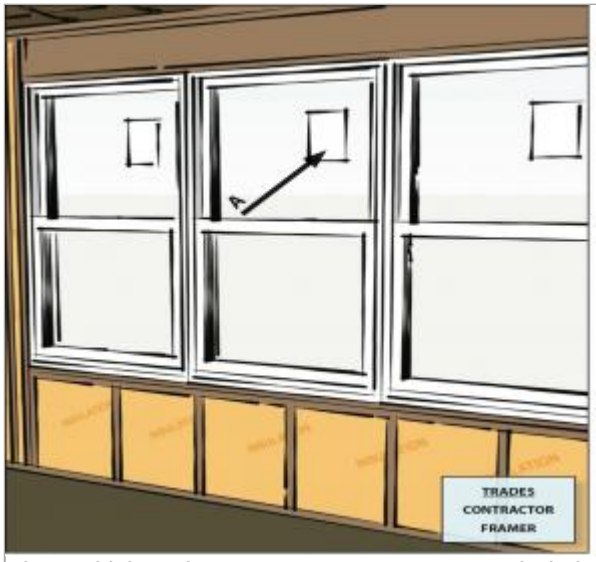
ENERGY STAR Windows

Last Updated: 03/14/2016

Scope



Choose high-performance ENERGY STAR-rated windows.

Select and install high-performance windows, preferably windows that are ENERGY STAR rated or that meet or exceed the ENERGY STAR program requirements for windows, doors, and skylights.

If you are seeking certification under the ENERGY STAR Certified Homes program or the U.S. Department of Energy's Zero Energy Ready Home program, see the following and the Compliance tab for more specific guidance.

- The **ENERGY STAR Certified Homes** program requires that builders install windows that meet or exceed the U-factor and solar heat gain coefficients (SHGC) specified in the **2009 International Energy Conservation Code**.
- The U.S. Department of Energy's **Zero Energy Ready Home Program** requires builders to meet or exceed **ENERGY STAR Eligibility Criteria for Windows, Doors, and Skylights**.

See the **Compliance Tab** for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.

Description

ENERGY STAR estimates that installing ENERGY STAR-rated windows rather than standard windows can save homeowners about 7% to 15% on their utility bills. ENERGY STAR windows typically consist of two or more panes of glass in a fiberglass, vinyl, wood, or combination frame (Figure 1). An odorless, colorless, nontoxic inert gas such as argon or krypton fills the space between the panes to provide better insulation than just air. Special low-emissivity (low-e) coatings on one or more of the glass surfaces reduce the infrared radiation from a warm pane of glass to a cooler pane, thereby making the window more energy efficient (lowering the U-factor). These coatings also reflect ultraviolet (UV) rays to minimize fading of furniture and drapes. A spacer keeps the panes of glass the right distance apart; some spacers are made of non-metal insulating materials that also insulate the edges of the glass panes reducing heat transfer through the window.

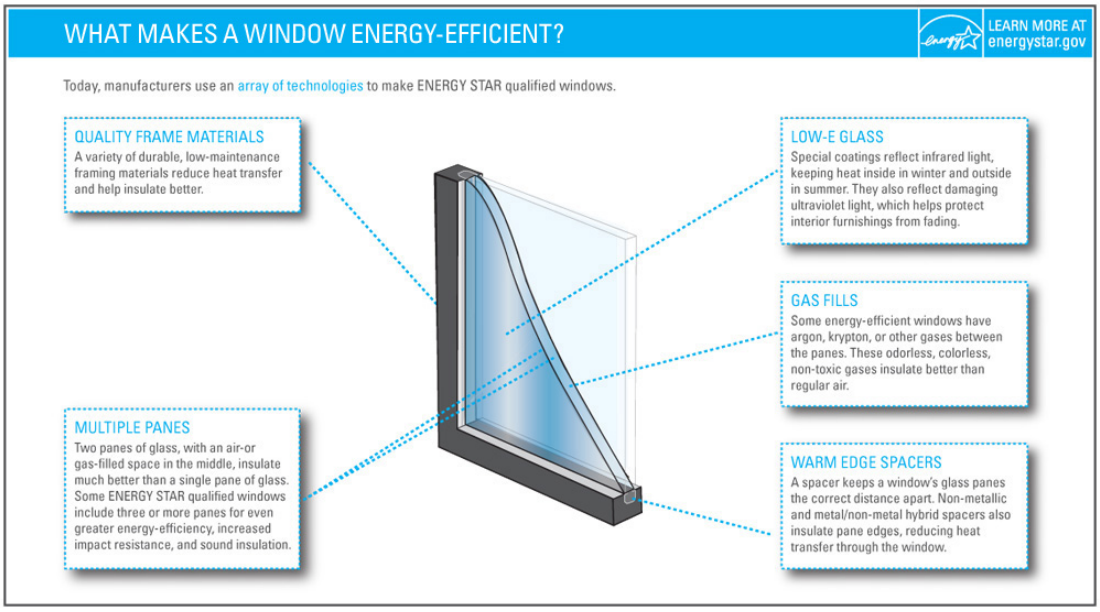


Figure 1 - High-performance windows like ENERGY STAR-rated windows have features like dual or triple panes, insulated frames, and low-e coatings to improve their efficiency.

