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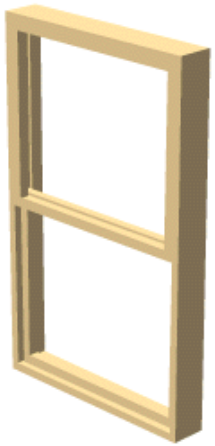
Staff Workshop for Residential Envelope
Residential High Performance Windows & Doors

June 1, 2017



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Los Angeles Department of Water & Power · SMUD · SDGE A Sempra Energy utility · SoCalGas A Sempra Energy utility · Southern California Edison · Pacific Gas and Electric Company

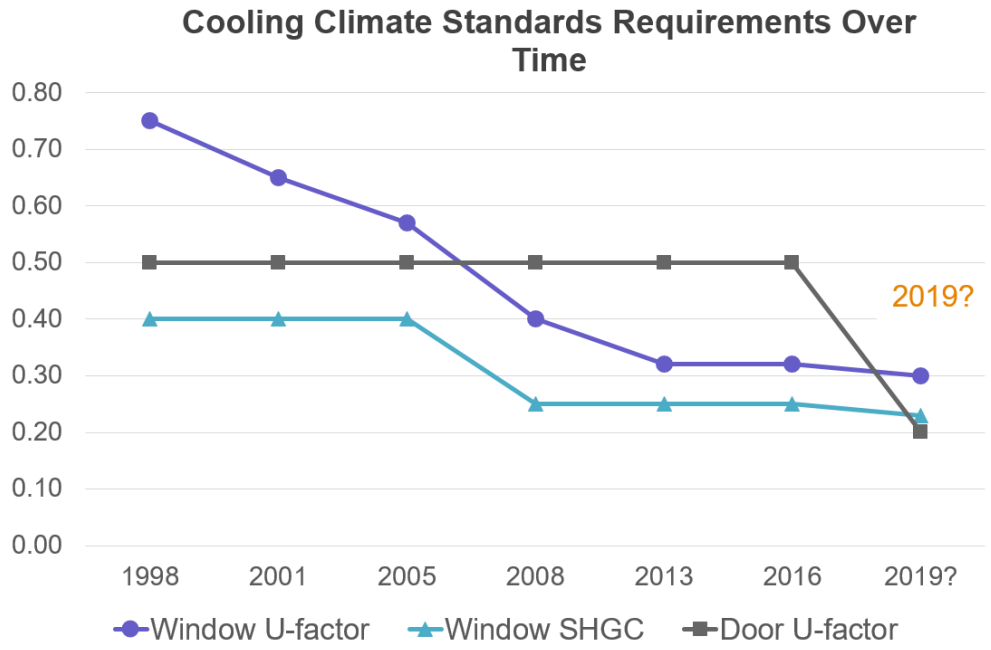
Agenda

1. Background
2. Proposed Code Changes
3. Technical and Market Barriers
4. Compliance and Enforcement
5. Cost Effectiveness and Energy Impacts
6. Next Steps

1. Background

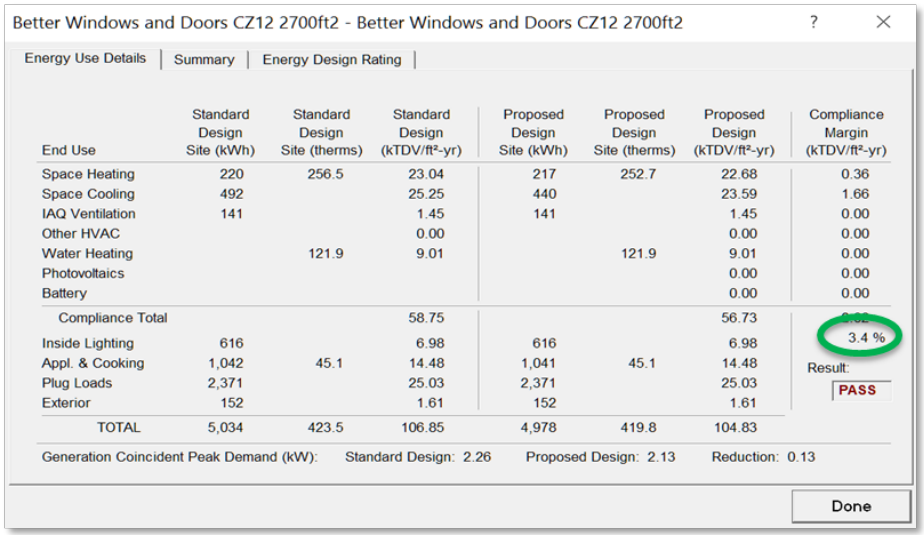
Prescriptive Window and Door Performance in Recent Standards

