ENERGY STAR® for Windows, Doors, and Skylights

Version 6.0 Draft 1 Criteria and Analysis Report

July 2012

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Executive Summary

The U.S. Environmental Protection Agency (EPA) is pleased to share the *ENERGY STAR for Windows, Doors, and Skylights Version 6.0 Draft 1 Criteria and Analysis Report*. The criteria revision process began with the release of the *Version 6.0 Product Specification Framework Document* in October 2011. EPA has reviewed the comments and suggestions received in response to the pertinent issues in that document and performed additional research and analysis to develop the criteria proposed in this report. The criteria revision process is described in Section 1, which also includes an overview of the *ENERGY STAR Products Program Strategic Vision and Guiding Principles*.

Highly-efficient windows, doors, and skylights are more widely available than ever before. Current market share for ENERGY STAR qualified windows has reached 81%, doors are at 71%, and skylights are at 70%. As such, EPA is revising the criteria to provide improved differentiation in the market place and to ensure that ENERGY STAR stays ahead of the most recent residential energy codes. Based on the research and analyses summarized in Sections 3-5, EPA believes that the proposed criteria (listed below) will achieve these goals while offering consumers a wide selection of ENERGY STAR products.

Draft 1 Version 6.0 Specification

Windows

Zone	U-Factor	SHGC
Northern	≤ 0.27	Any
Tradeoff	= 0.28	≥ 0.32
North-Central	≤ 0.29	≤ 0.40
South-Central	≤ 0.31	≤ 0.25
Southern	≤ 0.40	≤ 0.25

Air Leakage ≤ 0.3 cfm/ft^2

Doors

Glazing Level	U-Factor	SHGC
Opaque	≤ 0.17	N/A
≤ ½-Lite	≤ 0.23	≤ 0.25
> ½-Lite	≤ 0.30	≤ 0.25

Air Leakage ≤ 0.3 cfm/ft^2 for sliding doors
Air Leakage ≤ 0.5 cfm/ft^2 for swinging doors

Skylights

Zone	U-Factor	SHGC
Northern	≤ 0.45	≤ 0.35
North-Central	≤ 0.47	≤ 0.30
South-Central	≤ 0.50	≤ 0.25
Southern	≤ 0.60	≤ 0.25

Air Leakage ≤ 0.3 cfm/ft^2

To arrive at the proposed criteria, EPA examined the National Fenestration Rating Council (NFRC) Certified Products Directory (CPD) to determine feasibility and confirmed availability of these products by collecting data on products available for sale. EPA examined and evaluated the performance of various product designs and components, looking specifically at several issues raised by stakeholders. Cost-effectiveness calculations show that the proposed Version 6.0 windows specification offers average payback periods of 6-16 years over the four ENERGY STAR climate zones. These analyses are summarized in Section 3, which also provides possible considerations for the Version 7.0 windows criteria. The proposed Version 6.0 window specification would provide first-year aggregate national energy savings potential of 2.21 trillion British thermal units (tBtu) over the Version 5.0 specification.

The research that EPA conducted showed that the proposed door and skylight criteria are technologically feasible. The skylights product availability research indicates that high-performance skylights are readily available on the market today.

EPA is proposing two new additions to the specification: an air leakage requirements and an installation instructions requirement. EPA has opted to match the air leakage requirements of the 2012 International Energy Conservation Code (IECC). The installation instructions requirement is detailed in the Draft 1 specification and in Section 2 of this report.

EPA welcomes stakeholder comments on all topics related to this specification revision, especially with regard to specific questions posed in this report. Written comments should be sent to windows@energystar.gov by Friday, September 28, 2012. EPA plans to provide information about the forthcoming stakeholder meeting under separate cover shortly after the publication of this report.

1 Introduction

The U.S. Environmental Protection Agency (EPA) recognizes and appreciates window, door, and skylight stakeholders' support of the ENERGY STAR program and the industry's interest in helping EPA shape requirements for this product category. As such, EPA is pleased to share the ENERGY STAR for Windows, Doors, and Skylights Version 6.0 Draft 1 Criteria and Analysis Report with stakeholders. This report outlines the research and analyses performed to determine appropriate criteria for this program. The Agency welcomes stakeholder comments on all topics related to this specification revision, especially with regards to specific questions posed in this report. Please send comments by Friday, September 28, 2012, to windows@energystar.gov.

EPA understands that this level of research and analysis has typically been provided for this product category in the past. Please note, however, that the criteria revisions for other product categories do not include this type of extensive report. For other product categories, the draft specifications are simply annotated to describe the reasons for various changes. While few changes have been made to the current process for the Version 6.0 revision, stakeholders should expect future criteria revisions to be brought more in line with the revision process for the other ENERGY STAR product categories.

1.1 Guiding Principles for ENERGY STAR Criteria Revisions

As outlined in the *ENERGY STAR Products Program Strategic Vision and Guiding Principles* at http://www.energystar.gov/ia/partners/prod_development/downloads/ENERGY_STAR_Strategic_Vision_and_Guiding_Principles.pdf, the criteria revision process seeks to strike a balance between six guiding principles of the program:

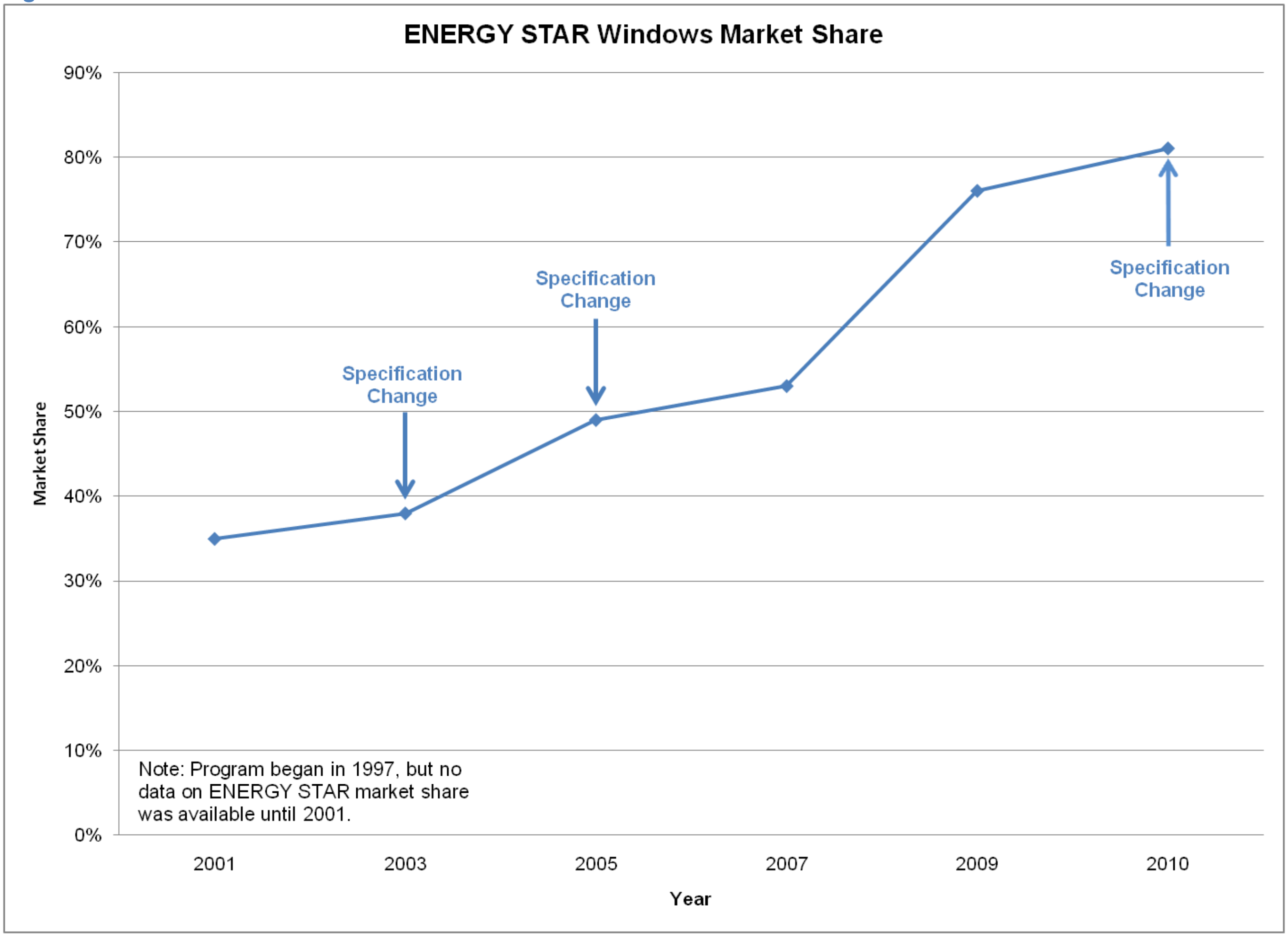
1. Significant energy savings can be realized on a national basis.
2. Product performance can be maintained or enhanced with increased energy efficiency.
3. Purchasers will recover their investment in increased energy efficiency within a reasonable period of time.
4. Energy-efficiency can be achieved through one or more technologies such that qualifying products are broadly available and offered by more than one manufacturer.
5. Product energy consumption and performance can be measured and verified with testing.
6. Labeling would effectively differentiate products and be visible for purchasers.

Experience has shown that it is typically possible to achieve the necessary balance among these principles by selecting efficiency levels reflective of the top 25% of models available on the market (not market share) when the specification goes into effect. At the same time, windows, doors, and skylights are a unique product category, as reflected by this analysis, and considerations such as cost-effectiveness may lead to performance levels representing a somewhat larger percentage of what might be available at the time of implementation.

Under the current specification, market share for ENERGY STAR qualified windows has a reached a level that no longer provides differentiation for the consumer in the market place (the sixth guiding principle). As show in Figure 1, ENERGY STAR market share for windows has continued to grow over the past ten years, despite multiple changes in program criteria. Market share for doors and skylights are also high, with doors at 71% and market share for skylights at 70%.[1]

[1] Ducker Worldwide LLC, ENERGY STAR Window & Door Tracking Program, 2011.

Figure 1: ENERGY STAR Market Share 1999-2010[2]



This ever-increasing market share suggests that innovation and/or cost-effectiveness in the market place is outpacing the specification revision cycle. In order to provide sufficient differentiation in the marketplace, EPA would like to see a market share of less than 50% after the Version 6.0 specification takes effect. According to some stakeholders, the specification ranges proposed in the Framework Document would result in a 41% market share. Some stakeholders expressed concern that this was too high, but EPA recognizes that a 41% market share would represent more than a 50% reduction from the current market share. This is a dramatic change, but EPA sees this as an important step away from the industry perception of ENERGY STAR as de facto code. ENERGY STAR seeks to identify the most energy-efficient products available. Not all products should qualify for ENERGY STAR, especially immediately after a specification revision. It is expected for market share to grow in the years following the specification revision as manufacturers create new designs and find ways to reduce product costs.

The proposed criteria levels are meant to acknowledge those manufacturers that are investing in advanced technology while motivating those seeking to remain competitive in an increasingly energy-

[2] Market share data in this graph comes from the following sources: Ducker Research Company, Inc., Study of the U.S. Market for Windows, Door and Skylights, 2002. Exhibit D.14: Conventional Residential Windows – Energy Ratings; Ducker Research Company, Inc., Study of the U.S. Market for Windows, Door and Skylights, 2006. Exhibit D.15: Conventional Residential Windows – Energy Ratings; Ducker Research Company, Inc., Study of the U.S. Market for Windows, Door and Skylights, 2008. Exhibit D.15: Conventional Residential Windows – Energy Ratings; Ducker Worldwide LLC, ENERGY STAR Window & Door Tracking Program, 2010, Page 5.; Ducker Worldwide LLC, ENERGY STAR Window & Door Tracking Program, 2011, Page 5.

efficient product market. Specifically, EPA wanted to select a Northern Zone U-factor that would incorporate more triple-pane windows while encouraging development of higher-performance double-pane windows. Cost-effectiveness is an important consideration when evaluating potential criteria levels. Many stakeholders shared concerns during the last criteria revision about the cost of triple-pane windows. Based on the research and analysis completed to date, EPA has not found any dramatic changes in the prices of triple-pane units. There are, of course, manufacturers that specialize in triple-pane windows and, as such, have lower than average costs, but these manufacturers are still a small subset of the mainstream.

Stakeholders pointed out that it will become increasingly difficult for ENERGY STAR to select cost-effective criteria that are ahead of codes. EPA acknowledges that there are diminishing returns in energy savings as products become more efficient. This is true with any product category, and EPA sunsets those programs that cease to have potential to pull the market forward in energy efficiency. Fortunately, there is still room for improvement in the fenestration industry before this point is reached.

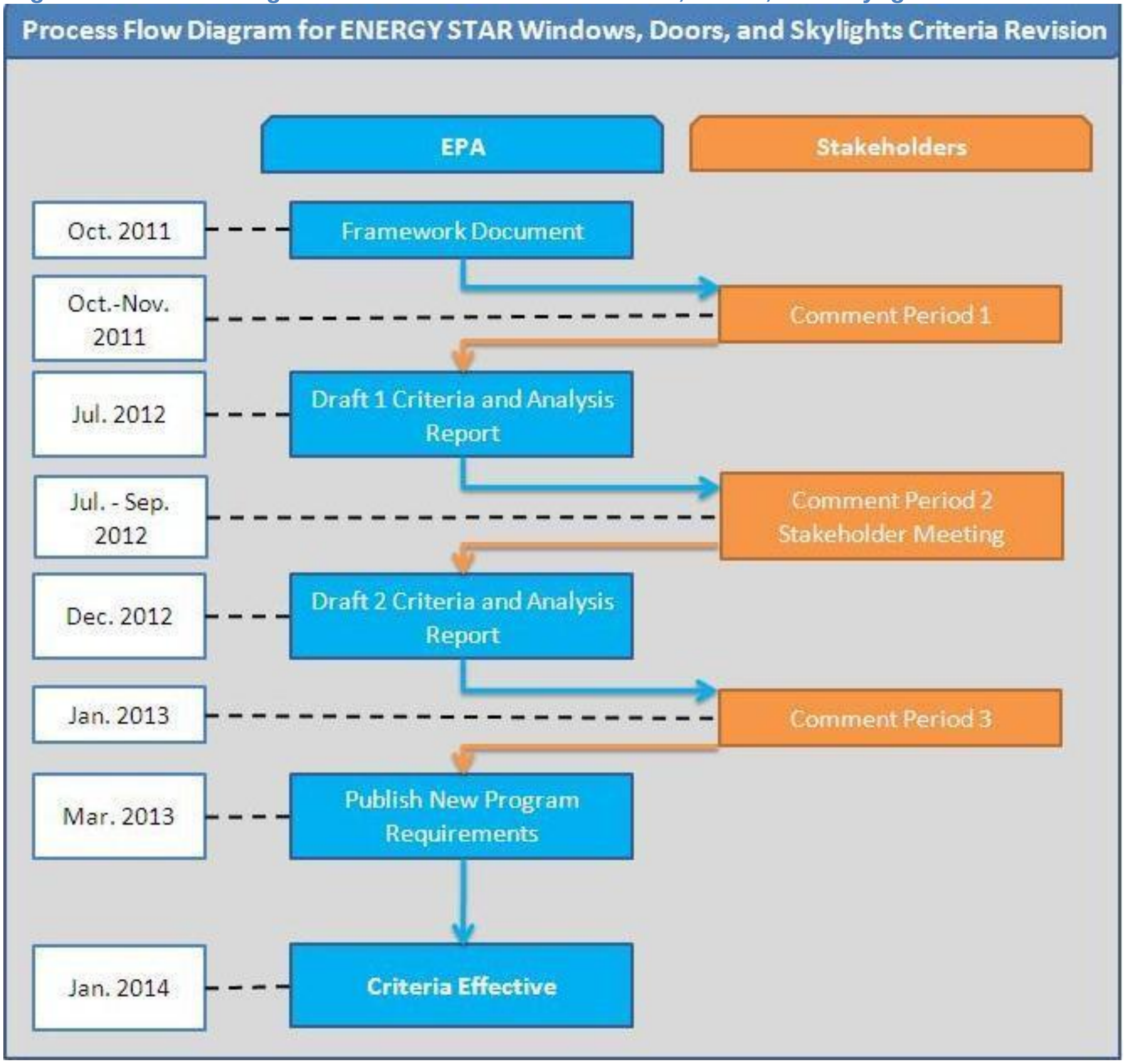
1.2 Criteria Revision Process for Windows, Doors, and Skylights

The Version 6.0 criteria revision process is similar to the Version 5.0 criteria revision process. Some documents and processes have been renamed, but the components of the Version 5.0 revision are still present.

