation measures and still achieve compliance. The proposed values will closely align the standard energy budget with the standard window product.

Methodology

The essence of the proposed measure is a reduction to the fenestration U-factor and SHGC requirements for prescriptive component Package D. To evaluate appropriate U-factor and SHGC values and their energy impact, the following approach was taken:

1. Using CEC certified Micropas 7.1 compliance software, run the reference house in each of the 16 climate zones with the values in 2005 Package D.
2. Run the house again in each climate zone with various potential 2008 U-factor and SHGC values.
3. Evaluate the energy savings in each climate zone with the proposed values.
4. Determine the most beneficial values for each zone.
5. Assess the TDV energy savings achieved by the proposed values in each zone.
6. Compare the net present value of TDV savings to the cost premium associated with the upgraded measures.

Life cycle cost reductions are achieved in all climate zones with the proposed Package D measures. Additional calculations will be re-run in the near future to verify the proposed values when a version of Micropas for the 2008 Standards is available.

Development of the new prescriptive Package S was similar but without life-cycle cost calculations:

1. Run the reference house in all 16 climate zones with the proposed new Package D energy features.
2. Run it again in each climate zone with a higher fenestration U-factor and a variety of other conservation measures, seeking a package of features that achieved energy equivalence with Package D.
3. Identify an energy equivalent group of suitable features for each zone and incorporate those into Package S.
4. Review accepted structural rating systems and identify appropriate criteria for Package S.

Analysis and Results

Energy Savings Calculations

Micropas compliance runs were performed on the reference 1761 square foot house in each climate zone. Table A below gives the compliance margin (TDV savings) in kBtu/sq.ft./year for two scenarios, both showing savings compared to the current standard allowed energy use:

1. Proposed 2008 Package D with modified U-factor and SHGC. The values are for TDV savings beyond the current zero margin base house. All 16 climate zones show significant savings.
2. Proposed 2008 Package S with equivalent component measures. The values are for TDV savings beyond the current base. Package S components were selected to result in TDV savings equal to or better than proposed Package D. Note that Package S TDV savings were 2-5% less than proposed Package D in 3 climate zones, but a simple average across all 16 climate zones shows Package S to achieve savings almost 15% greater than the proposed Package D.

Table A: Compliance Margin in kBtu/sq.ft./year (*TDV savings*) by Climate Zone for proposed Package D with modified fenestration values and Package S with proposed fenestration and upgraded conservation measures.

Climate Zone	Proposed Package D	Proposed Package S
1	2.79	3.19
2	3.52	4.11
3	4.29	4.17
4	4.11	4.4
5	4.67	4.72
6	3.96	4.26
7	2.02	2.5
8	2.26	3.45
9	2.74	4.17
10	2.46	4.15
11	3.72	4.36
12	3.41	3.66
13	3.38	4.18
14	4.47	4.24
15	6.99	8.17
16	7.17	7.05
Average margin	3.87	4.42

Cost-Effectiveness Calculations

Package D, the proposed reference Alternative Component Package must be cost-effective. To determine cost-effectiveness, the Net Present Value of the TDV savings calculated for each climate zone must be greater than the differential cost of the proposed measure.

U-factor Upgrade costs

The 2005 version of Package D allows a U-factor of 0.67 in Climate Zones 3-9. This value can be achieved with some aluminum frame windows. The proposed Package D prescribes a U-factor of 0.40 in all climate zones, which cannot be met with most solid or thermal break metal frame products. California aluminum window manufacturers largely sell high-end windows intended for the custom home market at premium prices well above the cost of vinyl. However, some manufacturers make and sell both aluminum and vinyl frame products. One formerly 100% aluminum regional California manufacturer whose product line is now 96% vinyl frame stated that it is impossible for him to produce aluminum windows at a price lower than or equal to vinyl. His cost for aluminum has gone up 40% this year, such that his material costs are no more for vinyl than for an aluminum window.

Table B below shows Net Present Value savings far greater than any suggested incremental aluminum to vinyl frame cost in all relevant climate zones.