ENERGY STAR windows are independently performance tested according to procedures established by the National Fenestration Rating Council (NFRC). The NFRC label shows performance ratings in five categories.

- U-Factor measures the rate of heat transfer and tells you how well the window insulates. U-factor values generally range from 0.25 to 1.25 and are measured in Btu/h•ft²•°F. The lower the U-factor, the better the window insulates.
- Solar Heat Gain Coefficient (SHGC) measures the fraction of solar energy transmitted and tells you how well the product blocks heat caused by sunlight. SHGC is measured on a scale of 0 to 1; values typically range from 0.25 to 0.80. The lower the SHGC, the less solar heat the window transmits.
- Visible Transmittance (VT) measures the amount of light the window lets through. VT is measured on a scale of 0 to 1; values generally range from 0.20 to 0.80. The higher the VT, the more light you see.
- Air Leakage (AL) measures the rate at which air passes through joints in the window. AL is measured in cubic feet of air passing through one square foot of window area per minute. The lower the AL value, the less air leaks through the window. Most industry standards and building codes require an AL of 0.3 cfm/ft².
- Condensation Resistance measures how well the window resists water build-up. Condensation Resistance is scored on a scale from 0 to 100. The higher the condensation resistance factor, the less build-up the window allows.

The NFRC label is combined with the ENERGY STAR label, which shows the U.S. regions where the labeled window meets ENERGY STAR specifications (Figure 2).

Figure 2 - All ENERGY STAR-qualified windows display the ENERGY STAR label, showing the climate zones for which this product qualifies and the National Fenestration Rating Council (NFRC) ratings.

ENERGY STAR establishes U-Factor and SHGC criteria for ENERGY STAR windows based on climate using a climate zone map developed by ENERGY STAR (see Figure 3). The criteria show the highest U-factor permissible in each climate zone and the SHGC criteria in each climate zone, with higher SHGCs in colder climates and lower SHGCs in hotter climates. The climate zones shown on this map equate to the climate zones shown in the **International Energy Conservation Code (IECC) map**, as follows: the Southern region = CZ 1 and 2, the South-Central region = CZ 3, the North-Central region = CZ 4, and the Northern region = CZ 5, 6, 7, and 8.

Figure 4 shows the ENERGY STAR Program Requirements for Residential Windows, Door, and Skylights, Version 6.0. This version took effect on January 1, 2015, with the exception of the criteria for windows in the northern climate, which took effect on January 1, 2016.

Figure 3 - ENERGY STAR Climate Zone Map for Windows

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	

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/ft2

[1] Btu/h ft2·°F
[2] Solar Heat Gain Coefficient

Figure 4 - ENERGY STAR Climate-Specific Criteria for Windows and Skylights, Version 6.0.

How to Purchase and Install ENERGY STAR Windows

1. Determine your ENERGY STAR climate zone for the ENERGY STAR window criteria using the ENERGY STAR **climate zone finder** tool, which bases the climate zone on the county in which the home is located.
2. Look for ENERGY STAR-labeled products that meet the criteria for your climate zone. If ordering from a showroom or building materials supplier, ask for a product that meets the ENERGY STAR criteria in your climate zone.
3. If you are seeking to have your home certified under either the DOE Zero Energy Ready Home program or the ENERGY STAR Certified Homes program, see the Compliance tab for additional window specifications to meet those program criteria.
4. Check with local utilities and check the ENERGY STAR website for information about the **federal tax credit** for ENERGY STAR-rated windows. Also see the DOE **Database of State Incentives for Renewables & Efficiency** for information on additional state, federal, and local tax credits and exemptions.
5. Follow the manufacturer's installation instructions when installing the windows to avoid voiding the warranty. Some warranties require that you use an installer certified by the manufacturer.
6. Properly install windows to keep air and moisture out. See the guide **Fully Flashed Window and Door Openings**.
7. Properly air seal around window rough openings. See the guide **Window and Door Rough Openings**.