1.2.1 Overview of Process

EPA has outlined its criteria revision approach in Figure 2 to clarify the process for stakeholders. EPA may use a simplified or streamlined process for future criteria revisions, but changes from the Version 5.0 criteria revision are minimal for the Version 6.0 criteria revision. For instance, during the Version 5.0 criteria revision, the U.S. Department of Energy (DOE) announced its proposed criteria ranges in a letter. For Version 6.0, this was done in the Framework Document. Under EPA, draft criteria are typically identified as Draft 1, Draft 2, and so forth in the interest of clarity. Additionally, draft criteria are typically released as draft program specifications, rather than simply included as tables in an analysis report (as was done for the Version 5.0 criteria revision). Note that the criteria revision process is still governed by the Energy Policy Act of 2005 (EPAct), which mandates that partners must have 270 days notification prior to the final specification taking effect.

Figure 2: Process Diagram for ENERGY STAR Windows, Doors, and Skylights Criteria Revision



1.2.2 *Revised Timeline*

A general timeline is incorporated in Figure 2 in the previous section, but Table 1 below provides specific dates for major milestones in the criteria revision process. Please note that this is a tentative timeline and EPA may need to modify dates based on budgetary or other needs.

Table 1: Tentative Timeline for Criteria Revision

Tentative Timeline	
Draft 1 Criteria and Analysis Report	July 2012
Stakeholder Meeting	August 2012
Comment Period	July – September 2012
Draft 2 Criteria and Analysis Report	December 2012
Comment Period	January 2012
Publish New Program Requirements	March 2013
Criteria Take Effect	January 1, 2014

Many stakeholders requested that the effective date be moved to 2015 in order to allow more manufacturers to “comply” or redesign products to meet the new criteria. As with other product categories, EPA's expectation is that market share may drop immediately after the criteria revision and come back up over time.

EPA has set the implementation date at January 1, 2014. This allows four years between the effective dates of Version 5.0 and Version 6.0 and more than two years between the publication of the Framework Document and the implementation date of the final specification.

Stakeholders also requested that the ENERGY STAR specification revision process be aligned with the code development cycle. ENERGY STAR is a voluntary program aimed at recognizing the most energy-efficient products and, as such, it is driven primarily by product improvements rather than code advancement. EPA plans to continue monitoring developments in code to ensure the criteria remain relevant. The final action hearings for the 2015 International Energy Conservation Code (IECC) are scheduled for October 2013, prior to the anticipated effective date of the ENERGY STAR criteria.

2 Overview of Version 6.0 Draft 1 Criteria

Specific revisions to the window, door, and skylight criteria are covered later in this document (in Sections 3, 4, and 5, respectively). This section highlights changes made to the program specification language; program elements considered for adoption; program elements remaining unchanged; and new additions to the program requirements. For ease of reference, EPA has added line numbers to the Version 6.0 Draft 1 program requirements.

2.1 General Modifications to Program Requirements

General program requirement modifications are meant to clarify rather than modify the program specification. In the interest of maintaining consistency across all ENERGY STAR product categories, EPA has reordered and refined the language in the product specification. Over time, document structures change, typographical errors are identified, and definitions or policies may be clarified. These changes are integrated into the program specification during the criteria revision process. Where necessary, EPA has included explanatory text for these changes.

2.2 Program Elements Considered for Adoption

In the Framework Document, EPA welcomed stakeholder feedback on a number of program elements with insufficient data and/or justification for inclusion in the Version 6.0 specification. EPA thanks stakeholders for their detailed and insightful feedback on these topics. Based on this feedback, EPA took a closer look at many of these issues.

2.2.1 Structural Requirements

Early in the criteria revision process, stakeholders had the opportunity to participate in informal feedback calls regarding a number of issues. When the topic of including structural requirements was raised, all stakeholders who participated in this process cited the need to have structural performance certified through the American Architectural Manufacturers Association (AAMA) or the Window and Doors Manufacturers Association (WDMA). As such, the Framework Document cited a lack of ENERGY STAR partner participation in these two programs as a main reason for excluding structural requirements from the draft specification. During the Framework Document comment period, however, stakeholders countered that there are at least four agencies that provide structural certification: AAMA, WDMA, Keystone Certifications, and the National Accreditation & Management Institute, Inc. (NAMI).

Stakeholders claimed that many ENERGY STAR qualified products already have structural certification. Unfortunately, there is no unified database for structural certification like there is for thermal performance, which makes it difficult to verify this assertion. Further, each certification program has its own protocol for labeling certified products, which would require EPA to develop educational content for consumers on how to read these labels (as is currently done for the NFRC temporary label). One stakeholder recommended that partners simply submit proof of structural testing without requiring certification, but third-party certification is now a mandate for all ENERGY STAR specification criteria so this is not a viable option for the program.

Other stakeholders expressed concern about whether a structural requirement would add value to the ENERGY STAR program, specifically because structural requirements may not translate to immediate energy-saving benefits. While this may be true, EPA believes a structural requirement could help ensure that consumers are purchasing quality fenestration, supporting the renewed effort to deliver on the ENERGY STAR brand purchase. For this reason, EPA may reconsider including a structural requirement in the Version 7.0 criteria, but after taking all the elements above into consideration, EPA has ultimately decided not to add a structural requirement to the Version 6.0 specification.

2.2.2 Products Installed at High-Altitude

Though no formal definition of “high-altitude” exists in the fenestration industry, the input received during both the Version 5.0 and Version 6.0 criteria revisions seems to indicate that stakeholders largely coalesce around a figure of 5,000-6,000 feet as the altitude at which products manufactured at a lower elevation must rely on capillary (or breather) tubes to prevent glass deflection. In the Version 5.0 criteria revision, DOE found that less than 3% of the U.S. population lives in counties where at least half of the county area lies at or above 6,000 feet, which leaves an even smaller percentage of products that must rely on capillary tubes.

Some have proposed creating “sub-zones” for high-altitude products, but DOE also evaluated this option during the previous criteria revision and determined that the resulting zones would be too small to be discernible on a product qualification map. Another suggestion was to grant exemptions to products installed at high-altitudes, but this creates label complexity, confusion for the consumer, increased enforcement responsibility for EPA, and the need for additional educational content, all of which mean increased program costs for both EPA and manufacturers. Finally, stakeholders noted that creating any type of “exemption” opens the door for other specialty products to seek special treatment under the product specification. Therefore, EPA does not propose providing exemptions, separate criteria, or climate sub-zones for these products.

Several stakeholders have expressed support for this position and agreed with EPA’s reasoning, citing available technologies and alternative paths which allow these products to meet the proposed criteria. Multiple stakeholders have indicated that they have found ways (both proprietary and non-proprietary) to achieve high-efficiency in products installed at high altitudes and had no concerns about manufacturing cost-effective product for these regions. Specifics of the technologies involved have not been disclosed to EPA, so EPA encourages manufacturers to continue research and development in this area.

2.2.3 Impact-Resistant Products

DOE found during the last criteria revision that there are some high-performance impact-resistant products available on the market today and the number of households required to buy impact-resistant products in the Northern Zone is small. At least one manufacturer has an impact-resistant product that meets the proposed specification in the Northern Zone, and this product was developed over two years ago. Impact-resistance is considered a specialty feature, especially in the Northern Zone. The focus of the ENERGY STAR program is moving the general market forward and, as such, cost-effectiveness is sought for more common products and features.

Further, there is no database of impact-resistant products with which EPA can assess the performance of these products and no one in the industry has volunteered the necessary performance data. Without solid data with which to evaluate the performance of these products, EPA cannot make an objective decision regarding separate criteria or an allowance for these products.

2.2.4 Daylighting Criterion

As stated in the Framework Document, EPA considers "daylighting" a property that can only be evaluated at a room or whole-building level. Individual fenestration products cannot truly be evaluated for their daylighting properties. This notion seems to be supported by the lack of an NFRC-certified daylighting metric.

As an alternative to a daylighting criterion, some stakeholders suggested that EPA consider a light-to-solar gain ratio to ensure that the clarity of fenestration products – particularly windows and skylights – is not sacrificed in the pursuit of lower Solar Heat Gain Coefficient (SHGC) ratings. Informal stakeholder feedback indicates that a Visible Transmittance (VT) of less than 0.40 is considered undesirable by consumers because the glass appears darker. EPA analyzed this potential metric using double-hung window performance data from the NFRC Certified Products Directory (CPD) and determined that that such a criterion does not make sense for the program. There is no criteria level for light-to-solar gain ratio that excludes low-VT products without also unnecessarily excluding high-VT products that would otherwise qualify. Thus, while a VT/SHGC metric sounds promising in principal, it does not appear to strike a balance between added quality and readily available product. Additionally, Section 3.2.5 shows that products at even the lowest SHGC level proposed can still achieve reasonable VT levels.

2.2.5 Lifecycle Analysis (LCA)

In the Framework Document, EPA stated that it did not plan to include an LCA component in the Version 6.0 specification. Many stakeholders supported this position, citing that more analysis is needed before a LCA requirement is incorporated into the product specification. EPA plans to continue to monitor developments in fenestration LCA and supports such assessments as resources allow. EPA also agrees with many stakeholders' statements that that industry participation is an important aspect of such assessments. While some stakeholders recommended "credits" in the specification for recycled or bio-based content as a short-term substitute, EPA prefers to defer such an effort until a more complete picture of product impact is available.

2.3 Program Elements Remaining Unchanged

EPA does not propose changes to two program elements: the ENERGY STAR climate zones and the classification of Tubular Daylighting Devices (TDDs) as skylights.

2.3.1 ENERGY STAR Climate Zones

As stated in the Framework Document, the climate zone map was the subject of ample discussion and research efforts during the Version 5.0 criteria revision process. The current climate zone map takes local codes and regional efficiency efforts into account, while also matching IECC climate zones as closely as possible. EPA has no intention of revising the map during this specification revision and has not received compelling evidence from stakeholders that it is necessary or desirable to do so. EPA seeks to avoid the unnecessary additional cost that manufacturers would incur if the map (and therefore the ENERGY STAR label and related graphics) were to change. EPA may reconsider the map during the next criteria revision.

2.3.2 Classification of TDDs

EPA analysis (see Section 5.2.1) indicates that a separate specification is not required for TDDs and many stakeholders seem to concur with this assessment. The data indicate that most TDDs would not have any issue meeting the proposed skylight classification, and so EPA proposes that TDDs retain their classification as skylights for the Version 6.0 product specification.

2.4 New Additions to Program Requirements

EPA has added two new requirements to the product specification: air leakage qualification criteria and basic installation instructions for qualified products.

2.4.1 Air Leakage

The Version 6.0 specification includes a minimum air leakage performance requirement for ENERGY STAR qualified products as follows:

- Air Leakage ≤ 0.3 cfm/ft^2 for windows, sliding doors, and skylights
- Air Leakage ≤ 0.5 cfm/ft^2 for swinging doors

EPA has opted to match the air leakage requirements of the 2012 IECC to help ensure that ENERGY STAR qualified products help consumers avoid unnecessary additional heating and cooling costs.

For testing purposes, EPA proposes allowing either NFRC 400 or ASTM E283 to determine air leakage ratings. Stakeholders indicated that there could be some discrepancy between the testing sizes used for NFRC 400 and ASTM E283, which is why both tests have been included in the draft specification. EPA wants to eliminate the need for duplicative testing and the associated cost burden. EPA received a number of stakeholder comments regarding certification bodies (other than NFRC) that provide air leakage testing, but early discussions with NFRC revealed that it might be possible to have inspection agencies load non-NFRC air leakage ratings into the CPD. EPA plans to discuss this option with NFRC and also look into including the air leakage results (or a proxy for these results) in the forthcoming ENERGY STAR filter for the CPD.

EPA plans to work with NFRC to ensure that the proposed labeling methodology outlined in the specification can be allowed under NFRC procedure. Stakeholders have expressed some concern about the additional costs associated with labeling for air leakage, so EPA proposes allowing partners to update their NFRC temporary labels as products come up for recertification. The proposed labeling approach is binary (with companies listing "≤ 0.3" or "≤ 0.5" or leaving the space blank, as appropriate), but also provides consumers and code officials an indication of the air leakage achieved by a given product. EPA may consider using other labels as a proxy for this requirement, but needs to ensure that other labels can achieve a similar effect. As such, EPA encourages organizations that would like their labels considered as a proxy for this requirement to submit samples and descriptions of the labels so that EPA can better evaluate the air leakage portion of the label.

2.4.2 Installation Instructions

Several stakeholders spoke to the importance of a quality installation. Poor installation can lead to air infiltration, water leakage, reduced functionality of the unit, accelerated product decline, and even house-wide problems with mold. Callbacks and follow-up maintenance resulting from improper installation lead to added expenses for manufacturers and consumers and reflect poorly on manufacturers and the ENERGY STAR brand.

To improve access to proper installation information, EPA has proposed that manufacturers make installation instructions available to consumers and installers online or provide instructions with the product itself. The installation instruction requirement seeks to cover the basics of installation, including written descriptions and diagrams for applicable installation options.

EPA recognizes and respects that manufacturers may have their own installation procedures, but also understands that some companies may not have the resources to develop their own installation instructions. As such, EPA's installation instruction requirement allows manufacturers to provide their own set of instructions or link to installation instructions from a trade association or other organization (e.g. a parent company). Further, the requirement includes relatively broad guidelines to encompass a wide range of products and installation scenarios. The relevant language from the Draft 1 specification is included below.

> Installation Instructions: To qualify for ENERGY STAR, products shall have installation instructions readily available online or packaged with the product. Electronic versions of instructions may be provided on the website of a retailer, manufacturer, and/or industry association. These instructions shall include:
>
> - A list of hardware and tools required for installation, including those provided by the manufacturer and those not provided by the manufacturer.
> - Diagrams/pictures and descriptions of the product and parts provided by the manufacturer.
> - General guidance on safely removing old products and preparing the frame for installation, including proper management of lead paint when applicable. (Inclusion of diagrams/pictures is preferred, but optional.)
> - Detailed flashing instructions including diagrams/pictures or reference to the applicable flashing manufacturer's instructions.
> - Instructions on properly shimming the product to achieve an installation that is flush, level, and plumb. (Inclusion of diagrams/pictures is preferred, but optional.)
> - Guidance on sealing and weatherproofing to prevent air and water infiltration. (Inclusion of diagrams/pictures is preferred, but optional.)
> - Variations of the above based on whether the job is a pocket installation, rough opening installation with exterior sheathing intact, and/or rough opening installation with exterior sheathing removed (e.g. new construction installation), as applicable to the product.
>
> Disclaimer: EPA makes no warranties, expressed or implied, nor assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of the contents of installation instructions, or any portion thereof. Further, EPA cannot be held liable for defects or deficiencies resulting from the proper or improper application of installation instructions.