Table B: Net Present Value of TDV savings for Climate Zones 3-9

Climate Zone	TDV savings	House area	Window area	TDV/NPV factor	NPV proposed	NPV/ft. glass
3	4.29	1761	352.2	$0.16	$1,240.26	$3.52
4	4.11	1761	352.2	$0.16	$1,188.22	$3.37
5	4.67	1761	352.2	$0.16	$1,350.12	$3.83
6	3.96	1761	352.2	$0.16	$1,144.85	$3.25
7	2.02	1761	352.2	$0.16	$583.99	$1.66
8	2.26	1761	352.2	$0.16	$653.38	$1.86
9	2.74	1761	352.2	$0.16	$792.15	$2.25

SHGC Upgrade costs

The proposed Package D fenestration modifications will require low-E glass (or some other more expensive equivalent) in Climate Zones 5 and 6 to achieve the prescriptive SHGC value. Low-E glass is already required in Climate Zones 2, 4, and 7-15 and was shown to be cost-effective as part of the AB970 proceedings. At that time, the incremental cost of low-E was determined to average approximately $1.50 per square foot of window area. Since that time, low-E has become the glass of choice for most window manufacturers and their customers. Thus, the incremental cost of low-E has come way down; some California manufacturers charge purchasers $0.15 or less per square foot additional for low-E glass. Even recent generation very low SHGC products are overwhelmingly cost-effective. Table C below shows the NPV of the proposed TDV savings to be far greater than the incremental cost of low-E glass.

Table C: Net Present Value of TDV savings for Climate Zones 5 and 6

Climate Zone	TDV savings	Reference house floor/glass areas	TDV NPV all fuel types	NPV proposed	NPV/ sq. ft. glass
Zone 5	4.67 kBtu/ft/yr	1761/352.2 sq. ft.	$0.16	$1,330	$3.76
Zone 6	3.96 kBtu/ft/yr	1761/352.2 sq. ft.	$0.16	$1,145	$3.25

Conclusion

Although the proposed Package D values do not demand upgrade of both glass and frame type in any climate zone, the calculated NPV is great enough to easily offset the incremental cost of both in all climate zones. Note that all the calculations were run with 2005 compliance software but using 2008 NPV values. These will be re-visited and confirmed with 2008 software before adoption.

Recommendations

Proposed changes to the residential fenestration requirements are delineated in the following excerpts from the existing and proposed tables of prescriptive values.

The modified Table C (below) for alternative component Package D identifies the altered values in red with underscores. The footnotes allowing alternative compliance without HERS verification are eliminated as shown by strikethrough marking. These alternatives depended largely on improved window performance values to offset the absence of HERS verified measures, particularly tested duct leakage. As of mid-2005 there are more than 1400 certified HERS raters in California with many more expected by the time the 2008 Standards are implemented. It is likely that HERS raters will be available to verify required measures throughout the state.

The new Table S (below) for alternative component Package S offers an energy equivalent prescriptive compliance method for metal frame fenestration products. It offsets the allowance of higher fenestration U-factors with other upgraded conservation features and compels the use of products with a structural rating not required by other compliance measures. No change is proposed to the existing Table B for Alternative Component Package C (not shown).

CURRENT 2005 PACKAGE D REQUIREMENTS – unchanged

TABLE 151-C ALTERNATIVE COMPONENT PACKAGE D

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FENESTRATION																
Maximum U-factor[2]	0.57	0.57	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.57	0.57	0.57	0.57	0.57	0.57	0.55
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	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	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	NR

PROPOSED 2008 PACKAGE D U/SHGC – no other changes

TABLE 151-C ALTERNATIVE COMPONENT PACKAGE D

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FENESTRATION																
Maximum U-factor[2]	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	NR	0.40	**0.40**	**0.40**	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	**035**	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	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	NR

PROPOSED NEW PACKAGE S for 2008

Use of this package requires fenestration products with LC-25 or better rating per AAMA/WDMA/CSA 101/I.S.2/A440-05; alternates that may still be used include AAMA/WDMA 101/I.S.2/NAFS-02 and AAMA/WDMA 101/I.S.2-97. Future amendments to the AAMA/WDMA Standard shall be incorporated into this package as appropriate.