- Prescriptive window performance has increased dramatically since the 1998 standards
- Opaque door requirements have not changed for many code cycles



Big Impact on Building Energy Use

- Reducing U-factors (Btu/ft^2-hr-F):
  - reduces heating and cooling loads
- Reducing Solar Heat Gain Coefficient (SHGC, dimensionless):
  - reduces cooling loads
  - can increase heating loads
- Example 3.4% Savings
  - 2700ft^2 prototype
  - Climate zone 12
  - 0.30 U-factor
  - 0.23 SHGC



Better Windows and Doors CZ12 2700ft2 - Better Windows and Doors CZ12 2700ft2

Energy Use Details | Summary | Energy Design Rating

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	220	256.5	23.04	217	252.7	22.68	0.36
Space Cooling	492		25.25	440		23.59	1.66
IAQ Ventilation	141		1.45	141		1.45	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		121.9	9.01		121.9	9.01	0.00
Photovoltaics						0.00	0.00
Battery						0.00	0.00
Compliance Total			58.75			56.73	
Inside Lighting	616		6.98	616		6.98	3.4 %
Appl. & Cooking	1,042	45.1	14.48	1,041	45.1	14.48	Result:
Plug Loads	2,371		25.03	2,371		25.03	PASS
Exterior	152		1.61	152		1.61	
TOTAL	5,034	423.5	106.85	4,978	419.8	104.83	

Generation Coincident Peak Demand (kW): Standard Design: 2.26 Proposed Design: 2.13 Reduction: 0.13

Done

Some Things to Keep in Mind: Fenestration is a Unique Energy Feature

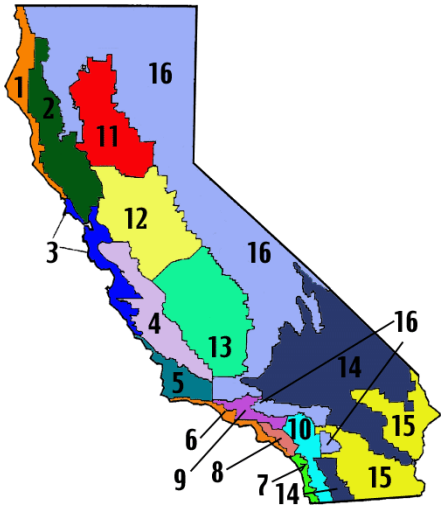
- Windows provide daylight, ventilation and egress
- Homes typically have 15 to 25 windows and doors
  - Each window type can have different ratings due to differences in frame to glass ratio
- Orientation and climate vary significant
  - It is tricky to balance lower U-factor and the appropriate SHGC with a single product
  - Lower SHGC lowers cooling, but can increase heating especially in TDV analysis

Current Code Requirements - Windows

Existing Title 24, Part 6 Requirements

- U-factor ≤ **0.32**
- SHGC ≤ **0.25**
- No SHGC requirement zones 1, 3 and 5

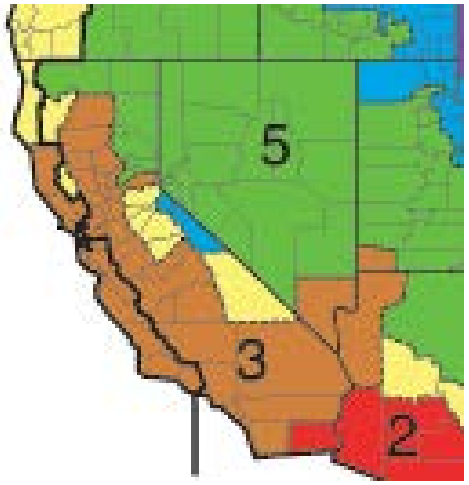
Title 24 Climate Zones
based on climate



Existing Model Code Requirements

- 2015 IECC U-factor between 0.40 to **0.32**
- 2018 IECC U-factor **0.30** in zones 5-8
- SHGC 0.25 in cooling climates