2.5 Questions for Stakeholder Feedback

1. Do stakeholders have any data demonstrating that any of the "program elements considered for adoption" need to be incorporated into the Version 6.0 criteria?
2. Do stakeholders have any data demonstrating that any of the "program elements remaining unchanged" need to be reconsidered under the Version 6.0 criteria?
3. Do stakeholders have any data demonstrating that any of the "new additions to program requirements" will present undue hardship and should not be added to the Version 6.0 criteria?

3 Version 6.0 Draft 1 Criteria for Windows

EPA's research and analysis indicates that the proposed windows criteria (see Table 2) can provide national energy savings, are technologically feasible, and provide cost-effective savings for consumers, paying back incremental price premiums in a reasonable period of time. The criteria do not require products to use proprietary technology and do not require consumer to compromise on non-energy performance of the product. Products meeting the criteria are available for sale today while also providing product differentiation in the market place for consumers.

Table 2: Draft 1 Criteria for ENERGY STAR Qualified Windows

Zone	U-Factor	SHGC
Northern	≤ 0.27	Any
Tradeoff	= 0.28	≥ 0.32
North-Central	≤ 0.29	≤ 0.40
South-Central	≤ 0.31	≤ 0.25
Southern	≤ 0.40	≤ 0.25

Table 3: Current Criteria for ENERGY STAR Qualified Windows

Zone	U-Factor	SHGC
Northern	≤ 0.30	Any
Tradeoffs	= 0.31 = 0.32	≥ 0.35 ≥ 0.40
North-Central	≤ 0.32	≤ 0.40
South-Central	≤ 0.35	≤ 0.30
Southern	≤ 0.60	≤ 0.27

EPA proposes continuing to allow high-gain and low-gain products to compete in the Northern Zone. In addition to allowing any SHGC in the Northern Zone, EPA is also proposing one set of equivalent energy performance criteria for those companies that manufacture high-gain products.

3.1 Overview

EPA worked with LBNL to determine that the proposed windows criteria can save 2.21 trillion British thermal units (tBtu) per year, or approximately $39.78 million per year in energy cost savings as compared to the Version 5.0 specification. To evaluate the feasibility of the criteria and determine product availability, EPA examined two data sets looking specifically at high-performance (low U-factor) windows, the performance of various glazing levels and gas-fills, potential glass type issues, and performance of various frame materials. Stakeholders provided many specific recommendations with regard to potential criteria levels, two of which are addressed in this section. Gauging cost-effectiveness involved determining incremental product costs from manufacturer-volunteered data sets, modeling household energy savings for the proposed criteria, and then calculating product payback. In an effort to help manufacturers begin planning for the next set of windows criteria, possible considerations for the Version 7.0 windows criteria are in Section 3.5.

3.2 Technological Feasibility and Product Availability

EPA concluded that the proposed criteria for windows are technologically feasible. Additionally, research shows that products are available for sale that can meet these criteria. To reach this determination, two sets of data were analyzed: the NFRC CPD and a database of products available for sale.

3.2.1 NFRC CPD Data Analysis

For two decades, NFRC has been the definitive source for fenestration performance data. NFRC is responsible for developing and upholding strict industry ratings and test procedures. One of NFRC's primary functions is to maintain a database of all certified fenestration products, including their configurations, component materials, and performance metrics.

For this criteria revision, EPA relied on NFRC's comprehensive list of double-hung windows to gain a better understanding of the performance manufacturers are able to achieve. EPA focused its analyses on double-hung windows, as these are the most commonly sold type of window[3] and are also typically the worst performing by virtue of their low glass-to-frame ratio. By basing its decisions primarily on the performance of double-hung windows, EPA is taking a conservative approach towards specification development.

Figure 3 shows the variation in performance for CPD windows with a variety of components. For example, double- and triple-pane windows significantly outperform single-pane windows but high performing double-pane windows can perform comparably to some triple-pane windows in terms of U-factor. This figure also shows a marked improvement in U-factor when relying on argon gas fill (rather than air) and also shows that argon windows can perform comparably to krypton-filled windows. The figure also shows that spacer improvements allow the window to reach lower U-factors.

Figure 3: Range of Performance for Double-Hung Windows in the CPD

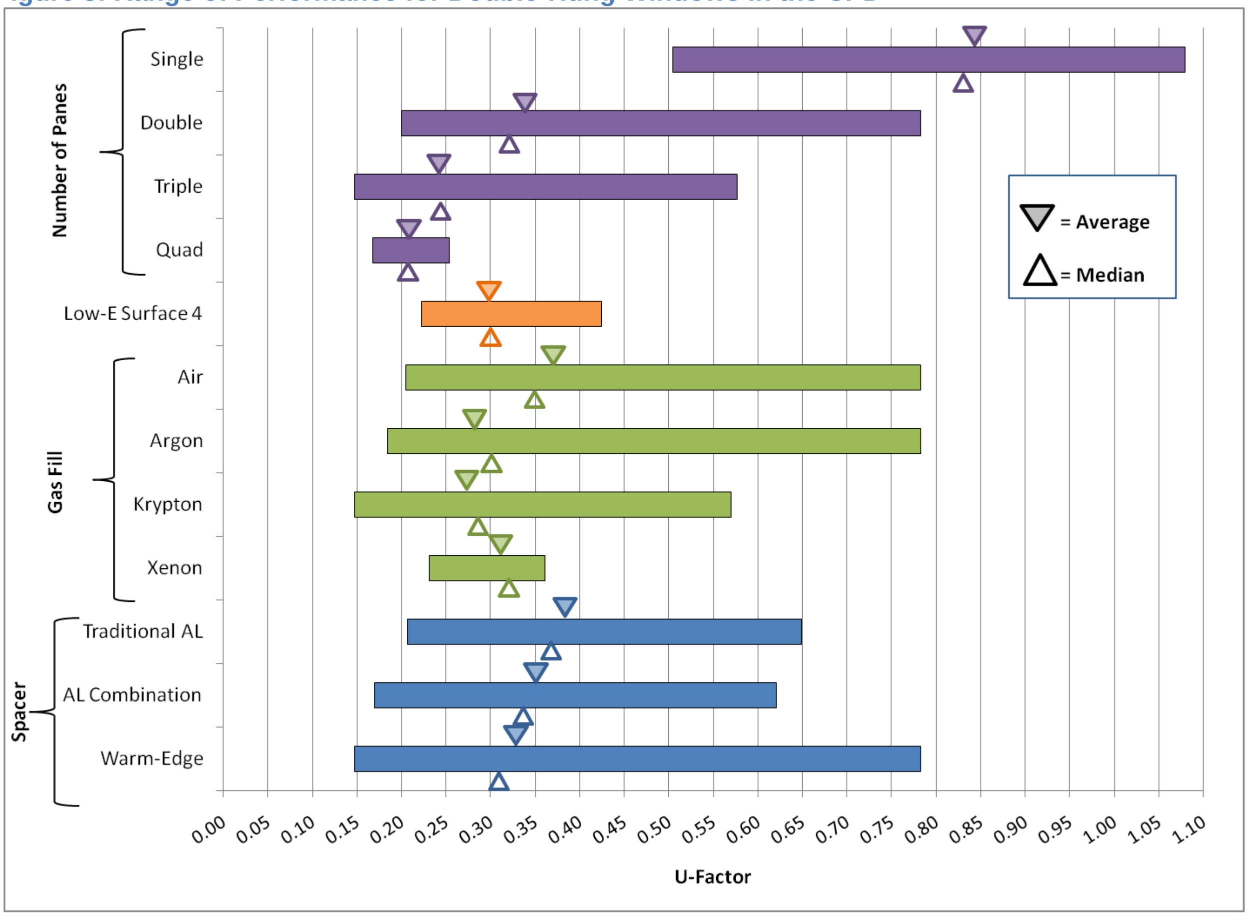
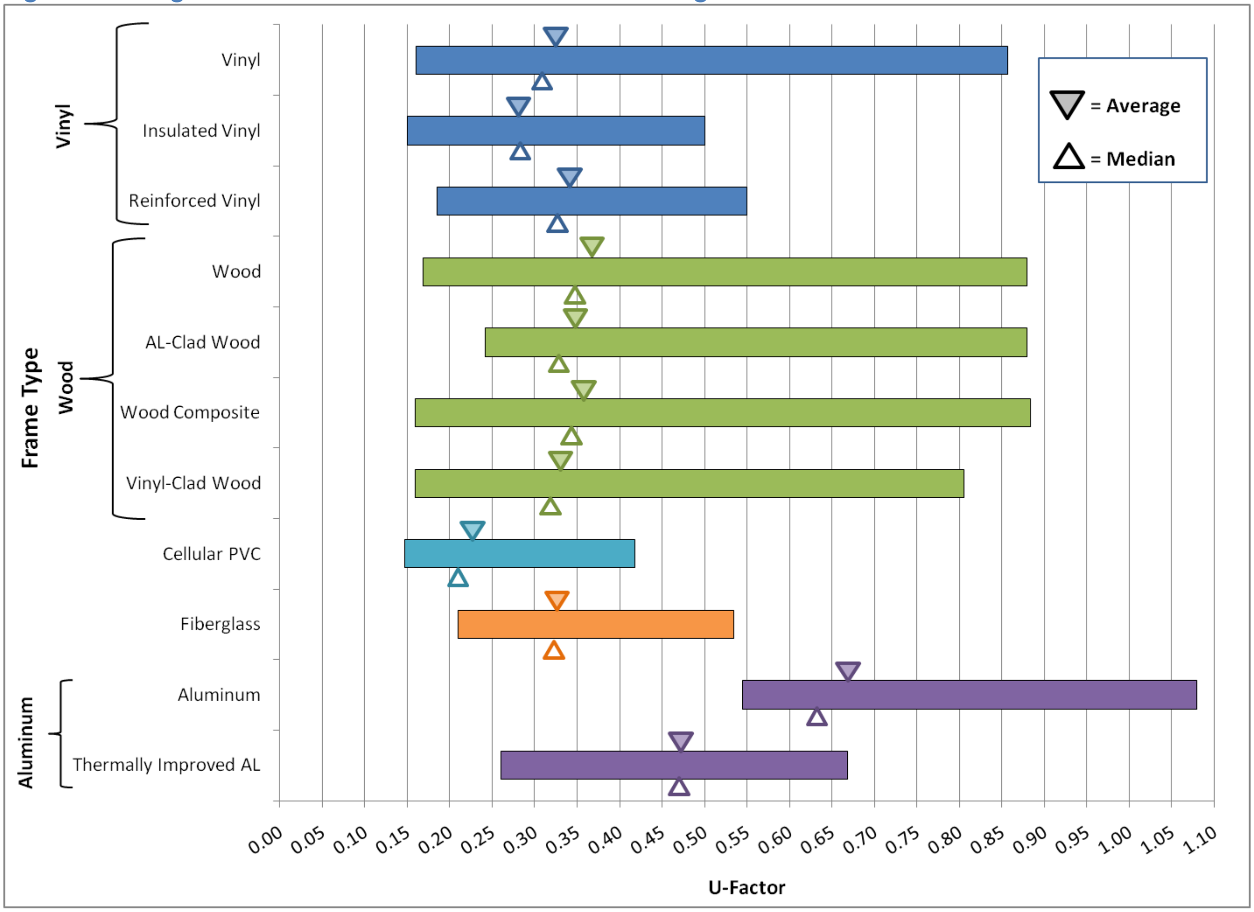


Figure 4 shows ranges of frame performance in the CPD by frame type. In general, wood, vinyl, and fiberglass perform comparably, although insulated vinyl windows tend to be more efficient. Cellular PVC windows, while still relatively uncommon, are capable of outperforming all three, while aluminum and thermally-improved aluminum windows are the lower performing models.

[3] Ducker Research Company, Inc. "Study of the U.S. Market for Windows, Doors and Skylights" prepared for the American Architectural Manufacturers Association and the Window & Door Manufacturers Association. 2010.

Figure 4: Range of Frame Performance for Double-Hung Windows in the CPD



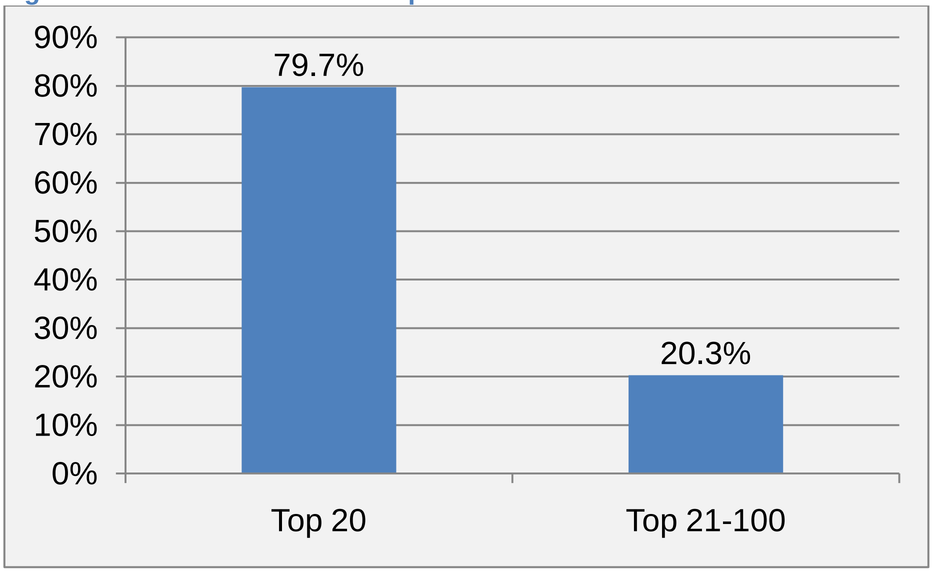
3.2.2 Products Available for Sale Methodology

While the CPD provides a comprehensive view of the windows that may be technically feasible to produce, manufacturers have indicated that listed products may not be produced and should therefore not be considered “available” for consumers. To address this issue and gain a better understanding of the products that are available to consumers, EPA performed the “products available for sale” analysis.

The products for sale analysis began with the identification of the top window manufacturers. *Window & Door Magazine* publishes an annual list of the Top 100 window and door manufacturers based on revenue. The top 20 companies on the list represent 79.7% of the market[4], so EPA concluded that focusing on products from these 20 companies would generally reflect the products available on the market. Further, each of the top 20 manufacturers produces ENERGY STAR qualified products and 14 of the top 20 sell to customers in all 50 states. These manufacturers’ combined market share has trended upwards since 2004, when they represented 69.82% of the market, further supporting the validity of this approach. Only two of the top 20 manufacturers did not publish windows specifications online.

[4] Estimate by D&R International, Ltd, based on: *Window & Door Magazine.* “Top 100 Manufacturers of 2010 – Rankings.” http://www.windowanddoor.com/2010Top100rankings1. (last accessed 5/24/2012)

Figure 5: Market Share of the Top 20 Window Manufacturers



After identifying the top window manufacturers, EPA collected and recorded data on all double- and single-hung windows, including technical specifications and components. Technical specifications included U-factor, SHGC, and VT. Components recorded included frame material, number of panes, gas fill, and glass coatings.

EPA then compared the products for sale database to see how well it represented the windows in the CPD. This comparison is illustrated in Figure 6 and Figure 7. In general, these databases correlate well at U-factors at and below 0.50. At the criteria levels proposed, EPA believes Figure 6 demonstrates that the CPD is representative of products available for sale.