Table 1. Fenestration Requirements (adapted from the 2009 IECC, Table 402.1.1)

IECC Climate Zone	U-Factor	SHGC
1	1.2	0.30
2	0.65	0.30
3	0.50	0.30
4 except Marine	0.35	No requirement
5 and Marine 4	0.35	No requirement
6	0.35	No requirement
7 and 8	0.35	No requirement

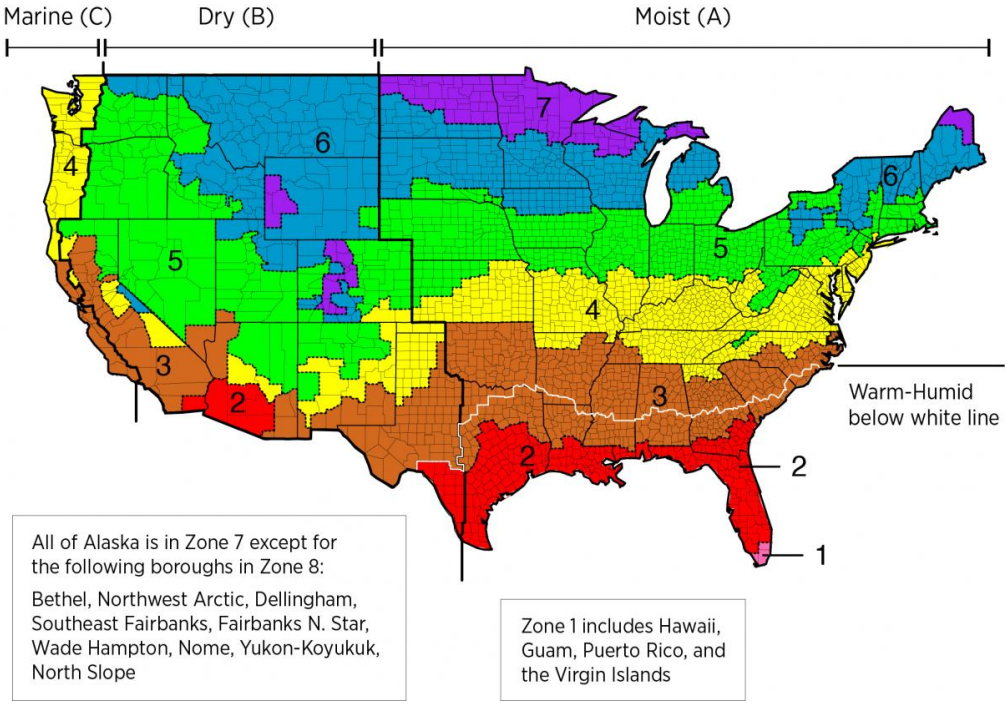
Ensuring Success

Look for or request ENERGY STAR-qualifying products when purchasing windows, and follow ENERGY STAR criteria to purchase windows appropriate for the climate zone where they will be installed.

Climate

If you are building to meet an energy-efficiency program certification, refer to that program's guidance for climate-specific criteria. Criteria for the DOE Zero Energy Ready Home and ENERGY STAR Certified Homes are provided in the Compliance tab.

To maximize beneficial solar heat gain and minimize unwanted solar heat gain, consider window location and sizing when designing the house. Limit the number of west-facing windows, especially in hot climates, to limit late afternoon glare and solar heat gain. Locate south-facing windows under properly sized overhangs or covered porches to minimize heat gain from high summer sun and maximize gain from low winter sun. Locating deciduous shade trees to the south and west will also minimize summer solar gain and maximize winter solar gain. Consider selecting different window models for different sides of the house to maximize beneficial solar gain and minimize unwanted heat gain (EPA 2013).



IECC Climate Zone Map

Training

Right and Wrong Images

Display Image: ES_TESRC_1.1_PG42_2b_102811_0.jpg

Reference: Thermal Enclosure System Rater Checklist Guidebook

Author(s): EPA
Organization(s): EPA

Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

Display Image: ES_TESRC_1.1_PG42_2b_102811_0.jpg

Reference: Thermal Enclosure System Rater Checklist Guidebook

Author(s): EPA
Organization(s): EPA

Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

Display Image: [ES_TESRC_1.1_PG42_3c_102811_0.jpg]

Reference: [Thermal Enclosure System Rater Checklist Guidebook]

Author(s): EPA
Organization(s): EPA

Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

Display Image: [ES_TESRC_1.1_PG42_3c_102811_0.jpg]

Reference: [Thermal Enclosure System Rater Checklist Guidebook]

Author(s): EPA
Organization(s): EPA

Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

CAD

None Available

Compliance

The Compliance tab contains both program and code information. Exact code language is copyrighted and may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

DOE Zero Energy Ready Home Program

The U.S. Department of Energy Zero Energy Ready Home Program's **National Program Requirements** (Rev 05) specifies as a mandatory requirement (Exhibit 1, #2.1) that all windows installed meet or exceed the latest **ENERGY STAR Program Requirements for Residential Windows, Doors, and Skylights** in effect at the time of project permitting.

The DOE Zero Energy Ready Home program allows builders to choose either a prescriptive path or a performance path in order to certify their home as a Zero Energy Ready Home. In addition to choosing windows that are ENERGY STAR labeled, builders using the prescriptive path must meet or exceed the more stringent window criteria listed in Exhibit 2 of the DOE ZERH **National Program Requirements** (shown in Table 1 below). Builders using the performance path must use these criteria when modeling the target home.