TABLE 151-S ALTERNATIVE COMPONENT PACKAGE S (Structural)

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BUILDING ENVELOPE																
Insulation minimums[1]																
Ceiling	R38	R30	**R38**	R30	**R38**	**R38**	R30	R30	R30	R30	R38	R38	R38	R38	R38	**R49**
Wood-frame walls	R21	**R19**	**R19**	**R19**	**R19**	**R19**	**R19**	**R19**	**R19**	**R19**	R19	R19	R19	R21	R21	R21
Radiant Barrier	NR	REQ	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	**REQ**
FENESTRATION																
Maximum U-factor[2]	0.50	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.45
Maximum Solar Heat Gain Coefficient (SHGC)[3]	**NR**	**0.40**	**0.40**	**0.25**	**0.40**	**0.40**	**0.25**	**0.40**	**0.40**	**0.40**	**0.25**	**0.25**	**0.30**	**0.25**	**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	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	NR
DUCTS																
Duct Insulation	**R-8**	R-6	**R-8**	R-6	R-6	R-4.2	R-4.2	R-4.2	R-6	R-6	**R-8**	**R-8**	**R-8**	R-8	R-8	R-8

7. As an alternative under Package S in climate zone 1, glazing with a maximum 0.57 U-factor and a 92% AFUE furnace or an 8.4 HSPF heat pump may be substituted for the package S glazing U-factor requirement. All other requirements of Package S must be met.

8. As an alternative under Package S in climate zone 16, glazing with a maximum 0.57 U-factor and a 90% AFUE furnace or an 8.4 HSPF heat pump may be substituted for the package S glazing U-factor requirement. All other requirements of Package S must be met.

Material for Compliance Manuals

The Energy Standards will require modification to include reference to new Alternative Component Package S.

The Residential Compliance Manual will be revised to incorporate the changes to Package D and Package D footnotes, and to include new Package S. A brief description in the Manual of the intent and requirements of new Package S should be included, perhaps with one Q&A example.

Acknowledgements

The Pacific Gas and Electric Company sponsored this report as part of its CASE (Codes and Standards Enhancement) Project. Fred Salisbury of PG&E is the project manager for this Residential CASE study. Pat Eilert is the program manager for the CASE program. Enercomp, Inc. is the contractor for the Residential Windows CASE project. The research, analysis and reporting was prepared by Ken Nittler of Enercomp and Bill Mattinson of SOLDATA Energy Consulting. Valuable editorial and research assistance was provided by Jana Edmondson of SOLDATA, Ray Bjerrum of Merzon Industries, Charlie Macher of Blomberg Window Systems, and Paul Thompson of Cardinal Glass.

Bibliography and Other Research

California Energy Commission, 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.

California Energy Commission, 2005 Building Energy Efficiency Standards Residential Compliance Manual.

California Energy Commission by Architectural Energy Corporation, Life Cycle Cost Methodology for 2008 California Building Energy Efficiency Standards.

American Architectural Manufacturers Association / Window and Door Manufacturers Association / Canadian Standards Association. AAMA/WDMA/CSA 101/I.S.2/A440-05 Standard/Specification for Windows, Doors and Unit Skylights.

Appendices

Appendix 1: Tables of Proposed Alternative Component Package Measures

The full text of the proposed new Tables and footnotes are presented in the following pages.