Figure 6: Correlation of U-Factors Between CPD Products Available for Sale

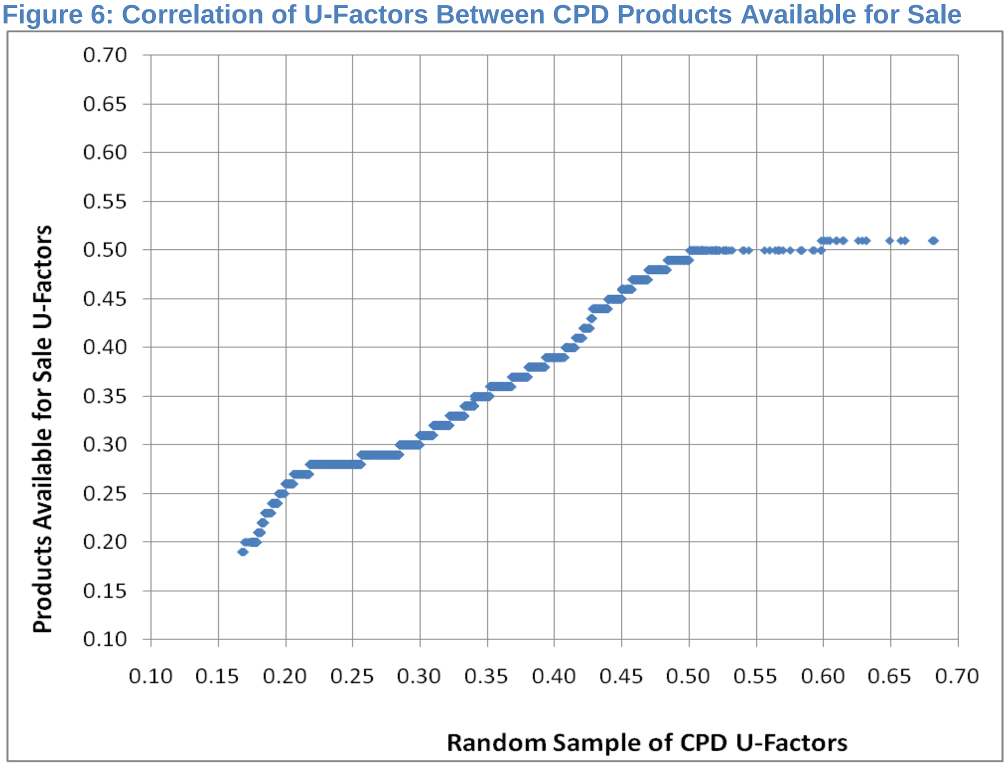
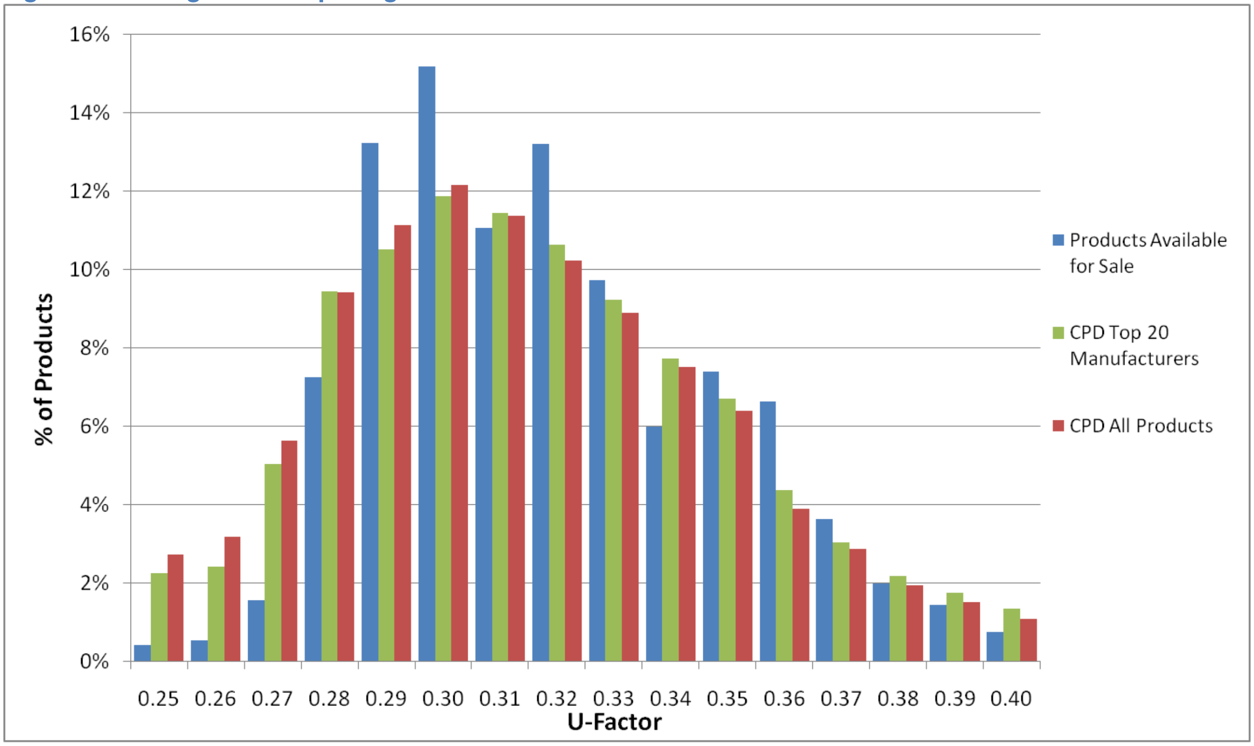


Figure 7: Histogram Comparing CPD and Products Available for Sale at Different U-Factors



3.2.3 Availability of Low U-Factor Windows

In setting the windows criteria, EPA first considered whether windows at various U-factors would have adequate availability. In the Northern Zone, approximately 41.5% of the products in the CPD that meet the current ENERGY STAR specification can meet the proposed U-factor of 0.27. This represents more than 142,000 double-hung windows (see Figure 8). The "products available for sale" database indicates a smaller proportion of qualifying products (13.0%) as shown in Figure 9.

Figure 8: Distribution of CPD Products by U-Factor and SHGC

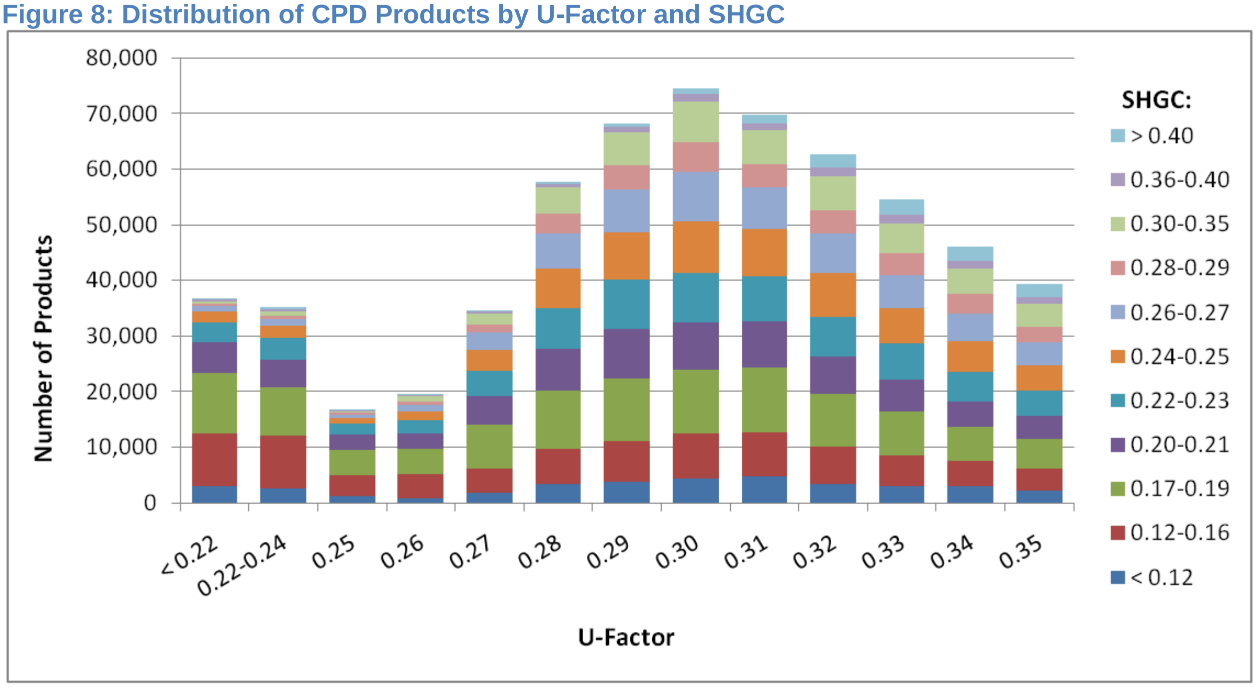
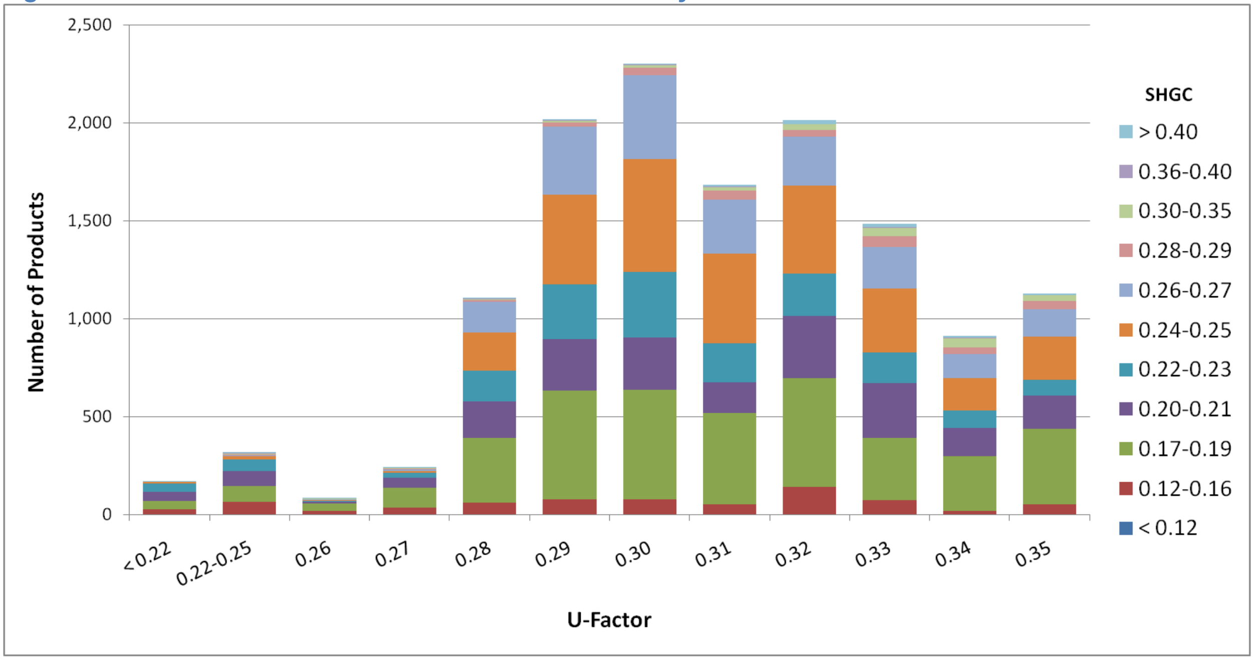


Figure 9: Distribution of Products Available for Sale by U-Factor and SHGC



3.2.4 Glazing Level and Gas Fill

EPA looked at the CPD and the database of products available for sale to determine at which point the market shifts from double- to triple-pane windows. EPA found that while manufacturers are capable of producing triple-pane products, they primarily rely on double-pane products to meet the demand for more efficient windows.

Figure 10 demonstrates that double-pane windows are more common in the CPD at a U-factor of 0.27. Figure 11 paints a similar picture based on products actively marketed by manufacturers. The CPD indicates that triples are the dominant windows at U-factors below 0.27.

Figure 10: Distribution of CPD Products by Glazing Level

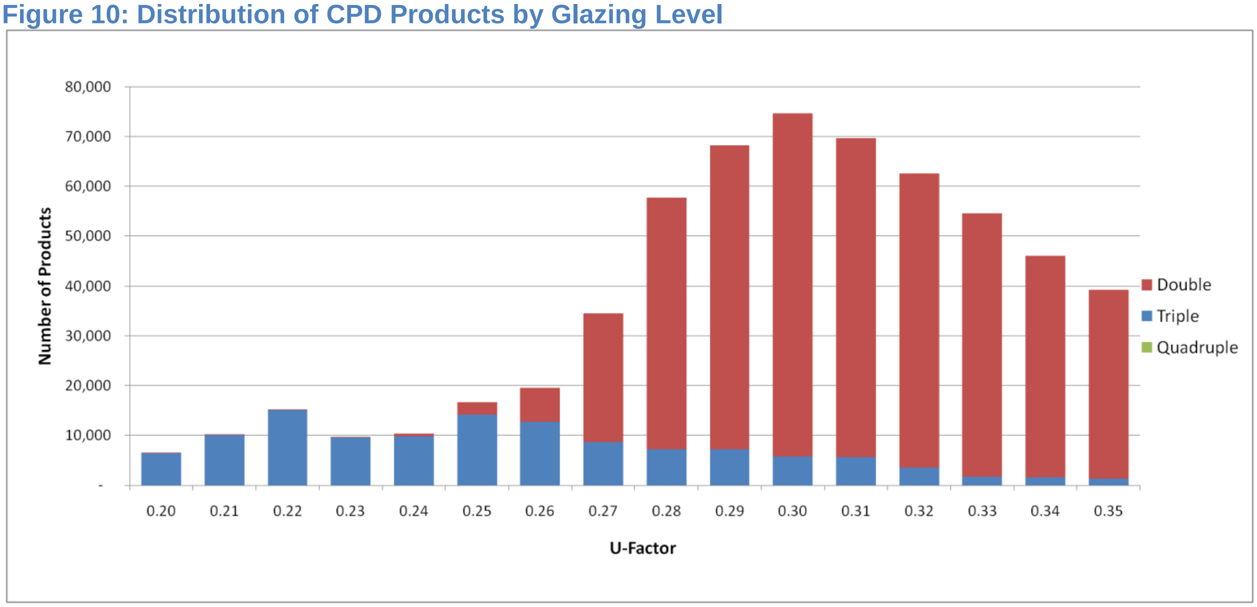
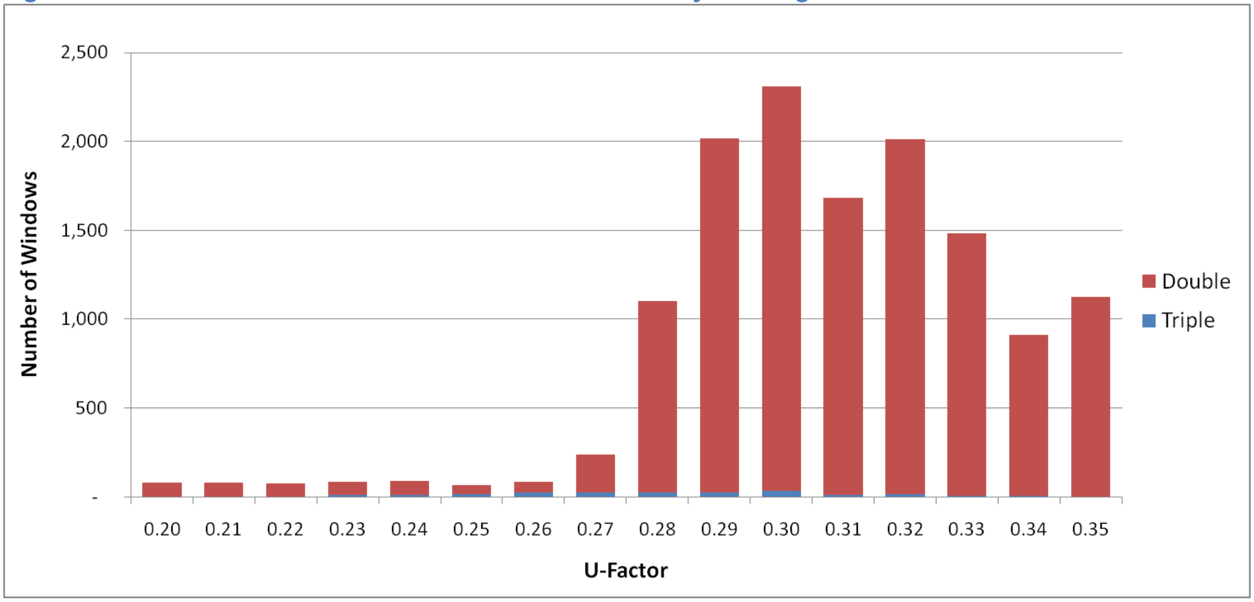


Figure 11: Distribution of Products Available for Sale by Glazing Level



By layering gas fill into these figures, it becomes apparent that argon-filled double-pane windows can qualify under the proposed criteria, so manufacturers can opt to avoid krypton or other exotic gas fills. Figure 12 and Figure 13 show distribution of products by gas fill and glazing level that qualify for ENERGY STAR at various U-factors (shown on the x-axis). These figures are cumulative in nature, meaning the distribution represents all products at or below a given U-factor.