Table 1. Window Criteria excerpted from DOE Zero Energy Ready Home National Program Requirements (Rev 05) Exhibit 2

Windows [25,26,27]			
	Hot Climates (2012 IECC Zones 1,2,)	**Mixed Climates** (2012 IECC Zones 3,4 except Marine)	**Cold Climates** (2012 IECC Zones 4 Marine 5,6,7,8)
SHGC	0.25	0.25	any
U-Value	0.4	0.3	0.27
Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs.28			

Relevant Footnotes from the DOE Zero Energy Ready Home National Program Requirements:

(12) Windows shall meet the applicable ENERGY STAR Window Product Criteria based on the following schedule:

- For projects permitted on or before 8/31/2015, windows shall meet ENERGY STAR Windows Eligibility Criteria Version 5.0.
- For projects permitted after 8/31/2015, windows shall meet ENERGY STAR Windows Eligibility Criteria Version 6.0; except for Climate Zones 5 through 8 and Zone 4 Marine, which must follow ENERGY STAR Windows Eligibility Criteria Version 6.0 for projects permitted after 8/31/2016.

See **www.energystar.gov/windows** for current ENERGY STAR Windows Eligibility Criteria. For homes achieving PHIUS+ certification where triple glazed window assemblies with thermal breaks/spacers between the panes are used, such windows are deemed to meet this requirement even in the absence of an ENERGY STAR certification.

(13) Fenestration shall meet the applicable ENERGY STAR Windows Eligibility Criteria for U and SHGC, with the following exceptions:

a. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements;

b. An area-weighted average of fenestration products ? 50% glazed shall be permitted to satisfy the SHGC requirements;

c. 15 square feet of glazed fenestration per dwelling unit shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above;

d. One side-hinged opaque door assembly up to 24 square feet in area shall be exempt from the U-factor requirements and shall be excluded from area-weighted averages calculated using a) and b), above;

e. Fenestration utilized as part of a passive solar design shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above. Exempt windows shall be facing within 45 degrees of true South and directly coupled to thermal storage mass that has a heat capacity > 20 btu / ft3x?F and provided in a ratio of at least 3 sq. ft. per sq. ft. of South facing fenestration. Generally, thermal mass materials will be at least 2 in. thick.

(25) All decorative glass and skylight window areas count toward the total window area to above-grade conditioned floor area (WFA) ratio.

(26) DOE strongly encourages all DOE Zero Energy Ready Home partners to consider using R-5 windows in cold climates in anticipation of them becoming the state-of-the-art window choice in the near future. Visit the DOE web site (**http://www1.eere.energy.gov/buildings/windowsvolumepurchase/**) for more details and sources of these windows.

(27) For homes using Exhibit 2 for Prescriptive compliance with the DOE Zero Energy Ready Home, the following exceptions to the U-Value and SHGC requirements in Exhibit 2 apply:

a. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements;

b. An area-weighted average of fenestration products ? 50% glazed shall be permitted to satisfy the SHGC requirements;

c. 15 square feet of glazed fenestration per dwelling unit shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above;

d. One side-hinged opaque door assembly up to 24 square feet in area shall be exempt from the U-factor requirements and shall be excluded from area-weighted averages calculated using a) and b), above;

e. Fenestration utilized as part of a passive solar design shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above. Exempt windows shall be facing within 45 degrees of true South and directly coupled to thermal storage mass that has a heat capacity > 20 btu / ft3x ?F and provided in a ratio of at least 3 sq. ft. per sq. ft. of South facing fenestration. Generally, thermal mass materials will be at least 2 in. thick.

(28) For Prescriptive Path: All decorative glass and skylight window areas count toward the total window area to above-grade conditioned floor area (WFA) ratio. For homes using the Prescriptive Path that have a WFA ratio > 15%, the following additional requirements apply:

a. In Climate Zones 1, 2, and 3, an improved window SHGC is required and is determined by:
Improved SHGC = [0.15 / WFA] x [ENERGY STAR SHGC]
Where the ENERGY STAR SHGC is the maximum allowable SHGC in Exhibit 1, ENERGY STAR Reference Design, for the Climate Zone where the home will be built.

b. In Climate Zones 4, 5, 6, 7, and 8, an improved window U-Value is required and is determined by:
Improved U-Value = [0.15 / WFA] x [ENERGY STAR U-Value]
Where the ENERGY STAR U-Value is the maximum allowable U-Value in Exhibit 1, ENERGY STAR Reference Design, for the Climate Zone where the home will be built.

ENERGY STAR Certified Homes

Builders, contractors, and home owners wishing to meet the fenestration (window) requirements of ENERGY STAR Certified Homes should see the ENERGY STAR Certified Homes **National Program Requirements**. The latest version (Ver 3.0, Rev. 08) provides builders with a performance path that includes mandatory requirements plus a set of efficiency features builder must use to design and model a reference design house to determine the HERS Index target for the floor plan they wish to build.

The mandatory requirements specify that the builder must comply with the ENERGY STAR Rater Field Checklist, which states in item 1.1 “Fenestration meets or exceeds levels specified in Item 2.1 of the Rater Design Review Checklist.” Item 2.1 of the Rater Design Review Checklist states that fenestration “meets or exceeds 2009 IECC requirements.” The 2009 IECC window requirements are summarized in Table 1.