TABLE 151-C ALTERNATIVE COMPONENT PACKAGE D

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BUILDING ENVELOPE																
Insulation minimums[1]																
Ceiling	R38	R30	R30	R30	R30	R30	R30	R30	R30	R30	R38	R38	R38	R38	R38	R38
Wood-frame walls	R21	R13	R13	R13	R13	R13	R13	R13	R13	R13	R19	R19	R19	R21	R21	R21
"Heavy mass" walls	(R4.76)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R4.76)	(R4.76)	(R4.76)	(R4.76)	(R4.76)	(R4.76)
"Light mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Below-grade walls	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R13
Slab floor perimeter	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	R7
Raised floors	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19
Concrete raised floors	R8	R8	R0	R0	R0	R0	R0	R0	R0	R0	R8	R4	R8	R8	R4	R8
Radiant Barrier	NR	REQ	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
FENESTRATION																
Maximum U-factor[2]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	035	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	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	NR
THERMAL MASS[4]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SPACE-HEATING [5]																
Electric-resistant allowed	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
If gas, AFUE =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If heat pump, HSPF[6] =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE-COOLING																
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system,	NR	REQ[9]	NR	NR	NR	NR	NR	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	NR
Refrigerant charge measurement or Thermostatic Expansion valve																
DUCTS																
Duct sealing	REQ[8]	REQ[9]	REQ[10]	REQ[11]	REQ[10]	REQ[10]	REQ[10]	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	REQ[8]
Duct Insulation	R-6	R-6	R-6	R-6	R-6	R-4.2	R-4.2	R-4.2	R-6	R-6	R-6	R-6	R-6	R-8	R-8	R-8
WATER-HEATING	System shall meet Section 151 (f) 8 or Section 151 (b) 1															

Footnote requirements to TABLE 151-B and TABLE 151-C

1 The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see Section 151 (f) 1 A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by 0.65. Any insulation installed on heavy or light mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air. The exterior wall used to meet the R-value in parentheses cannot also be used to meet the thermal mass requirement.

2 The installed fenestration products shall meet the requirements of Section 151 (f) 3.

3 The installed fenestration products shall meet the requirements of Section 151 (f) 4.

4 If the package requires thermal mass, the thermal mass shall meet the requirements of Section 151 (f) 5.

5 Automatic setback thermostats shall be installed in conjunction with all space-heating systems in accordance with Section 151 (f) 9.

6 HSPF means "heating seasonal performance factor."

7 Electric-resistance water heating may be installed as the main water heating source in Package C only if the water heater is located within the building envelope and a minimum of 25 percent of the energy for water heating is provided by a passive or active solar system or a wood stove boiler. A wood stove boiler credit shall not be used in Climate Zones 8, 10, and 15, nor in localities that do not allow wood stoves.

~~*8 As an alternative under Package D in climate zones 1 and 16, glazing with a maximum 0.42 U-factor and a 90% AFUE furnace or a 7.6 HSPF heat pump may be substituted for duct sealing. All other requirements of Package D must be met.*~~

~~*9 As an alternative under Package D in climate zones 2, 8, and 9, glazing with a maximum 0.38 U-factor and maximum 0.31 SHGC may be substituted for duct sealing and either refrigerant charge measurement or a thermostatic expansion valve. All other requirements of Package D must be met.*~~

~~*10 As an alternative under Package D in climate zones 3, 5, 6 and 7, glazing with a maximum 0.42 U-factor may be substituted for duct sealing. All other requirements of Package D must be met.*~~

~~*11 As an alternative under Package D in climate zone 4, glazing with a maximum 0.38 U-factor and maximum 0.36 Solar Heat Gain Coefficient may be substituted for duct sealing. All other requirements of Package D must be met.*~~

~~*12 As an alternative under Package D in climate zones 10, 11, and 12, glazing with a maximum 0.38 U-factor and maximum 0.31 Solar Heat Gain Coefficient, and a minimum 13.0 SEER space cooling system may be substituted for duct sealing and either refrigerant charge measurement or a thermostatic expansion valve. All other requirements of Package D must be met.*~~

~~*13 As an alternative under Package D in climate zone 13, glazing with a maximum 0.38 U-factor and maximum 0.31 Solar Heat Gain Coefficient, and a minimum 15.0 SEER space cooling system may be substituted for duct sealing and either refrigerant charge measurement or a thermostatic expansion valve. All other requirements of Package D must be met.*~~

~~*14 As an alternative under Package D in climate zone 14, glazing with a maximum 0.38 U-factor and maximum 0.31 Solar Heat Gain Coefficient, and a minimum 16.0 SEER space cooling system may be substituted for duct sealing and either refrigerant charge measurement or a thermostatic expansion valve. All other requirements of Package D must be met.*~~

Use of this package requires fenestration products with LC-25 or better rating per AAMA/WDMA/CSA 101/I.S.2/A440-05; alternates that may still be used include AAMA/WDMA 101/I.S.2/NAFS-02 and AAMA/WDMA 101/I.S.2-97. Future amendments to the AAMA/WDMA referenced Standard shall be incorporated into this package as appropriate.