Figure 12 is based on the CPD and shows where windows shift to triple-pane and where argon-filled, double-pane products become infeasible. Figure 13 shows that, even at very low U-factors, manufacturers primarily market double-pane windows.

Figure 12: Distribution of CPD Windows by Gas Fill

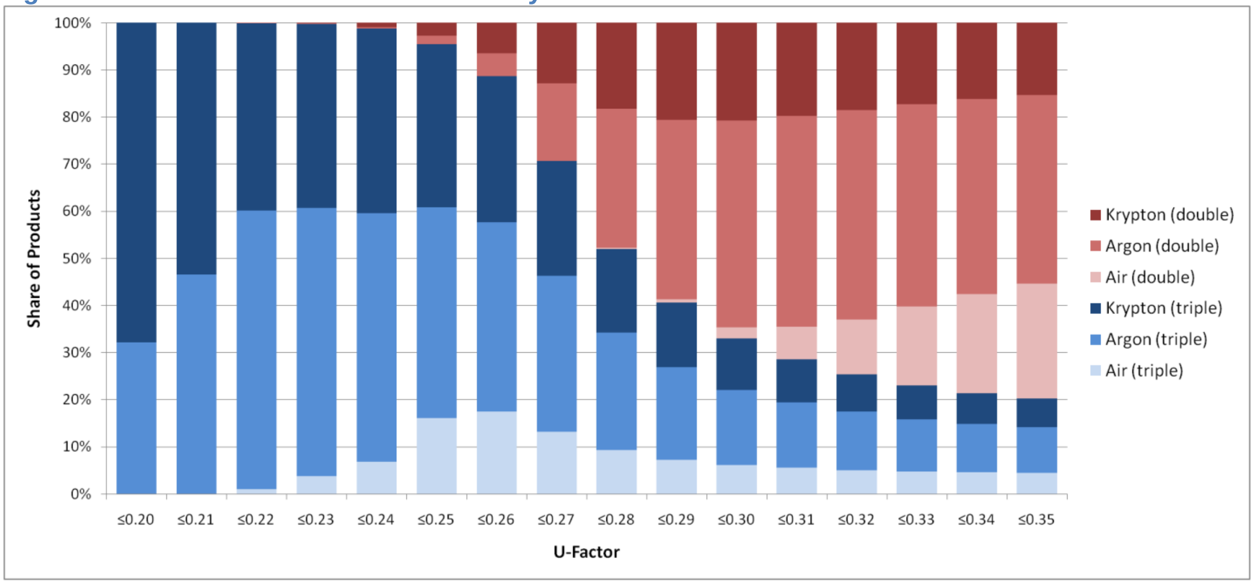
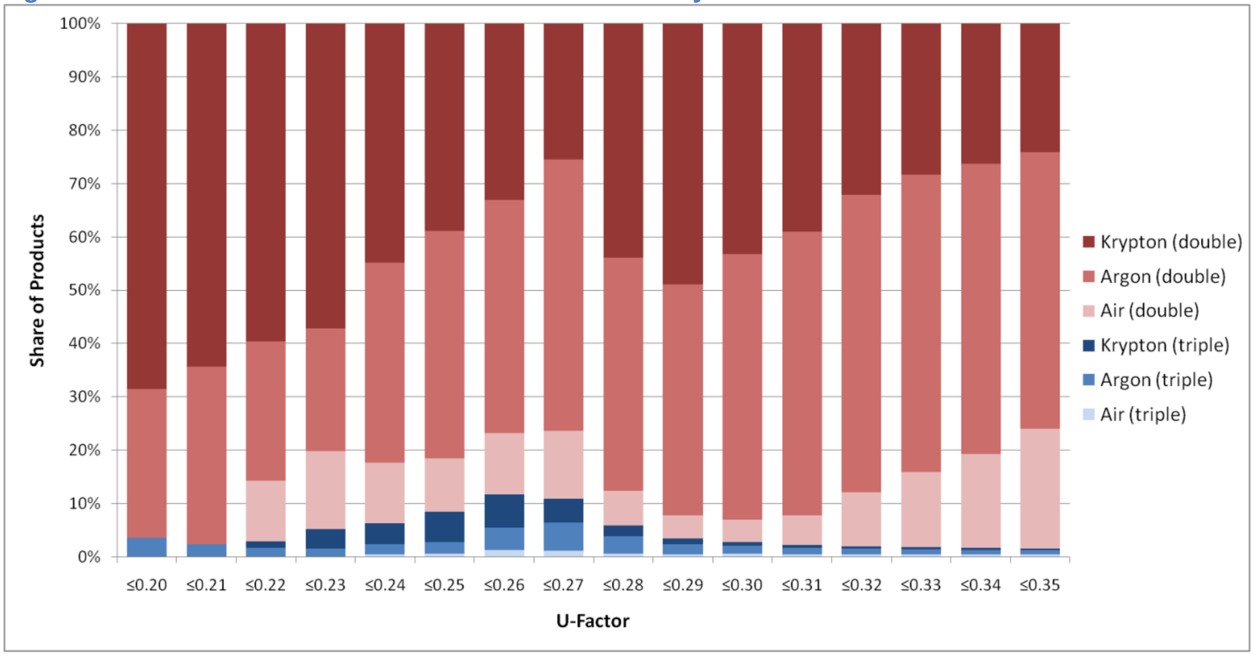


Figure 12 indicates that triple-paned windows dominate at U-factors below 0.27 and EPA is therefore hesitant to set a U-factor below that level in the Northern Zone. A cumulative view of the CPD shows that approximately 30% of the windows at or below 0.27 U-factor are double-pane, whereas only 10% of the windows at or below 0.26 U-factor are double-pane.

Figure 13: Distribution of Products Available for Sale by Gas Fill

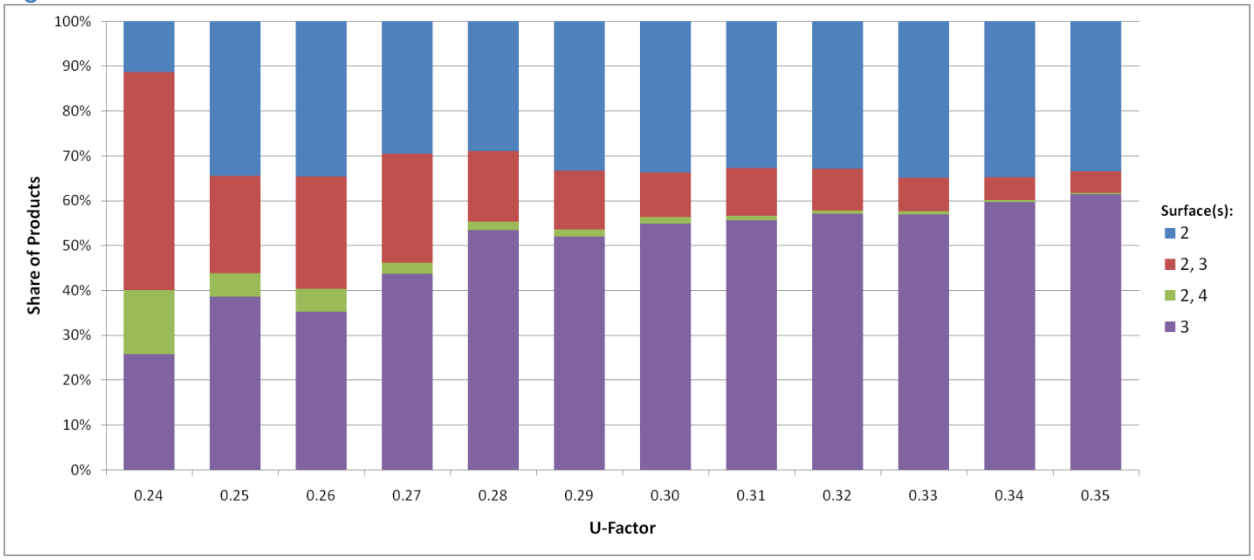


EPA sought to ensure that qualifying double-pane windows were able to reach the proposed levels using argon gas fill, and over half of the qualifying double-pane windows have argon gas. The database of products available for sale also illustrates that argon-filled double-pane windows are more common than triple-pane windows at a U-factor of 0.27. Further supporting EPA's U-factor proposal is the cumulative view of the market, in which more than 50% of the actively marketed qualifying products are double-pane and argon-filled.

3.2.5 Glass Type

Stakeholders commented that a stringent U-factor in the Northern Zone would force manufacturers to rely on fourth surface low-e coatings. The CPD provides information on the type and location of coatings. EPA graphed double-pane, double hung windows by U-Value and glazing surface to determine whether or not fourth surface low-e coatings actually dominate the market at any given level. Figure 14 shows the distribution of windows in the CPD across U-factor levels. This figure shows that fourth surface coatings, depicted by the green bar, represent a small share of the double-hung windows between 0.24 and 0.27, indicating there are other ways to achieve low U-factors in double-pane windows.

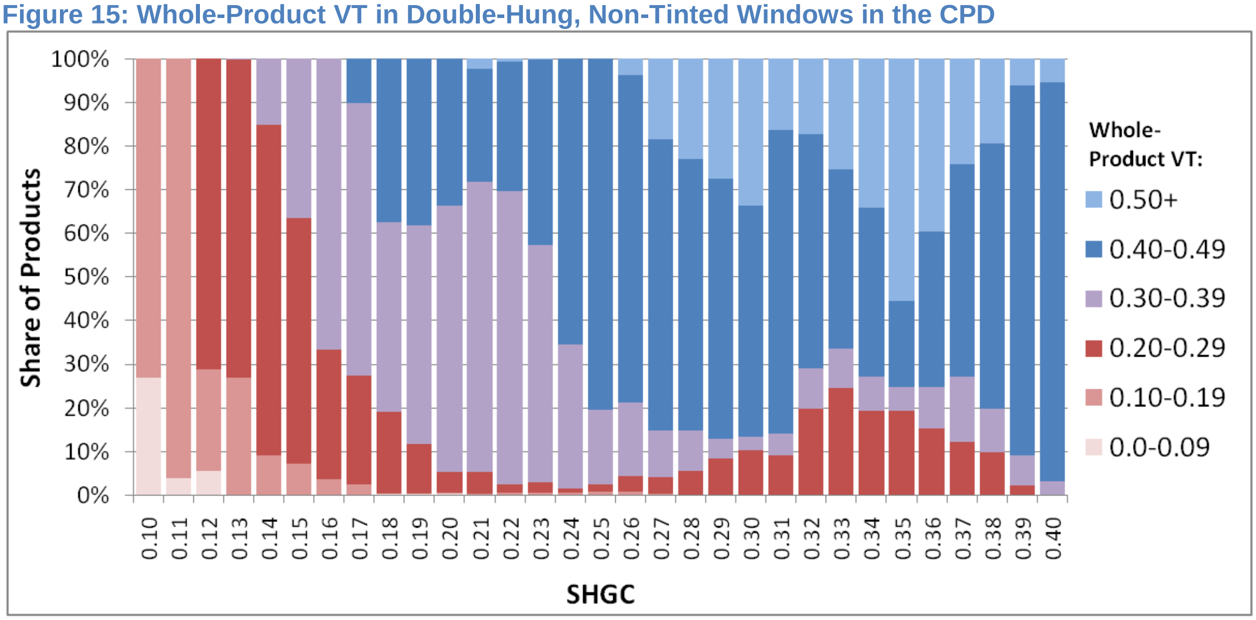
Figure 14: Distribution of Low-E Surfaces for Double-Pane Windows in the CPD



Stakeholders also commented that a stringent SHGC in the Southern Zone could lead to windows that appear dark to consumers. To study the relationship between SHGC and VT, EPA studied products in the CPD to determine whether or not consumers would face an unintentional darkening at very low SHGC values.

EPA understands from informal stakeholder input that a VT rating of 0.40 is the minimum value generally considered acceptable to consumers. EPA plotted SHGC against VT (see Figure 15) and found that clear, low-e windows generally do not have trouble achieving a VT of 0.40 at SHGCs as low as 0.24.

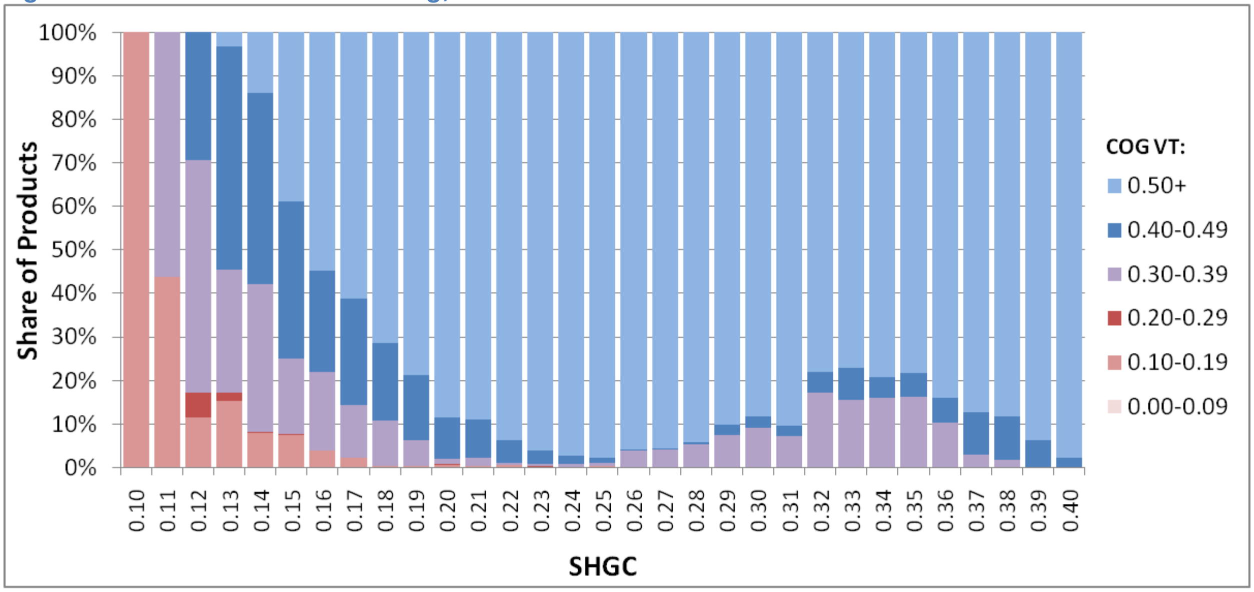
Figure 15: Whole-Product VT in Double-Hung, Non-Tinted Windows in the CPD



The issue at hand, however, is whether or not the glass package may appear visually darker at low SHGCs. With this in mind, EPA then looked at center of glass (COG) VT ratings at various SHGCs. Figure 16 shows this relationship between COG VT and SHGC for non-tinted windows. In this figure, more than 50% of the products have glass with a VT of above 0.40, even at SHGCs as low as 0.14. More than 80% of the windows with SHGCs of less than 0.19 have COG VT ratings of 0.40 or above;

70% of these windows have COG VT ratings of at least 0.5. Given this analysis, EPA does not believe the proposed criteria would adversely impact the visual appearance of clear glass packages.