Table 1. Fenestration Requirements, adapted from the 2009 IECC, Table 402.1.1

IECC Climate Zone	U-Factor	SHGC
1	1.2	0.30
2	0.65	0.30
3	0.50	0.30
4 except Marine	0.35	No requirement
5 and Marine 4	0.35	No requirement
6	0.35	No requirement
7 and 8	0.35	No requirement

The ENERGY STAR reference design house requirements includes minimum fenestration performance requirements, which are shown in Table 2.

Table 2. ENERGY STAR Reference Design Fenestration Requirements, excerpted from the ENERGY STAR National Program Requirements Exhibit 1: ENERGY STAR Reference Design Home

Envelope, Windows, & Doors				
Windows and doors modeled, as illustrated below:				
Window U-Value:	0.60 in CZs 1,2 &	0.35 in CZ 3	0.32 in CZ 4	0.30 in CZs 4 C,5,6,7,8
Window SHGC:	0.27 in CZs 1,2	0.30 in CZ 3	0.40 in CZ 4	Any in CZs 4 C,5,6,7,8

Relevant Footnotes from the ENERGY STAR Certified Homes (Version 3/3.1, Revision 08), Rater Design Review Checklist

(3) All windows, doors and skylights shall meet or exceed the component U-factor and SHGC requirements specified in 2009

IECC Table 402.1.1. If no NFRC rating is noted on the window or in product literature (e.g., for site-built fenestration), select the U-factor and SHGC value from Tables 4 and 10, respectively, in 2013 ASHRAE Fundamentals, Chapter 15. Select the highest U-factor and SHGC value among the values listed for the known window characteristics (e.g., frame type, number of panes, glass color, and presence of low-e coating). Note that the U-factor requirement applies to all fenestration while the SHGC only applies to the glazed portion. The following exceptions apply:

a. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements;

b. An area-weighted average of fenestration products ? 50% glazed shall be permitted to satisfy the SHGC requirements;

c. 15 square feet of glazed fenestration per dwelling unit shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above;

d. One side-hinged opaque door assembly up to 24 square feet in area shall be exempt from the U-factor requirements and shall be excluded from area-weighted averages calculated using a) and b), above;

e. Fenestration utilized as part of a passive solar design shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using a) and b), above. Exempt windows shall be facing within 45 degrees of true South and directly coupled to thermal storage mass that has a heat capacity > 20 btu / ft3xoF and provided in a ratio of at least 3 sq. ft. per sq. ft. of South facing fenestration. Generally, thermal mass materials will be at least 2 in. thick.

In Passive House (PHIUS+) certified homes, where triple-glazed window assemblies with thermal breaks / spacers between the panes are used, such windows meet the intent of Item 2.1 and shall be excluded when assessing compliance of a) through e), above.

2009 IECC

Section 303.1.3 Fenestration product rating: U-factors of fenestration products (windows, doors, and skylights) are determined per NFRC 100 and labeled and certified by the manufacturer. The SHGC must be determined per NFRC 200 and labeled and certified by the manufacturer. Products with no labels will be assigned a default U factor as listed in Table 303.1.3(1) and a default SHGC value as listed in Table 303.1.3(3).

Table 402.1.1 lists insulation and fenestration requirements by building component.

Section 402.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section 402.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section 402.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section 402.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

2009 IRC

Table N1102.1.1 Insulation and Fenestration Requirements by Component. Section N1101.5 Fenestration product rating: U-factors of fenestration products (windows, Doors, and skylights) are determined per NFRC 100 and labeled and certified by the manufacturer. The SHGC must be determined per NFRC 200 and labeled and certified by the manufacturer. Products with no labels must meet the requirements of Table N1101.5(1) – Table N1101.5(3). Section N1102.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section N1102.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section N1102.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section N1102.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

2012 IECC

Section R303.1.3 Fenestration product rating: U-factors of fenestration products (windows, doors and skylights) are determined per NFRC 100 and labeled and certified by the manufacturer. The SHGC and visible transmittance must be determined per NFRC 200 and labeled and certified by the manufacturer. Products with no labels must meet the requirements of Table R303.1.3(1) – Table R303.1.3(3). Section R402.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section R402.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section R402.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section R402.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

2012 IRC

Section N1101.12.3 Fenestration product rating: U-factors of fenestration products (windows, Doors, and skylights) are determined per NFRC 100 and labeled and certified by the manufacturer. The SHGC and visible transmittance must be determined per NFRC 200 and labeled and certified by the manufacturer. Products with no labels must meet the requirements of Table N1101.12.3(1)-N1101.12.3(3). Section N1102.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section N1102.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section N1102.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section N1102.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