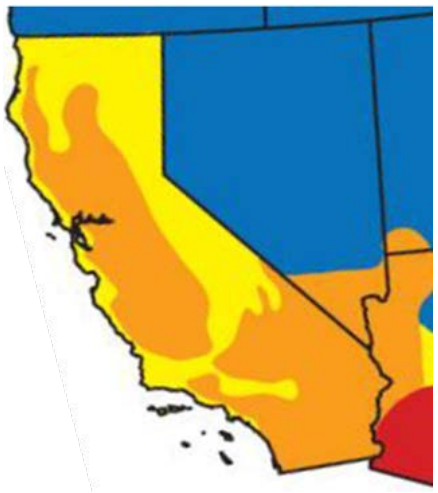
IECC Climate Zones
based on county by climate



Other considerations

- Energy Star **0.30** U-factor and **0.25** SHGC
- Federal Tax credits during the downturn required **0.30** U-factor and 0.30 SHGC

Energy Star Climate Zones
based on climate



Current Code Requirements – Opaque Doors

- U-factor 0.50 usually used in compliance software
- Doors with < 50 percent glass treated as opaque
- Glazed Doors ≥ 50 percent glass modeled as window
  - Most sliding glass doors and French doors in this category

Table 4.5.1 – Doors

Description		U-factor (Btu/°F-ft²)
		A
Uninsulated single-layer metal *swinging doors* or *non-swinging doors*, including single-layer uninsulated access hatches and uninsulated smoke vents:	1	1.45
Uninsulated double-layer metal *swinging doors* or *non-swinging doors*, including double-layer uninsulated access hatches and uninsulated smoke vents:	2	0.70
Insulated metal *swinging doors*, including fire-rated *doors*, insulated access hatches, and insulated smoke vents:	3	0.50
Wood *doors*, minimum nominal thickness of 1-3/4 in. (44 mm), including panel *doors* with minimum panel thickness of 1-1/8 in. (28 mm), and solid core flush *doors*, and hollow core flush *doors*:	4	0.50
Any other wood *door*:	5	0.60
Uninsulated single layer metal *roll up doors* including fire rated *door*	6	1.45
Insulated single layer metal *sectional doors*, minimum insulation nominal thickness of 1-3/8 inch; expanded polystyrene (R-4 per inch).	7	0.179

Source: ASHRAE 90.1-2007, Section A7.

Energy Star Windows and Doors

Windows

Climate Zone	U-Factor[1]	SHGC[2]	
Northern*	≤ 0.27	Any	Prescriptive
	= 0.28	≥ 0.32	Equivalent Energy Performance
	= 0.29	≥ 0.37	
	= 0.30	≥ 0.42	
North-Central	≤ 0.30	≤ 0.40	
South-Central	≤ 0.30	≤ 0.25	
Southern	≤ 0.40	≤ 0.25	

Air Leakage ≤ 0.3 cfm/ft^2

[1] Btu/h ft^2·°F
[2] Solar Heat Gain Coefficient

* The effective date for the Northern Zone prescriptive and equivalent energy performance criteria for windows is January 1, 2016.

Doors

Glazing Level	U-Factor[1]	SHGC[2]	
Opaque	≤ 0.17	No Rating	
≤ ½-Lite	≤ 0.25	≤ 0.25	
> ½-Lite	≤ 0.30	Northern North-Central	≤ 0.40
		Southern South-Central	≤ 0.25

Air Leakage for Sliding Doors ≤ 0.3 cfm/ft^2
Air Leakage for Swinging Doors ≤ 0.5 cfm/ft^2