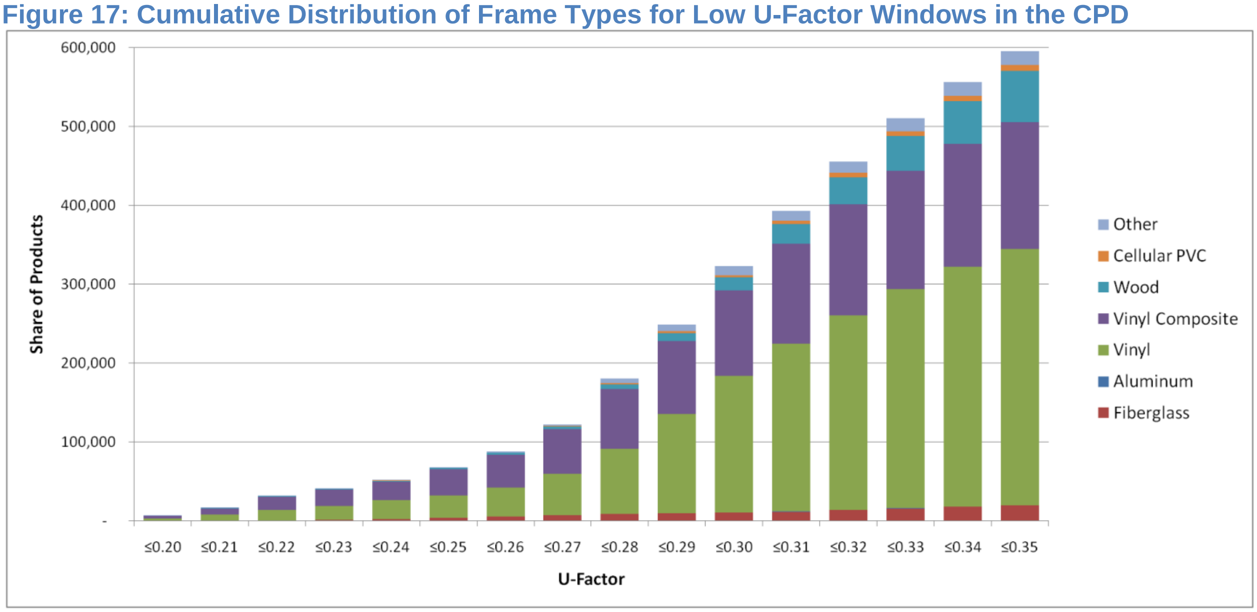
Figure 16: COG VT in Double-Hung, Non-Tinted Windows in the CPD



3.2.6 Frame Materials

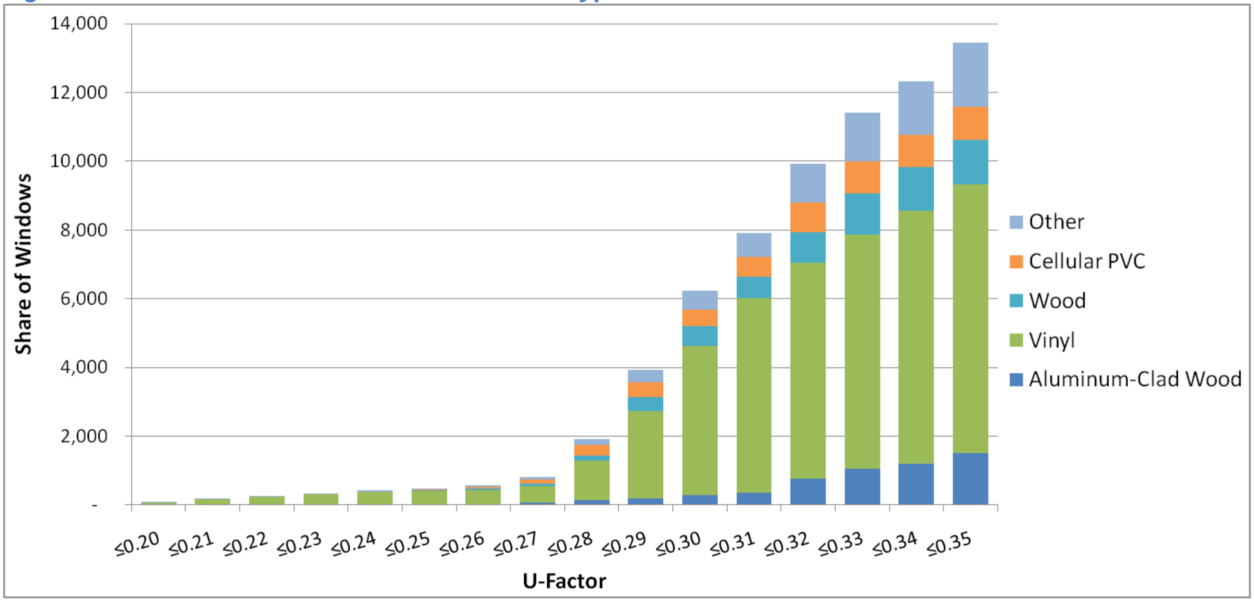
EPA looked at products in the CPD and products available for sale and determined that a variety of framing materials can be used to meet the U-factor in the Northern Zone (see Figure 17).

Figure 17: Cumulative Distribution of Frame Types for Low U-Factor Windows in the CPD



The database of products available for sale also shows a high prominence of vinyl windows at the proposed Northern Zone U-factor (Figure 18), but indicates a higher prevalence of cellular PVC windows.

Figure 18: Cumulative Distribution of Frame Types for Low U-Factor Windows Available for Sale



On the opposite end of the spectrum, stakeholders expressed concern that a tighter specification in the Southern Zone would prevent aluminum windows from being able to qualify. EPA's analysis of the CPD found that 0.2% of currently qualified windows in the Southern Zone have aluminum frames, and this market share would be reduced to 0.1% under EPA's current proposal. EPA believes that at such low market shares, consumer choice would not be reduced in a significant manner.

3.2.7 Exploration of Select Alternative Proposals for Windows

Following the publication of the Framework Document, EPA received proposals from stakeholders requesting that alternative criteria be considered. EPA specifically analyzed and would like to address two that represent a significant deviation from its current approach:

- Allowing any SHGC rating in the North-Central Zone
- Establishing a minimum SHGC in the Northern Zone

Some stakeholders commented that high solar gain could be beneficial in the North-Central Zone. EPA examined this issue further and agrees that there are situations in which high-gain products could marginally reduce annual energy consumption. At the same time, ENERGY STAR criteria need to meet or exceed code. IECC 2012 currently specifies a maximum SHGC of 0.40 in the North-Central Zone, and EPA has opted to match that criterion, but allowing any SHGC in the North-Central Zone creates the potential for an ENERGY STAR qualified window to be in violation of code.

A few stakeholders claimed that low solar gain products may lead to higher energy consumption in the Northern Zone. Stakeholders specifically recommended that EPA consider one of the following two specifications: SHGC greater than or equal to 0.32 or SHGC greater than or equal to 0.40. Once again, EPA recognizes that there are situations in a heating climate where high solar gain can be beneficial in reducing heating loads, but EPA reviewed the CPD data and determined that high-gain, low U-factor products are extremely uncommon (see Table 4). As such, the proposed Northern Zone criteria will continue to allow both high-gain and low-gain products to qualify for the program, which enables manufacturer and consumer choice. Additionally, EPA is proposing one set of equivalent energy performance criteria for those companies that produce high-gain products.

Table 4: Low U-Factor Windows from the CPD Meeting Proposed SHGC Minimums

Windows with U-Factor ≤ 0.27	Double- and Triple-Pane		Double-Pane Only	
	Number	Percent	Number	Percent
SHGC ≥ 0.32	4,562	0.77%	1,489	0.31%
SHGC ≥ 0.40	933	0.16%	87	0.02%

Further, when examining the "products available for sale" database, there were no windows listed or promoted that met either of the criteria in Table 4. The ENERGY STAR guiding principles require that "products are broadly available." This lack of availability of high-gain windows in the current market was another key piece of information EPA used to decide not to set a minimum SHGC rating in the Northern Zone.

3.3 Cost-Effectiveness

To determine cost-effectiveness, EPA examined incremental product costs volunteered by manufacturers and calculated household energy savings for upgrading to ENERGY STAR. The methodologies and results are described below.

3.3.1 Incremental Product Costs

Due the extremely high levels of ENERGY STAR market share, EPA calculated two sets of marginal costs. The first set of marginal costs looked at actual cost impact to the manufacturer. The second set of marginal costs evaluated difference between ENERGY STAR and prevailing code to determine consumer payback.

Several manufacturer partners volunteered incremental cost data to achieve various levels of thermal performance. Eight manufacturer partners provided basic product data for best-selling ENERGY STAR qualified double-hung windows and the added cost to consumers to achieve 0.01 incremental improvements in U-factor and SHGC. All incremental costs were to be for the same size window as the best-selling product and manufacturers were asked to provide product data for the best-selling or cheapest window at each incremental U-factor or SHGC. Based on this data, EPA arrived at the incremental costs provided in Table 5.

Table 5: Average Incremental Product Costs Across Climate Zones

Zone	U-Factor	SHGC	Average Cost Increase Over Best-Selling ENERGY STAR Window[5]
Northern	0.27	Any	$34.00 $173.00 (incl. triple-pane)
North-Central	0.29	0.40	$28.00
South-Central	0.31	0.25	$21.00
Southern	0.40	0.25	$13.00

Incremental costs were not calculated for the tradeoff criteria in the Northern Zone as no manufacturers provided incremental cost data on products meeting the proposed tradeoff criteria. It is also worth noting that no manufacturers provided incremental cost data for products meeting the existing tradeoff criteria in the Northern Zone. The incremental cost in the Northern and North-Central Zones actually increases when higher SHGC products were included.

Similarly, double-pane windows are typically much more cost-effective than triple-pane windows (see "incl. triple-pane" in Table 5 above). As such, EPA has not considered the incremental costs of triple-

[5] Based on the data provided to D&R International, Ltd. (technical support contractor for EPA), the average best-selling ENERGY STAR qualified window had a U-factor of 0.30 and an SHGC of 0.28.

pane windows since the program focuses on promoting cost-effective products for consumers. As previously noted in this document, EPA is interested in promoting enhanced performance of double-pane windows while also acknowledging those manufacturers who have already made the shift to triple-pane windows, especially those that have found a way to do so in a cost-effective manner. The data in Table 5 demonstrates that the additional cost to manufacturers is reasonable.

The ENERGY STAR program calculates incremental cost and incremental energy savings over a "standard" product to evaluate payback and cost-effectiveness. For other products, a "standard" product is one that meets the minimum federal standard for that product category, but no minimum federal standard exists for windows. Based on feedback from manufacturers, the current marginal cost between their current best-selling ENERGY STAR qualified window and the next poorer-performing window (sometimes IECC 2009-compliant, sometimes double-pane clear) is about $20.

3.3.2 Household Energy Savings

Window energy savings are based on simulations of whole-house energy consumption using RESFEN 5.0 software.[6] Energy savings are estimated by replacing an entire set of windows in a typical home with more efficient products. Typical home assumptions are provided in Table 6. Assumptions reflect the typical home within a respective climate zone. Variable factors, including shell conditions and window packages, were determined based on IECC and LBNL methodologies. Remaining features were duplicated across all climates in order to have uniform results. House size and window area are based on Residential Energy Consumption Survey (RECS) data. Savings are relative to standard single-pane and clear double-pane windows as described in LBNL's Window Library.

EPA modeled typical one- and two-story detached single-family homes in 22 U.S. cities, representing all IECC climate zones. For each city, savings were determined for existing and new construction homes with either a heat pump or furnace heating and central air-conditioning. Annual energy expenditures are based on the Energy Information Administration's average annual residential fuel prices for each representative state.[7]

[6] http://windows.lbl.gov/software/resfen/resfen.html
[7] http://www.eia.gov/

Table 6: Assumptions for Windows Household Savings Analysis

Zones			Window Packages		Shell Conditions						
IECC	**ES**	**Cities[1]**	**Base**	**Proposed**	**Existing**	**New**	**HVAC**	**Size[3]**	**Window Area**	**Fuel Prices**	**Solar Gain**
1	S	Miami, FL	**Window 101:** Aluminum Single Clear; U-factor 1.16; SHGC 0.76 **Window 311**: Wood/Vinyl Double-Pane Clear; U-factor 0.49; SHGC 0.56	U-factor 0.40; SHGC 0.25	RESFEN 5 Default Insulation Levels[2]	2009 IECC Insulation Require-ments	Electric Heat Pump Heat/AC & Gas Furnace with Central AC	1700 SF (1-Story) with Slab Foundation & 2600 SF (2-Story) with Basement Foundation for Existing 1700 SF (1-Story) with Slab Foundation & 2800 SF (2-Story) with Basement Foundation for New	15% of floor area, equal orientation[4]	EIA State Average[5]	RESFEN 5 Typical Solar Gain[6]
2	S	Phoenix, AZ									
2	S	Houston. TX									
2	S	Jacksonville, FL									
3	SC	Los Angeles, CA		U-factor 0.31; SHGC 0.25							
3	SC	Jackson, MS									
3	SC	Oklahoma City, OK									
3	SC	Charlotte, NC									
3	SC	Sacramento, CA									
4	NC	Washington, DC	**Window 301**: Wood/Vinyl Single Clear; U-factor 0.84; SHGC 0.63 **Window 311:** Wood/Vinyl Double-Pane Clear; U-factor 0.49; SHGC 0.56	U-factor 0.29; SHGC 0.27							
4	NC	Kansas City									
4	NC	Lexington, KY									
4	N	Portland, OR		U-factor 0.27; SHGC 0.27							
5	N	Chicago, IL									
5	N	Boston, MA									
5	N	Pittsburgh, PA									
5	N	Denver, CO									
5	N	Boise, ID									
6	N	Missoula, MT									
6	N	Minneapolis, MN									
6	N	Binghamton, NY									
7	N	International Falls, MN									

Notes:

[1]Cities were chosen to mirror EPA Home Performance with ENERGY STAR analysis
[2]RESFEN library includes climate-specific insulation packages for typical existing buildings
[3]Based on averages from 2005 RECS data
[4]Even distribution of windows on each wall to normalize differences in savings from orientation
[5]Electric rates based on average of 2010-11 EIA annual residential data per state; Natural gas rates based on average of 2011 monthly residential data per state
[6]Represents a statistically average solar gain reduction for a typical house using factors of overhang, obstructions, and interior shading

EPA then modeled energy savings of the proposed specification over single- and double-pane windows (representative of much of the installed base).