2015 IECC

Section R303.1.3 Fenestration product rating: U-factors of fenestration products (windows, doors, and skylights) are determined by an accredited independent laboratory per NFRC 100 (except for garage doors whose U factors can be determined in accordance with either NFRC 100 or ANSI/DASMA 105.) They are labeled and certified by the manufacturer. The SHGC and visible transmittance are determined by an accredited independent laboratory per NFRC 200 and labeled and certified by the manufacturer. Products with no labeled U-factor must meet the requirements of Table R303.1.3(1) or Table R303.1.3(2). Products with no labeled SHGC must meet the requirements of Table R303.1.3(3). Table R402.1.2 specifies Fenestration U-factors and SHGC values by climate zone. Section R402.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section R402.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section R402.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section R402.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

2015 IRC

Section N1101.10.3 Fenestration product rating: U-factors of fenestration products (windows, Doors, and skylights) are determined by an accredited independent laboratory per NFRC 100 and labeled and certified by the manufacturer. The SHGC and visible transmittance are determined by an accredited independent laboratory per NFRC 200 and labeled and certified by the manufacturer. Products with no labels must meet the requirements of Table N1101.12.3(1)-N1101.12.3(3). Section N1102.1.2 (R402.1.2) Insulation and fenestration criteria are listed in Table N1102.1.2 by climate zone. Section N1102.3.1 U-factor: an area-weighted average is allowed to satisfy the U-factor requirements. Section N1102.3.2 Glazed fenestration SHGC: an area-weighted average of products with more than 50 percent glazing is allowed to satisfy the SHGC requirements. Section N1102.3.3 Glazed fenestration exemption: up to 15 square feet per dwelling unit may be exempted from U-factor and SHGC requirements under the prescriptive approach. Section N1102.3.4 Opaque door exemption: one side-hinged door up to 24 square feet may be exempted from the U-factor requirement.*

*Due to copyright restrictions, exact code text is not provided. For specific code text, refer to the applicable code.

Dynamic Glazing - Code Compliance Brief

Overview:

The intent of this brief is to provide additional information to help assure the measure will be deemed in acceptance with the code. Providing notes for codes officials on how to plan review and field inspect can help the builder or remodeler with the proposed designs and provide the jurisdiction with information for acceptance. Providing the same information to all interested parties (i.e., code officials, builders, designers) is expected to result in increased compliance and fewer innovations being questioned at the time of plan review and/or field inspection.

Dynamic glazing requirements were added to the residential portion of the International Energy Conservation Code (IECC) and International Residential Code (/IRC) in the 2015 version. Dynamic glazing is defined as "any fenestration[1] product that has the fully reversible ability to change its performance properties, including U-factor[2], solar heat gain coefficient (SHGC), or visible transmittance (VT)."[3] This variation in performance properties can be useful in addressing conflicts between, for example, the desire for views of the outdoors and desire for reduction in solar gain. There are two main types of dynamic glazing:

- switchable glazing products[4]
- internal shading systems.[5]

Commercially available dynamic glazing products typically focus on U-factor or SHGC, providing a range of thermal insulation or solar shading.[6] Switchable glazing products typically provide SHGC variability, while internal shading systems may provide both U-factor and SHGC variability. The range of solar shading may be provided by window films that automatically respond to sunlight or temperature or by integrated blinds or shades that are automatically controlled.

Because dynamic glazing products have multiple U-factor or SHGC values, the question immediately arises as to which value should be compared to the fenestration requirements in the 2015 IECC/IRC. The code requirements in the 2015 IECC/IRC state that, "… if the ratio of the higher to the lower value is greater than or equal to 2.4 and the product is automatically controlled to modulate the amount of solar gain into the space in multiple steps, the product may be permitted to comply with the requirements of the Insulation and Fenestration Requirements by Component Table R402.1.2."

For SHGC, the "upper SHGC" value for dynamic glazing is typically close to that of a "clear" window, while the "lower SHGC" for dynamic glazing is typically closer to that of a heavily tinted window. This means that for dynamic glazing products, the SHGC-0.25 requirement in climate zones 1-3 and the SHGC-0.40 requirement in climate zone 4 are not applicable. Instead, the ratio of the upper and lower SHGC values and the presence of an appropriate automated control system are substituted for the prescriptive SHGC values. A special note should be made of what are called "environmentally controlled dynamic glazing" products. These products change their SHGC based on the response of the materials incorporated into films applied to the glazing. There is not a separate "control system". Control is provided automatically by the atomic structure and properties of the film material. These products should be considered to have an appropriate automated control system.

For U-factor, the only systems that offer U-factor variability are internal shading systems. An internal shading system with

the shades “open” would typically be a “clear” window, whereas the same system with the shades “closed” would be opaque. The shading system may offer some U-factor benefit as well as SHGC benefit, with the U-factor benefit dependent on the type of material used for shading. These systems require some sort of external control system to change the mechanical shading system.