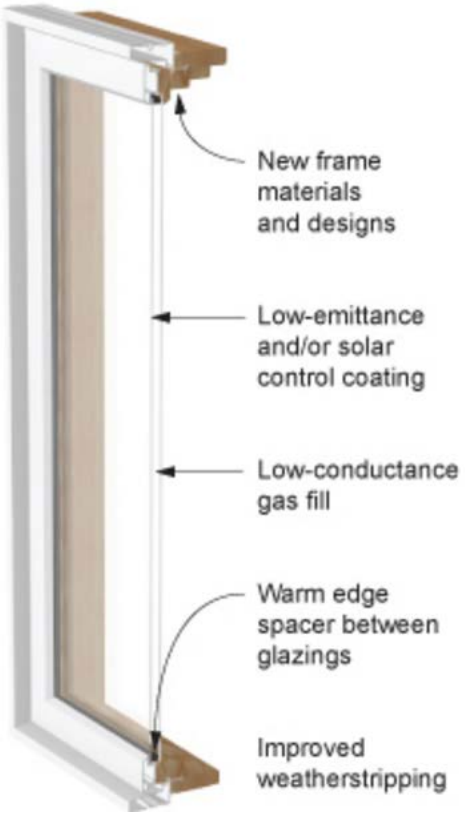
Skylights

Climate Zone	U-Factor[1]	SHGC[2]
Northern	≤ 0.50	Any
North-Central	≤ 0.53	≤ 0.35
South-Central	≤ 0.53	≤ 0.28
Southern	≤ 0.60	≤ 0.28

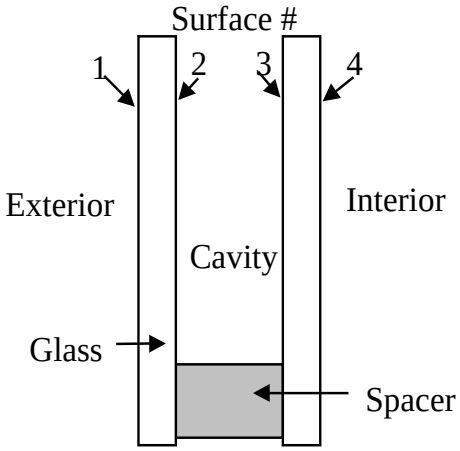
Air Leakage ≤ 0.3 cfm/ft^2

Recipe for a Prescriptive Windows

- Recipe for current code window:
  - Low conductance frame
  - Extra low solar gain low emissivity coating
  - Argon gas cavity fill in many cases
  - Improved spacer system



Anatomy of an IG Unit



Next Technology Steps for Windows

- No lower SHGC coatings available unless tinted compared to the typical coatings used to meet current prescriptive requirements
- Chromogenics that have variable SHGC are expensive, rarely used and require controls
- Triple glazing not widely available and requires redesign of many frames
- Inside surface low emissivity coatings have not caught on

2. Proposed Code Changes

Proposal - Windows

- U-factor ≤ 0.30
- SHGC
  - Climate zones 2, 4, and 6 through 15: ≤ 0.23
  - Climate zones 1, 3, 5 and now 16: no SHGC requirement
    - When using performance approach, SHGC in Standard Design is assumed to be 0.50

In many cases, this is the same window that is already used for current code compliance with a low conductance frame, low emissivity glass, argon gas fill and an improved spacer

Proposal – Windows Standards Language

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

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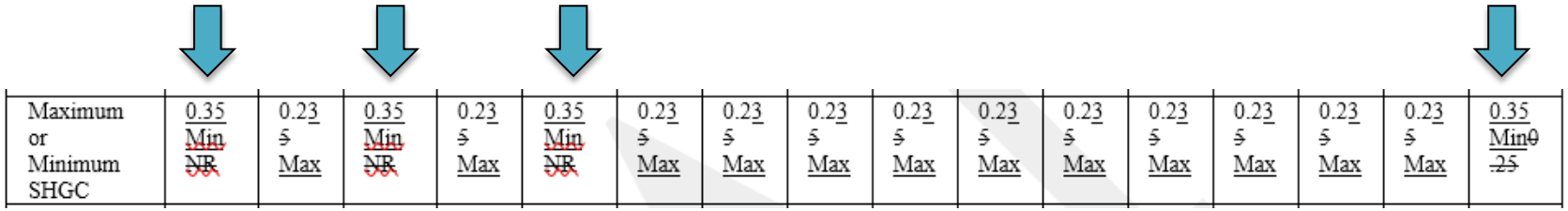
Alternative Proposal – Windows in Heating Climates

- Addresses stakeholder concerns to correct ACM treatment of SHGC in heating dominated climate zones 1, 3, 5 and 16
- One balanced possibility is to establish a minimum SHGC ≥ 0.35 to replace current “no requirement”
  - 0.35 typical of mid solar low emissivity coating widely available
  - Rewards higher SHGC with less penalty for lower SHGC
- Not possible to show energy savings in climate zone 1, 3 and 5 because the current 0.50 SHGC for “no requirement” is very favorable