Table 7: Annual Energy Savings for Windows Qualifying Under the Draft 1 Version 6.0 Specification

		Average Annual Savings (%) Over	
		Single-Pane Window in Installed Base	**Double-Pane Window in Installed Base**
Northern Zone	Binghamton, NY	$590.62 (20%)	$158.33 (6%)
	Boise, ID	$201.82 (20%)	$57.74 (6%)
	Boston, MA	$352.21 (18%)	$91.14 (6%)
	Chicago, IL	$345.51 (19%)	$111.43 (7%)
	Denver, CO	$265.26 (20%)	$65.10 (6%)
	International Falls, MN	$553.83 (18%)	$250.24 (10%)
	Minneapolis, MN	$399.12 (19%)	$125.55 (7%)
	Missoula, MT	$324.14 (21%)	$99.53 (7%)
	Pittsburgh, PA	$396.49 (21%)	$126.75 (8%)
	Portland, OR	$154.56 (19%)	$40.69 (6%)
North-Central Zone	Kansas City, MO	$169.79 (18%)	$52.82 (6%)
	Lexington, KY	$249.66 (18%)	$68.37 (6%)
	Washington, DC	$274.00 (18%)	$86.72 (6%)
South-Central Zone	Charlotte, NC	$273.27 (23%)	$40.15 (5%)
	Jackson, MS	$255.51 (28%)	$85.26 (11%)
	Los Angeles, CA	$77.70 (31%)	$2.74 (0%)
	Oklahoma City, OK	$357.82 (23%)	$62.77 (5%)
	Sacramento, CA	$288.13 (30%)	$85.75 (12%)
Southern Zone	Houston, TX	$265.81 (29%)	$129.70 (17%)
	Jacksonville, FL	$231.42 (28%)	$98.29 (14.6%)
	Miami, FL	$241.87 (33%)	$151.84 (23%)
	Phoenix, AZ	$406.05 (31%)	$194.16 (18%)

3.3.3 Payback

The final step in evaluating cost-effectiveness was to determine the period of time it takes homeowners to recover the increased marginal cost through energy bill savings, or payback. As previously mentioned, ENERGY STAR considers the marginal cost over a “standard” product, which is typically the product meeting the minimum federal standard. As such, IECC 2009 was used for the baseline product. Typical window lifetime is 20-30 years[8] so EPA based its analysis on a 25 year lifetime. Additionally, the typical home is assumed to have 22 windows, all of which were replaced in the model. In the event a homeowner moves, EPA has also provided simple payback estimates based on expected investment

[8] Seiders, David, et al. February 2007. “Study of Life Expectancy of Home Components.” Washington, DC: National Association of Home Builders.

recoupment for a window replacement project.[9] Payback periods are actually much shorter should the homeowner move within the payback period.

Table 8: Calculation of Simple Payback[10]

Zone	City	Annual Energy Cost Savings	Discounted Lifetime Energy Savings	Marginal Cost per Window	Simple Payback (years)	
						With 67% Cost Recoup
Northern Zone	Binghamton, NY	$158.33 (6%)	$2,756.94	$54.00	8	3
	Boise, ID	$57.74 (6%)	$1,005.39	$54.00	21	7
	Boston, MA	$91.14 (6%)	$1,586.95	$54.00	13	5
	Chicago, IL	$111.43 (7%)	$1,940.30	$54.00	11	4
	Denver, CO	$65.10 (6%)	$1,133.66	$54.00	19	6
	International Falls, MN	$250.24 (10%)	$4,357.49	$54.00	5	2
	Minneapolis, MN	$125.55 (7%)	$2,186.20	$54.00	10	4
	Missoula, MT	$99.53 (7%)	$1,733.22	$54.00	12	4
	Pittsburgh, PA	$126.75 (8%)	$2,207.18	$54.00	10	4
	Portland, OR	$40.69 (6%)	$708.54	$54.00	30	6
North-Central Zone	Kansas City, MO	$52.82 (6%)	$919.76	$48.00	20	7
	Lexington, KY	$68.37 (6%)	$1,190.60	$48.00	16	9
	Washington, DC	$86.72 (6%)	$1,510.11	$48.00	13	4
South-Central Zone	Charlotte, NC	$40.15 (5%)	$699.16	$41.00	23	8
	Jackson, MS	$85.26 (11%)	$1,484.62	$41.00	11	4
	Los Angeles, CA	$2.74 (0%)	$47.78	$41.00	329	109
	Oklahoma City, OK	$62.77 (5%)	$1,092.94	$41.00	15	5
	Sacramento, CA	$85.75 (12%)	$1,493.11	$41.00	11	4
Southern Zone	Houston, TX	$129.70 (17%)	$2,258.42	$33.00	6	2
	Jacksonville, FL	$98.29 (14.6%)	$1,711.45	$33.00	8	3
	Miami, FL	$151.84 (23%)	$2,643.99	$33.00	6	2
	Phoenix, AZ	$194.16 (18%)	$3,380.85	$33.00	4	2

The mean payback period across all zones is 13 years, while the median is 11 years (excluding Los Angeles due to low baseline energy costs). Mean payback periods for each zone are provided below.

[9] Hanley Wood provides estimates of the percentage of a remodeling project's costs that would be recouped in increased home value when the home is sold. For windows, this is estimated to be about 67%.

[10] Source: D&R International, Ltd., 2012. Annual energy cost savings are the difference between the average of multiple simulations of the proposed ENERGY STAR specification and double clear windows using RESFEN5 assumptions. EPA used simulations that reflect the range of typical energy consumption of local housing stock for each city. Lifetime energy savings estimates were calculated over 25 years using a 3% discount rate. The simple payback period is based on total marginal cost (assuming 22 windows per house) divided by annual energy cost savings, with no discounting. Payback periods are rounded up to the nearest whole integer.

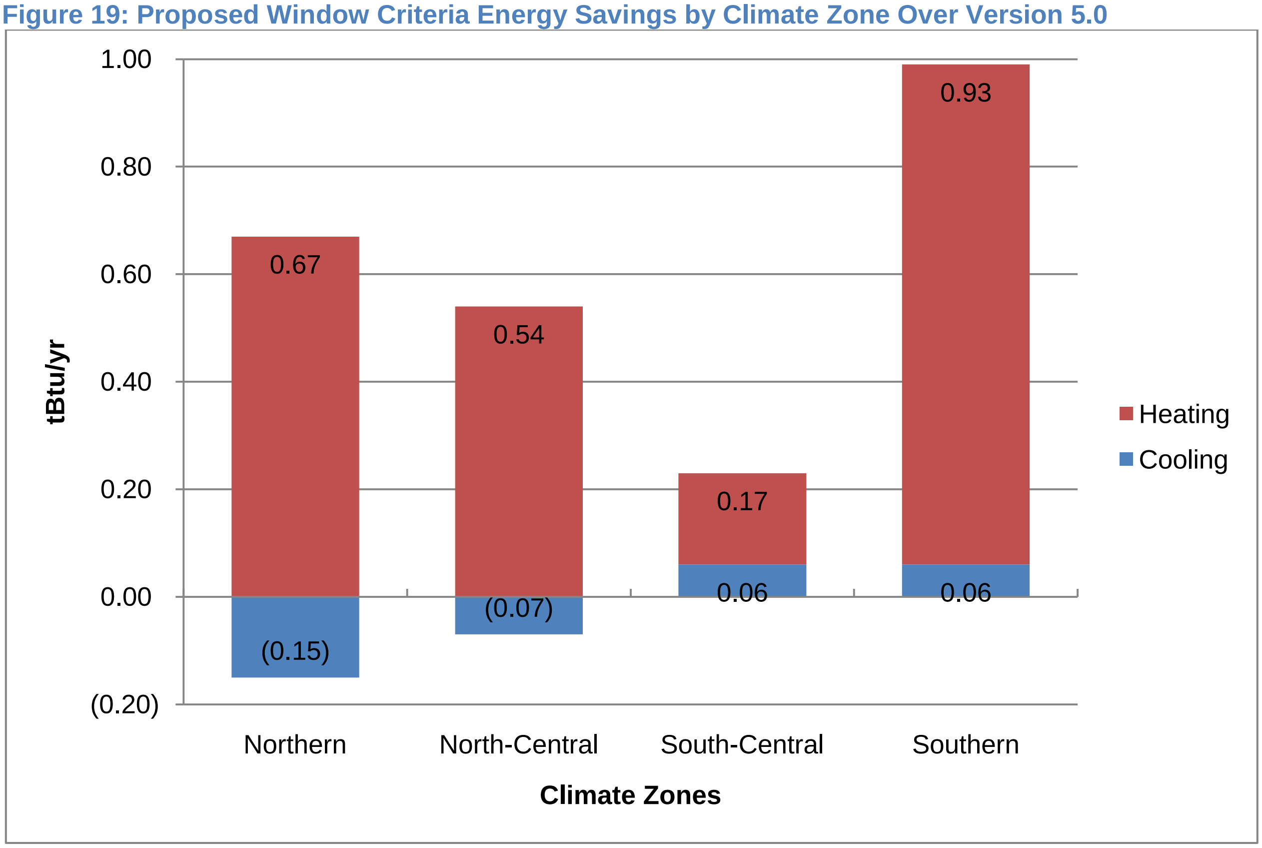
Table 9: Average Simple Payback for Each Climate Zone

Zone	Average Payback (years)
Northern	14
North-Central	16
South-Central[11]	15
Southern	6

3.4 Aggregate National Energy Savings Potential

Details of the criteria revision analysis methodology are provided in LBNL's "Technical Support for ENERGY STAR Windows Version 6 Specification Revision." This paper is posted at http://windows.lbl.gov/energystar/version6/, along with an overview of the Version 6.0 criteria revision analysis process. This process determined that the national aggregate energy savings under the proposed windows criteria would be 2.21 tBtu per year or approximately $39.78 million per year. These savings are based on first-year market savings over the Version 5.0 windows specification. Most of the savings is generated through reduced heating load, particularly in the Southern Zone, as illustrated in Figure 19.

Figure 19: Proposed Window Criteria Energy Savings by Climate Zone Over Version 5.0



With lower U-factors comes less "free heat loss" during the swing seasons (cooling degree days early or late in the cooling season) in the Northern and North-Central Zone.

LBNL estimates that 1 tBtu per year in space conditioning energy is approximately equal to $18 million per year. With this in mind, EPA calculated the approximate dollar savings at the climate zone level (see

[11] Average payback for the South-Central Zone excludes Los Angeles due to low baseline energy costs.

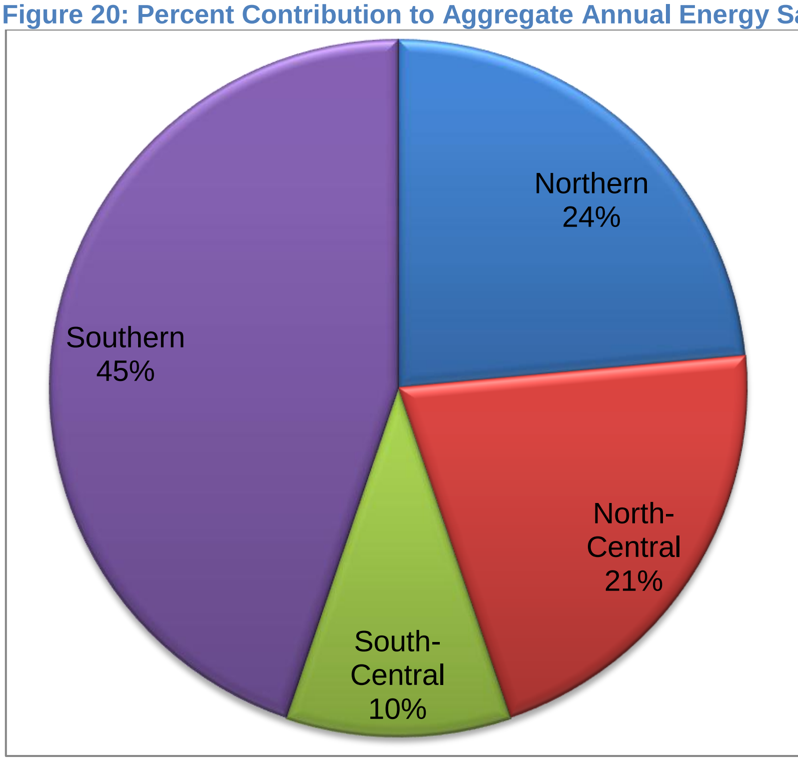
Table 10). Again these are first-year savings when compared to the Version 5.0 windows specification, not compared to the installed window base.

Table 10: Aggregate Annual Dollar Savings (in Millions) by Climate Zone Over Version 5.0

Zone	Heating Savings	Cooling Savings	Total Savings
Northern	$12.06	($2.7)	**$9.36**
North-Central	$9.72	($1.26)	**$8.46**
South-Central	$3.06	$1.08	**$4.14**
Southern	$16.74	$1.08	**$17.82**

As expected, the country's two most extreme climates generate the most savings. The Southern Zone savings are most dramatic due to the large shift in U-factor. Similarly, the heating savings are also substantial in the Northern Zone. Each zone's contribution to the overall aggregate savings is depicted in Figure 20 below.

Figure 20: Percent Contribution to Aggregate Annual Energy Savings Over Version 5.0



3.5 Possible Considerations for Version 7.0

With each criteria revision, ENERGY STAR for Windows, Doors, and Skylights takes a fresh look at the fenestration market to determine appropriate criteria levels for the next specification. Outlined below are some items that EPA may consider when it sets the Version 7.0 criteria.

3.5.1 Program Elements Considered during Version 6.0 Criteria Revision

In Section 2.2, EPA outlined a number of program elements that were considered for adoption for the Version 6.0 specification, but ultimately not included: structural requirements, products installed at high-altitude, impact-resistant products, daylighting criterion, and LCA. If additional information becomes available on any of these topics prior to the next criteria revision, EPA may consider program criteria related to these topics. Stakeholders are encouraged to provide EPA with updates on new data or research pertaining to any of these issues.

3.5.2 Program Elements Unchanged during Version 6.0 Criteria Revision

Section 2.3 highlighted two areas remaining unchanged in the Version 6.0 specification: ENERGY STAR climate zones and the classification of TDDs as skylights. EPA is seeking to keep the map unchanged during this criteria revision in an effort to reduce the costs and level of effort required by a label change out. The map may, however, be reconsidered during the Version 7.0 criteria revision if stakeholder comment and initial research indicate that a change in the climate zones may be warranted. Similarly, EPA may reconsider the classification of TDDs if anticipated criteria levels and/or changes in industry approach warrant a change.

3.5.3 Future Codes

As stated in Section 1.2.2, EPA plans to continue monitoring developments in code to ensure the criteria remain relevant. The final action hearings for IECC 2015 are scheduled for October 2013, prior to the anticipated effective date of the ENERGY STAR criteria. Given the slow adoption rate of IECC 2012, EPA does not anticipate revising the proposed criteria based on the outcomes of the IECC 2015 final action hearings. EPA does, however, reserve the right to revise the criteria as necessary if the final IECC 2015 prescriptive fenestration levels exceed the proposed Version 6.0 ENERGY STAR criteria. If the criteria were to be revised, there would be at least one comment period and manufacturers would still have a minimum of 270 days between the announcement of the final criteria and the effective date of the criteria.

3.5.4 Most Efficient Program

If a Most Efficient program for windows is put into place in the coming year, it could have a dramatic impact on future criteria revisions for the mainstream ENERGY STAR program. Having Most Efficient criteria that highlight the very top performers, allows ENERGY STAR for Windows, Doors, and Skylights to focus on less aggressive criteria levels. At the same time, a Most Efficient program could drive program innovation forward in such a way that more aggressive criteria levels are much more feasible than they would otherwise have been. Most Efficient also allows the opportunity to explore other program criteria or options, which may later be adopted into the Version 7.0 specification. For more information on the Most Efficient program, please visit www.energystar.gov/mostefficient.

3.5.5 Emerging Technologies

The past few years have held promising developments in emerging technologies such as electrochromic and vacuum insulated glazing. EPA plans to continue monitoring these technologies as it looks to set future criteria levels for windows, doors, and skylights.

3.6 Questions for Stakeholder Feedback

1. Do stakeholders have any data demonstrating that any of the proposed criteria need to be reconsidered?
2. Are there any issues not addressed in this section that have a direct bearing on the criteria levels selected?

4 Version 6.0 Draft 1 Criteria for Doors

EPA's research and analysis indicates that the proposed door criteria (see Table 11) would be technologically feasible and provide energy savings to consumers. The criteria do not require products to use proprietary technology and do not require consumers to compromise on non-energy performance of the product. The proposed criteria would differentiate products in the market place for consumers.