TABLE 151-S ALTERNATIVE COMPONENT PACKAGE S (Structural)

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BUILDING ENVELOPE																
Insulation minimums[1]																
Ceiling	R38	R30	R38	R30	R38	R38	R30	R30	R30	R30	R38	R38	R38	R38	R38	R49
Wood-frame walls	R21	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R21	R21	R21
"Heavy mass" walls	(R4.76)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R2.44)	(R4.76)	(R4.76)	(R4.76)	(R4.76)	(R4.76)	(R4.76)
"Light mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Below-grade walls	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R13
Slab floor perimeter	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	R7
Raised floors	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19	R19
Concrete raised floors	R8	R8	R0	R0	R0	R0	R0	R0	R0	R0	R8	R4	R8	R8	R4	R8
Radiant Barrier	NR	REQ	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
FENESTRATION																
Maximum U-factor[2]	0.50	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.50
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	0.40	0.25	0.40	0.40	0.25	0.40	0.40	0.40	0.25	0.25	0.30	0.25	0.25	0.40
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	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	NR
THERMAL MASS[4]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SPACE-HEATING [5]																
Electric-resistant allowed	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
If gas, AFUE =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If heat pump, HSPF[6] =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE-COOLING																
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system, Refrigerant charge measurement or Thermostatic Expansion valve	NR	REQ[9]	NR	NR	NR	NR	NR	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	NR
DUCTS																
Duct sealing	REQ[8]	REQ[9]	REQ[10]	REQ[11]	REQ[10]	REQ[10]	REQ[10]	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	REQ[8]
Duct Insulation	R-8	R-6	R-8	R-6	R-6	R-4.2	R-4.2	R-4.2	R-6	R-6	R-8	R-8	R-8	R-8	R-8	R-8
WATER-HEATING	System shall meet Section 151 (f) 8 or Section 151 (b) 1															

Footnote requirements to TABLE 151-S

1 The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see Section 151 (f) 1 A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by 0.65. Any insulation installed on heavy or light mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air. The exterior wall used to meet the R-value in parentheses cannot also be used to meet the thermal mass requirement.

2 The installed fenestration products shall meet the requirements of Section 151 (f) 3.

4 The installed fenestration products shall meet the requirements of Section 151 (f) 4.

4 If the package requires thermal mass, the thermal mass shall meet the requirements of Section 151 (f) 5.

5 Automatic setback thermostats shall be installed in conjunction with all space-heating systems in accordance with Section 151 (f) 9.

6 HSPF means "heating seasonal performance factor."

7. As an alternative under Package S in climate zone 1, glazing with a maximum 0.57 U-factor and a 92% AFUE furnace or a 8.4 HSPF heat pump may be substituted for the package S glazing U-factor requirement. All other requirements of Package S must be met.

8. As an alternative under Package S in climate zone 16, glazing with a maximum 0.57 U-factor and a 90% AFUE furnace or a 8.4 HSPF heat pump may be substituted for the package S glazing U-factor requirement. All other requirements of Package S must be met.

Appendix 2: Initial Project Announcement to Stakeholders

CASE Study for Residential Windows
To determine optimum U-factors and Solar Heat Gain Coefficients

Purpose
The intent of this CASE study is to evaluate possible changes to the prescriptive U-factor and Solar Heat Gain Coefficient (SHGC) for residential fenestration products, to consider various measures and their energy and economic impacts, and to propose appropriate values for incorporation into the 2008 Energy Standards.

Reference
The current Standards address residential windows (fenestration products) under Mandatory Measures and Prescriptive Packages for new construction, additions, and alterations. The mandatory measures set criteria for testing and labeling of fenestration products, establish default values for untested products, and set air leakage requirements. The prescriptive packages, specifically Compliance Package D, set the performance standard for fenestration products in terms of the U-factor and the SHGC. Details of the prescriptive fenestration measures are found in the Residential Compliance Manual and the Residential Alternative Compliance Manual (ACM). The prescriptive compliance methods dictate a maximum allowed U-factor and SHGC, while the performance approach allows use

of fenestration products with any U-factor or SHGC so long as offsetting conservation measures satisfy the allowed overall energy budget.