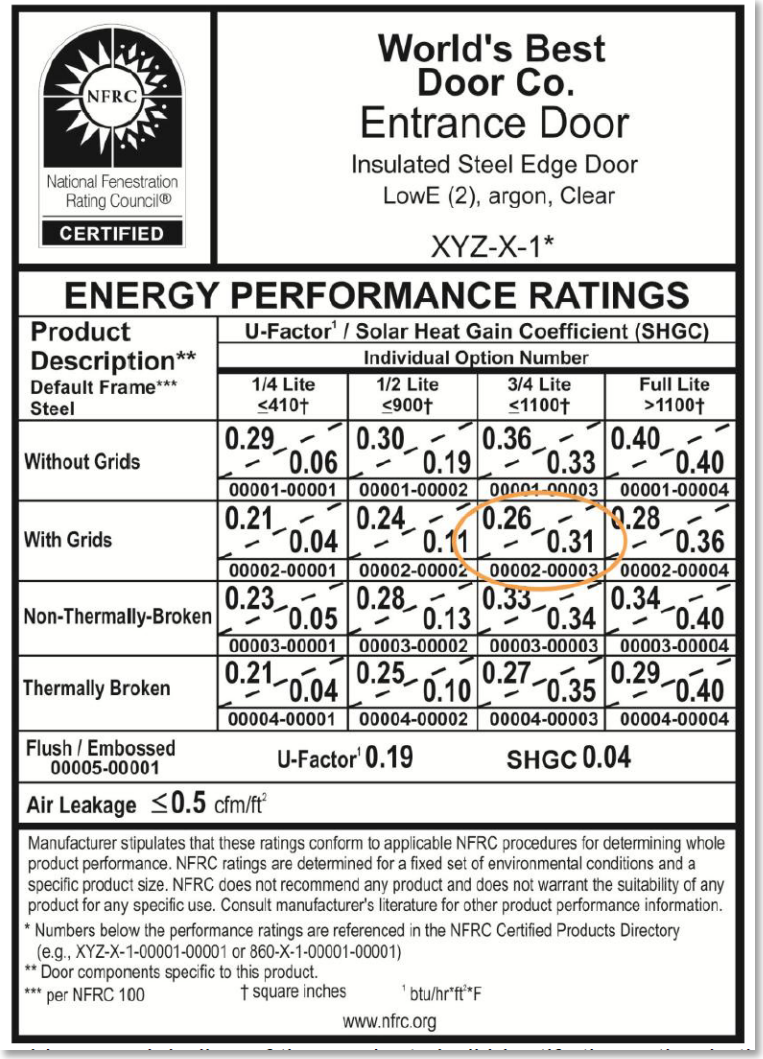


Maximum or Minimum SHGC	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.35 Min ~~NR~~	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.23 ~~5~~ Max	0.35 Min~~0~~ ~~.25~~

Proposal – Opaque Swinging Doors

- U-factor ≤ 0.20 for swinging non-glazed doors
- Exemption added for swinging fire protection doors
- Modify definition of glazed doors to 25% glazed or higher. Glazed doors modeled as windows

Will generally require an insulated door with an NFRC label.



National Fenestration Rating Council®
CERTIFIED

World's Best Door Co.
Entrance Door
Insulated Steel Edge Door
LowE (2), argon, Clear
XYZ-X-1*

ENERGY PERFORMANCE RATINGS

Product Description** / Default Frame*** Steel	U-Factor[1] / Solar Heat Gain Coefficient (SHGC) — Individual Option Number			
	1/4 Lite ≤410†	1/2 Lite ≤900†	3/4 Lite ≤1100†	Full Lite >1100†
Without Grids	0.29 / 0.06 00001-00001	0.30 / 0.19 00001-00002	0.36 / 0.33 00001-00003	0.40 / 0.40 00001-00004
With Grids	0.21 / 0.04 00002-00001	0.24 / 0.11 00002-00002	0.26 / 0.31 00002-00003	0.28 / 0.36 00002-00004
Non-Thermally-Broken	0.23 / 0.05 00003-00001	0.28 / 0.13 00003-00002	0.33 / 0.34 00003-00003	0.34 / 0.40 00003-00004
Thermally Broken	0.21 / 0.04 00004-00001	0.25 / 0.10 00004-00002	0.27 / 0.35 00004-00003	0.29 / 0.40 00004-00004
Flush / Embossed 00005-00001	U-Factor[1] 0.19		SHGC 0.04	

Air Leakage ≤0.5 cfm/ft²

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.