There is an exception to the dynamic glazing requirement that states that if both the upper and lower values for a dynamic glazing product are already at or below the prescriptive requirement. Given that one of the appealing features of dynamic glazing is the fact that it offers “better” views when in the high SHGC and high U-factor modes, the situation described in the exception is not expected to occur very often. However, it could happen, and the 2015 IECC/IRC is ready for it.

[1]Fenestration is defined in the 2015 IECC/IRC as either vertical fenestration or skylights. Vertical fenestration is defined as windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of at least 60 degrees from horizontal.
[2]U-factor is defined in the 2015 IECC/IRC as thermal transmittance, the coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h•ft2•?F).
[3]This definition is taken from the commercial section definitions in the 2015 IECC. The code change proposal that added dynamic glazing requirements to the residential section of the 2015 IECC must not have included the definition in the residential section.
[4] Switchable glazing products include electrochromic glass systems that can be tinted or untinted in response to an electronic control signal or environmental change. (Source: Footnote 7)
[5]Internal shading systems include blinds positioned between glass panes that can open and close.
(Source: Footnote 7)
[6]The third property that may be impacted by dynamic glazing is visible transmittance. VT is associated with the amount of visible light that passes through fenestration and this property is typically associated with daylighting. Consideration of VT or these daylighting systems for residential buildings are not required in the 2015 IECC.

Plan Review:

Per the ***IECC/IRC, Section R103.3/R106.3, Examination of documents***. The code official/building official must examine or cause to be examined construction documents for code compliance.

This section lists the applicable code requirements and details helpful for plan review regarding the provisions to meet the requirements for "dynamic glazing".

- **Construction Documentation**. Review the construction documents for the details on the windows and/or glass doors. — ***2015 IECC/IRC, Section R103.2/N1101.5 Information on construction documents***. Construction documents should include:
    - U-factors and SHGCs
    - Area-weighted U-factor and SHGC calculations
-

- **Ratings on Fenestration**. Confirm the products specified have been rated, certified, and labeled per the National Fenestration Rating Council (NFRC). Dynamic glazing products are labeled by the NFRC with a special label that shows the lower and upper values of SHGC that are associated with the product.[7]

  — ***2015 IECC/IRC, Section R303.1.3/N1101.10.3 Fenestration Product Rating***. U-factors of fenestration products (i.e., windows and glass doors) to be determined in accordance with NFRC 100 and the SHGC with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer.

  — ***2015 IECC/IRC, Section R402.4.3/N1102.4.3 Fenestration air leakage***. Windows and sliding glass doors to have an air infiltration rate of no more than 0.3 cfm per square foot when tested in accordance to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer.

  — ***2015 IECC/IRC, Section R402.3.1/N1102.3.1 U-factor***. An area-weighted average of fenestration products is permitted to satisfy the U-factor requirements prescriptively.

  — ***2015 IECC/IRC, Section R402.3.2/N1102.3.2 Glazed fenestration SHGC***. An area-weighted average of fenestration products more than 50% glazed is permitted to satisfy the SHGC requirements prescriptively.

  - **Dynamic glazing** shall be permitted to satisfy the SHGC requirements of Table R402.1.2/N1102.1.2 provided the ratio of the higher to lower labeled SHGC is greater than or equal to 2.4, and the *dynamic glazing* is automatically controlled to modulate the amount of solar gain into the space in multiple steps. *Dynamic glazing* shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing is not be permitted.
    - Exception: *Dynamic glazing* is not required to comply with this section of the code when both the lower and higher labeled SHGC already comply with the requirements of Table R402.1.1/R1102.1.2. (Note that there is no Table R402.1.1/R1102.1.2 in the 2015 IECC/IRC and this is an obvious typo that should refer to Table R402.1.2/N1102.1.2.)

  2015 IECC/IRC (Table R402.1.2/N1102.1.2)

Climate Zone	1	2	3	4 except Marine	5 and Marine 4	6	7	8
U-factor	NR	0.40	0.35	0.35	0.32	0.32	0.32	
SHGC	0.25	0.25	0.25	0.40	NR	NR	NR	

  — ***2015 IECC/IRC Section R402.5/N1102.5.1 Maximum fenestration U-factor and SHGC***. The area-weighted average maximum fenestration U-factor and SHGC permitted using the following tradeoffs:

  - Climate zones 4 and 5 – U-factor 0.48
  - Climate zones 6-8 – U-factor 0.40
  - Climate zones 1-3 – SHGC 0.50

  — ***2015 IECC/IRC Section R402.3.3/N1102.3.3 Glazed fenestration exemption***. Up to 15 square feet of glazed fenestration per dwelling unit is permitted to be exempt from the U-factor and SHGC requirements; however, this exception does not apply to the U-factor alternative approach or total UA alternative under Section R402.1.4 and R402.1.5.