Current Practice
The current 2005 Standards set U-factors at 0.57 in zones 1, 2, and 10-15. Zones 3-6 are at 0.67, and zone 16 at 0.55. SHGC is currently set at 0.40 in zones 2, 4, and 10-15, with no SHGC requirement in zones 1, 3, 5-9, and 16. These values are similar to those found in the 1998 Standards and modified in 2001 to expand the SHGC requirement to additional climate zones and adjustment of U-factors to account for changes in the National Fenestration Rating Council (NFRC) U-factor test procedure. Maximum U-factor values are defined for all climate zones and SHGC criteria only apply to climate zones with significant cooling loads. Glazing area as a percentage of floor area is fixed at 20% for all climate zones and west-facing glazing is limited to 5% in cooling zones. Additions, alterations, and replacement windows must meet the same criteria, with some exceptions for small projects.

Issues and potential barriers to change
The sum of measures included in the prescriptive packages is required by law to be cost-effective. However, for several reasons, the measures set in the packages may not always represent the most cost-effective products. This appears to be the case for residential windows.

The California window market shifted over the last decades from primarily aluminum frames to the current dominance of vinyl products. The concurrent emergence of low solar heat gain low emissivity (lowE) insulated glass was recognized and incorporated into the Standards by setting the prescriptive SHGC at 0.40 in cooling climates. That target could be met by any double pane window with the appropriate glass coating, regardless of frame type. The current prescriptive U-factors can be achieved with many aluminum products utilizing double pane lowE glass or can be far surpassed with non-metal frames of vinyl, wood, fiberglass or composite materials. With U-factors and SHGC values often both well under 0.40 for common vinyl windows, builders are currently able to eleminate other conservation measures or increase glass area when they choose those products.

As vinyl production has increased, the product price has dropped to a level roughly equal to aluminum. California builders are choosing vinyl frame windows with lowE glass for most new homes and homeowners are largely making the same choice for replacement windows. In fact, many large home improvement retailers no longer stock aluminum products, displaying only vinyl and wood windows – most with lowE glass.

That does not mean that aluminum products have or should entirely disappear from the California market. Some designers will prefer or require aluminum frame windows in new homes for aesthetic or structural reasons and some homeowners will wish to match the look of their original windows when adding or replacing fenestration products in an existing home. Since there is no mandatory U-factor restriction on fenestration, the computer performance compliance approach allows use of any window product in a home, providing offsetting improvements are made to other conservation measures.

Process
This CASE Study has just begun, but is on a fast track to develop potential changes to residential fenestration requirements for inclusion in the 2008 Standards. Interested parties are invited to review and comment on this document and the proposed methods and ultimate conclusions resulting from

this study. Stakeholders include the California Energy Commission, utilities, window and glass manufacturers and vendors, builders, environmental advocates, building officials, and energy consultants. Anyone responding to this initial email or requesting to be put on our mailing list will receive regular updates on the project and our work will be presented at California Energy Commission (CEC) workshops for public comment.

Methods

We propose to investigate availability, cost and suitability of alternative U-factor and SHGC values, and their impact on energy use in the various climate zones. Consideration will be given to products currently available, starting with the most commonly used, but with attention to alternatives that may deserve inclusion due to special construction circumstances. Initial focus will be on improvement to current U-factors, but must include consideration of SHGC values that are inherent to most lowE glass products. Specific attention will be paid to climates that may benefit from low U-factors but have little or no cooling load and no direct need of low SHGC values. Efforts will be made to refine fenestration requirements for additions, alterations, and replacements that sometimes present unique compliance challenges.

A series of compliance calculations will be performed in each climate zone to quantify potential energy savings for the proposed new values. Results will be evaluated and solutions ranked by ease of implementation and enforcement, cost-effectiveness, compatibility with other energy codes, and economic impact on California business.

End Product

One or more solutions may be proposed for adoption by the Energy Commission after review and comment by stakeholders and the public. Proposed changes to the Energy Standards, Residential Compliance and Alternative Compliance Manuals, and compliance forms will be developed to support the adoption process.