* Numbers below the performance ratings are referenced in the NFRC Certified Products Directory (e.g., XYZ-X-1-00001-00001 or 860-X-1-00001-00001)
** Door components specific to this product.
*** per NFRC 100 † square inches [1] btu/hr*ft²*F

www.nfrc.org

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Proposal – Opaque Swinging Doors Standards Language

Section 150.1(c)5

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.

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

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3. Technical and Market Barriers

Technical and Market Barriers - Windows

- No significant market barriers
- Products and technologies are already used frequently:
  - CalCerts registry data (Jan 2015- April 2016) indicates:
    - ~2/3 of windows in single family are ≤ SHGC 0.24
    - ~1/2 of windows in multi-family are ≤ SHGC 0.24
  - Product availability in retail stores suggests argon-fill windows is a standard feature
  - For new construction, 70 to 88 percent of residential windows meet the ENERGY STAR® Specification

In many cases, this is the same window that is already used for current code compliance with a low conductance frame, low emissivity glass, argon gas fill and an improved spacer

Technical and Market Barriers – Opaque Doors

- No significant market barriers
- Products and technologies are already used frequently
- Insulated doors outperform the default tables
- Credit for reducing the U-factor for doors will require NFRC labels
  - NFRC ratings for less than ¼, ½, ¾ or full lite
  - Proposal anticipated to increase the NFRC rating and labeling of opaque door products
- Exemption added for swinging fire protection doors between house and garage even though with fire sprinkler requirements, doors between house and garage are not an issue if attached garage have sprinklers.
- Over 70 percent of swinging doors met the ENERGY STAR® Specification over last few years

4. Compliance and Enforcement

Compliance Process

Design Phase

Permit Application Phase

Construction Phase

Inspection Phase

- No significant differences in the phases of compliance
  - Specification and installation of higher performance products
  - Increased use of NFRC door labels
- No known compliance or enforcement barriers

5. Cost Effectiveness and Energy Impacts

Cost Effectiveness Calculations - Methodology

1. Determine proposed measure changes
2. Calculate the incremental first cost and any added maintenance costs of the proposal
3. Do prototype analysis to establish the annual energy savings using CBECC-Res software
4. For Single Family, results are for the weighted prototype assuming 45% one story 2100 ft^2 and 55% two story 2700 ft^2 for an average of 2430 ft^2
5. Add up the 30-year energy cost savings (benefits) using the annual time dependent valuation (TDV) savings and the net present value factor of $0.173/kTDV
6. Calculate benefit-to-cost ratio

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - Window U-factor 0.32
  - Window SHGC:
    - climate zones 2, 4 and 6-16: 0.25
    - climate zones 1, 3, and 5: *no SHGC requirement, modeled at 0.5*
  - Opaque Door U-factor 0.50

- **Proposed Conditions**
  - Window U-factor 0.30
  - Window SHGC:
    - climates zones 2, 4 and 6-15: 0.23
    - climate zones 1, 3, 5 and 16: *no SHGC requirement, modeled at 0.5*
  - Opaque Door U-factor 0.20

All other energy features modeled with 2016 requirements based on climate zone in standard configuration using CBECC-Res with 2019 TDV.

Prototypes

Single Family Prototype 1

- 2,100 square feet
- One story
- 20% glazing, 40 ft^2 door
- Average 45% Prototype 1 statewide

Single Family Prototype 2

- 2,700 square feet
- Two stories
- 20% glazing, 40 ft^2 door
- Average 55% prototype 2 statewide

Multifamily

- 6,960 square feet
- Two stories
- 8 units
- 15% glazing, 160 ft^2 door

Incremental Costs

- Incremental first cost with builder markup of 30%:
  - Window $0.195 per square feet
  - Insulated Door $1.30 per square feet
- No additional incremental maintenance costs over 30-year period of analysis

Prototype	Window Area (ft^2)	Door Area (ft^2)	Incremental First Cost Per Building ($)
Single Family	486	40	**$147**
Multi Family	1044	160	**$412**