  — ***Flashing/Moisture Control***

  - ***2015 IRC, Section R703.4 Flashing***. Approved corrosion-resistant flashing to be applied shingle-fashion to prevent water from entering into wall cavities or from penetrating into building structural framing components. Self-adhered flashing must comply with AAMA 711. Flashing at exterior window and door openings must extend to the surface of the exterior wall finish or to the water-resistive barrier. Flashing must be installed in accordance with one or more of the following:
    - In accordance with fenestration manufacturer's installation and flashing instructions or in accordance with the flashing manufacturer's instructions. Where instructions or details are not provided, pan flashing is to be installed at the sill of exterior window and door openings and must be sealed or sloped to direct water to the surface of the exterior wall finish or water-resistive barrier. Openings using pan flashing must also incorporate flashing or protection at the head and sides.
    - Per the flashing design or method of a registered design professional.

- **Air Sealing/Air Leakage Control**

  — **2015 IRC/IECC, Table R402.4.1.1/N1102.4.1.1, Air Barrier and Insulation Installation, Windows and Doors.** Seal space between window/door jambs and framing.

[7]See **http://c.ymcdn.com/sites/www.nfrccommunity.org/resource/resmgr/factsheets_2013/dynamicglazing2.pdf** for explanation of the NFRC dynamic glazing rating system and label.

Field Inspection:

Per the ***2015 IECC, Section R104, Inspections,*** construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required

inspections include: footing and foundation, framing and rough-in, plumbing rough-in, mechanical rough-in, and final inspection.

Per the ***IRC, Section R109, Inspections,*** the wording is somewhat different in that for on-site construction, from time to time the building official, upon notification from the permit holder or his agent, can make or cause to be made any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.
This section provides details for inspecting to the specific provisions for "dynamic glazing" where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance.

- *Confirm windows meet the ratings approved on the construction documents.* If the labels have been removed from the products, ask the contractor or homeowner if they saved a label to confirm the ratings meet compliance.
- *Confirm the windows have been flashed and sealed properly*. An inspection during installation to make sure the windows have been flashed properly before the siding and trim goes up is recommended. The following websites provide information on flashing/sealing windows.
    - ***Guide with pictures on how to properly flash the window.***
    - ***Guide with pictures on how to properly seal the window.***

Technical Validation(s):

Advanced Glazing and Window Technologies, National Institute of Building Sciences

More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

1. **DOE Zero Energy Ready Home Case Study e2 Homes Winter Park, Florida [2-page summary version]**
   (845 KB)
   Author(s): PNNL
   Organization(s): PNNL
   Publication Date: January, 2013
   Case study about the first certified DOE Zero Energy Ready Home—the "Wilson Residence" in Winter Park, Florida.

2. **DOE Zero Energy Ready Home Case Study: BPC Green Builders, New Fairfield, Connecticut**
   Author(s): PNNL
   Organization(s): PNNL
   Publication Date: September, 2013
   Case study of a DOE Zero Energy Ready Home in west Connecticut that scored HERS 39 without solar PV. The 3,000 ft2 two-story home has R-33 double-walls, R-72 flat roof with closed-cell foam and blown cellulose, an ERV, and LED lighting.

3. **DOE Zero Energy Ready Home Case Study: e2 Homes, Winter Park, Florida**
   (1 MB)
   Author(s): PNNL
   Organization(s): PNNL
   Publication Date: January, 2013
   Case study of a DOE Challenge Home in Winter Park FL that scored HERS 57 without PV or HERS -7 with PV. This 4,305 ft2 custom home has autoclaved aerated concrete walls, a sealed attic with R-20 spray foam, and ductless mini-split heat pumps.

4. **Technology Solutions for New Manufactured Homes: Idaho, Oregon, and Washington Manufactured Home Builders**
   Author(s): BA-PIRC
   Organization(s): BA-PIRC
   Publication Date: November, 2013
   Case study describing a package of energy- efficiency measures for new manufactured homes in the Pacific Northwest, including triple-pane highly efficient windows.

References and Resources*

1. **DOE Zero Energy Ready Home National Program Requirements**
   Author(s): DOE
   Organization(s): DOE
   Publication Date: August, 2015
   Standard requirements for DOE's Zero Energy Ready Home national program certification.

2. **ENERGY STAR Certified Homes, Version 3 (Rev. 08) National Program Requirements**
   Author(s): EPA
   Organization(s): EPA
   Publication Date: September, 2015
   Document outlining the program requirements for ENERGY STAR Certified Homes, Version 3 (Rev. 08).

3. **ENERGY STAR Residential Windows, Doors, and Skylights**
   Author(s): EPA
   Organization(s): EPA
   Publication Date: January, 2014
   ENERGY STAR specifications for residential window, door and skylights, Version 6, effective January 1, 2015.

4.

Thermal Enclosure System Rater Checklist Guidebook
Author(s): EPA
Organization(s): EPA
Publication Date: October, 2011
Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

5. **What Makes it Energy Star? Performance Criteria**
Author(s): EPA
Organization(s): EPA
Publication Date: January, 2013
Information sheet outlining the criteria for ENERGY STAR qualified, windows, doors, and skylights.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide

The following Building America Teams contributed to the content in this Guide.

Pacific Northwest National Laboratory