Annual Energy Savings

- Following slides show kWh, kW and therm savings for the proposal
- In most cases, the proposal saves both kWh and therms
- There are a few cases where the kWh and therms go in different directions because of the nature of fenestration products where reducing the U-factor reduces both heating and cooling but a reducing SHGC is better for cooling but may increase heating depending on the climate zone
- Climate zone 16 impact due to switch from a low solar gain climate zone to a no requirement climate zone
- Multifamily results in draft CASE report

Statewide totals weight the climate zone values by the fraction of building starts for the climate zone

Annual Energy Savings Per Single Family Building (2430 ft^2 weighted)

Climate Zone	Annual Electricity Savings (kWh/yr)	Peak Electric Demand Reduction (kW)	Annual Natural Gas Savings (therms/yr)
1	17	0.00	21
2	10	0.04	3
3	8	0.00	11
4	14	0.06	1
5	9	0.00	12
6	9	0.03	-1
7	3	0.02	-1
8	26	0.07	0
9	44	0.08	0
10	57	0.10	0
11	96	0.11	3
12	47	0.12	3
13	97	0.11	4
14	88	0.11	2
15	198	0.14	0
16	-159	-0.71	139
Statewide	**47**	**0.06**	**6**

Incremental Cost Savings (Benefits)

- The following slides show the annual TDV energy savings and the 30-year TDV energy cost savings
- There are TDV energy savings in all climate zones and statewide
- Single Family:
  - Range from $81 to $3,239
  - Statewide weighted average: $814
- Multifamily Buildings
  - Range from $590 to $5,442
  - Statewide weighted average: $2,159
- Multifamily results in draft CASE report

On the following slides, **$2020** refers to the 30-year cost savings discounted to the value in 2020

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TDV Energy Savings Per Single Family Building

Climate Zone	TDV Energy Savings (TDV kBtu/yr)	30-Year TDV Energy Cost Savings ($2020)
1	4788	$831
2	2576	$441
3	2605	$455
4	3164	$543
5	2770	$483
6	1463	$251
7	505	$81
8	3500	$599
9	3426	$589
10	4135	$711
11	6120	$1,059
12	5041	$868
13	6143	$1,063
14	5748	$990
15	8623	$1,488
16	18442	$3,239
Statewide	**4713**	**$814**

Benefit-to-Cost Ratio

- The following slides show the benefit-to-cost ratio for the incremental cost divided by the 30 year energy cost savings
- Highly cost effective statewide
- One case – single family climate zone 7 - is not cost effective. Cost is estimated at $147. Savings at $81. Difference is $66.

Benefit-to-Cost Ratio Per Single Family Building

Climate Zone	Benefit to Cost
1	5.7
2	3.0
3	3.1
4	3.7
5	3.3
6	1.7
7	0.6
8	4.1
9	4.0
10	4.8
11	7.2
12	5.9
13	7.2
14	6.7
15	10.1
16	22.1
Statewide	**5.5**

Cost Effective in All Climate Zones except 7

If Benefit-to-Cost Ratio is >1, measure is cost effective.

Statewide, this proposal could have an incremental cost 5.5 times larger and still be cost effective!

Benefit-to-Cost Ratio Per Multi Family 8 Unit Building

Climate Zone	Benefit to Cost
1	5.8
2	4.9
3	2.2
4	5.0
5	1.4
6	2.7
7	1.9
8	3.9
9	5.8
10	6.6
11	9.8
12	7.8
13	9.9
14	9.2
15	13.2
16	12.8
Statewide	**5.2**

Cost Effective in All Climate Zones

If Benefit-to-Cost Ratio is >1, measure is cost effective.

Statewide, this proposal could have an incremental cost 5.2 times larger and still be cost effective!

Proposal Conclusions

- Proposal captures a modest improvement in window performance
- Proposal updates opaque door performance for first time since 1983 to require insulated doors
- First costs are modest compared to savings
- Proposed windows and opaque doors are already used frequently
- Proposal is cost effective for single family (except for in climate zone 7)
- Proposal is cost effective for multi family in all climate zones

Proposal recommends implementing new criteria in climate zone 7 to make the requirements consistent statewide

Next Steps

- Thanks for listening on behalf of the CASE team
- Keep an eye on Title24Stakeholders.com for more information