Table 11: Draft 1 Criteria for ENERGY STAR Qualified Doors

Glazing Level	U-Factor	SHGC
Opaque	≤ 0.17	N/A
≤ ½-Lite	≤ 0.23	≤ 0.25
> ½-Lite	≤ 0.30	≤ 0.25

Table 12: Current Criteria for ENERGY STAR Qualified Doors

Glazing Level	U-Factor	SHGC
Opaque	≤ 0.21	N/A
≤ ½-Lite	≤ 0.27	≤ 0.30
> ½-Lite	≤ 0.32	≤ 0.30

4.1 Overview

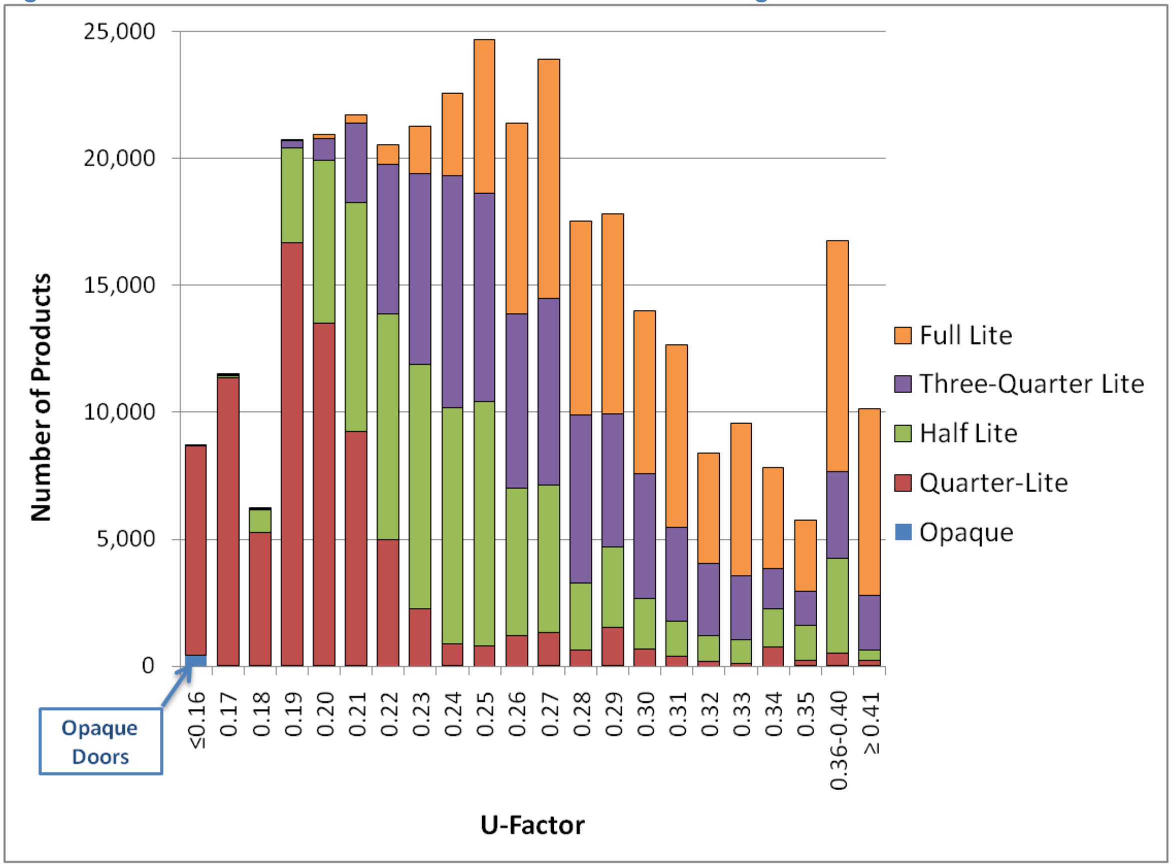
To evaluate the feasibility of the criteria, EPA examined the NFRC CPD looking specifically at high-performance (low U-factor and low SHGC) doors, the performance of various glazing levels, and the performance of various core and skin materials. Gauging cost-effectiveness involved determining incremental product costs from manufacturer-volunteered data sets, modeling household energy savings for the proposed criteria, and then calculating product payback. All research and analyses were conducted in a manner similar to the previous criteria revision.

The criteria were set with the aim of meeting or exceeding code, avoiding undue burdens to manufacturers, and reducing market share to add differentiation between qualified and nonqualified doors. EPA received feedback from stakeholders that the proposed SHGC levels might lead to visual inconsistency in window and door glass packages in whole-home replacements, so EPA has also examined this issue.

4.2 Technological Feasibility

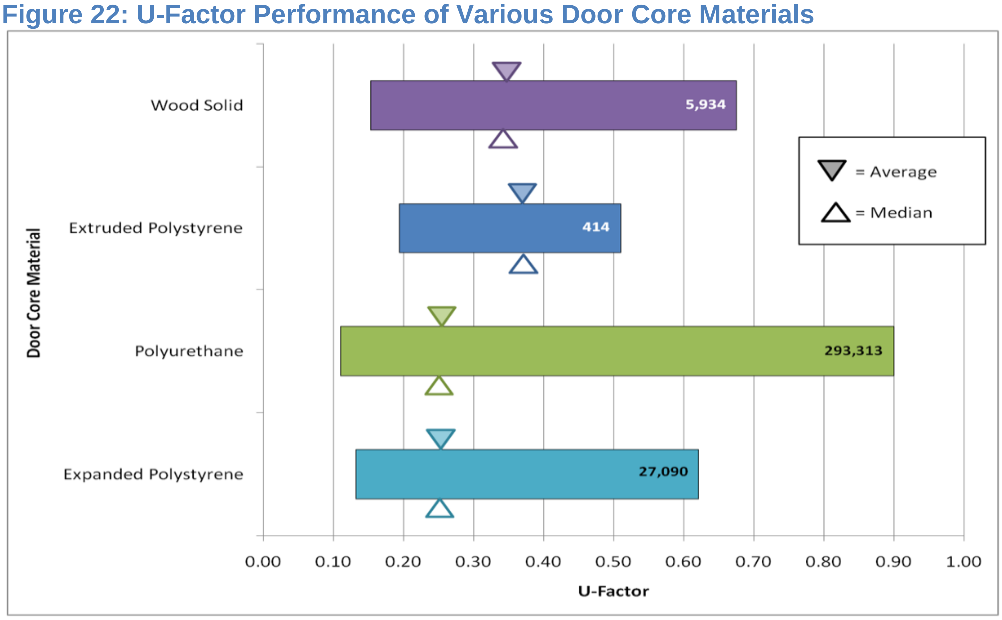
To determine technological feasibility, EPA reviewed the door data in the CPD and found that at the proposed criteria levels approximately 77% of opaque, half-lite, and quarter-lite doors would qualify. Of greater than half-lite doors about 67% would qualify (see Figure 21).

Figure 21: U-Factor Performance of Doors at Various Glazing Levels



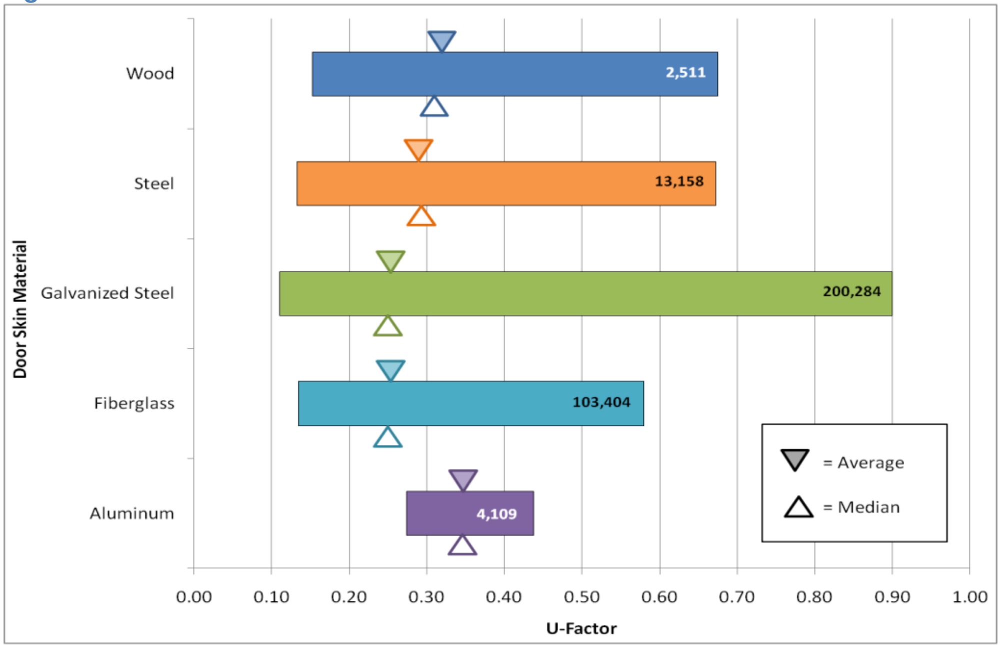
The four major core materials would be able to qualify, although there would be few qualifying extruded polystyrene doors. Polyurethane and expanded polystyrene are the two more efficient and most common core materials.

Figure 22: U-Factor Performance of Various Door Core Materials



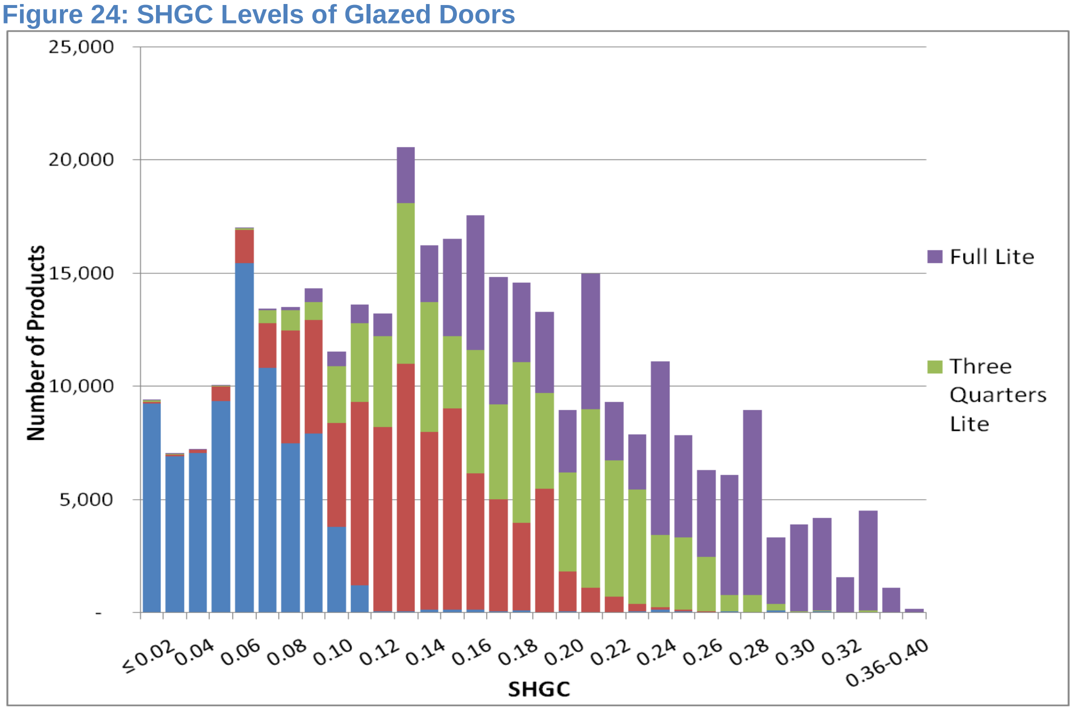
When looking at door skin material, wood, steel, and fiberglass doors can easily qualify under the proposed criteria levels, but only the most efficient aluminum doors would be able to qualify.

Figure 23: U-Factor Performance of Various Door Skin Materials



As with windows, the typical SHGC levels for glazed doors seem to be trending downward. Based on the CPD data and as shown in Figure 24, 83% of full-lite doors in the CPD can achieve an SHGC of 0.25 or less and 97% half-lite doors can meet the 0.25 SHGC criteria level.

Figure 24: SHGC Levels of Glazed Doors



EPA did receive feedback from stakeholders expressing concern about potential visible differences in glass packages between doors and windows for whole-house replacements under the proposed criteria. EPA investigated this issue by comparing glass packages and COG VT values for windows and doors at the proposed SHGC levels. Even at the SHGC "extremes" (e.g. a window qualifying in the North-Central Zone and a qualifying full-lite door), EPA did not see any indication of the need for differing glass packages or packages with varying COG VT. EPA does, however, welcome additional data on the issue if stakeholders maintain that this is a potential issue under the proposed criteria.

4.3 Cost-Effectiveness

To determine cost-effectiveness, EPA examined incremental product costs volunteered by manufacturers and calculated household energy savings for upgrading to ENERGY STAR. The methodologies and results are described below.

4.3.1 Incremental Product Costs

EPA contacted manufacturers last year and extended an invitation to directly participate in the criteria revision process by volunteering incremental cost data to achieve various levels of thermal performance. EPA requested basic product data for best-selling ENERGY STAR qualified doors and the added cost to consumers to achieve 0.01 incremental improvements in U-factor and SHGC. Manufacturers were asked to provide product data for the best-selling or cheapest doors at each incremental U-factor or SHGC. Based on this data, EPA arrived at the incremental costs provided in Table 13.

Table 13: Best-Selling Door and Average Cost Increase to Reach Version 6.0 Specification

	Best-Selling Specification		Proposed Specification		
Glazing Level	**U-Factor**	**SHGC**	**U-Factor**	**SHGC**	**Average Cost Increase Over Best-Selling Door**
Opaque	0.17	N/A	0.17	N/A	None (Same Product)
≤ ½-Lite	0.25	0.25	0.23	0.25	$13.00
> ½-Lite	0.30	0.26	0.30	0.25	$30.00

While the median cost increase for greater than half-lite doors was zero, EPA has selected the mean cost increase to be conservative. Similarly, the mean SHGC of 0.26 was selected for greater than half-lite doors though the median SHGC was 0.27. The mean and median SHGC for less than or equal to half-lite doors was 0.14, but 0.25 was selected to match the proposed spec and so as to not overstate savings. U-factor criteria for all doors are the mean and median of the dataset with the exception of less than or equal to half-lite, in which case the median U-factor was 0.24.

Double-pane doors are much more cost-effective than triple-pane doors, so EPA has not considered the incremental costs of triple-pane doors since the program focuses on promoting cost-effective products for consumers. As previously noted in this document, EPA is interested in promoting enhanced performance of double-pane products while also rewarding those manufacturers who have already made the shift to triple-pane, especially those that have found a way to do so in a cost-effective manner. Further, only 25% of greater than half-lite doors were triple-paned at the proposed specification.

4.3.2 Household Energy Savings

Door energy savings are based on simulations of whole-house energy consumption using RESFEN 5.0 software.[12] Energy savings are estimated by upgrading a single door in a single-family residence while keeping all other variables constant. EPA added 20 square feet of door to the models previously developed for the windows analysis. To remove orientation difficulties in estimating energy consumption, five square feet of an opaque door was added to each cardinal orientation to account for the variances in thermal loading. The overall U-factor and SHGC for each orientation were recalculated to include the more efficient door. Assumptions are provided in Table 14. Results of the household energy savings analysis for doors are provided in the next section.

[12] http://windows.lbl.gov/software/resfen/resfen.html

Table 14: Assumptions for Door Household Savings Analysis

Best-Selling	Proposed Spec	Component Areas	Variables
Opaque U-Factor 0.17 SHGC N/A **≤1/2 Lite:** U-factor 0.25 SHGC 0.25 **>1/2 Lite** U-factor 0.30 SHGC 0.26	**Opaque** U-Factor 0.17 SHGC N/A **≤1/2 Lite** U-factor 0.23 SHGC 0.25 **>1/2 Lite** U-factor 0.30 SHGC 0.25	**Windows** 15% of floor area, equal orientation **Doors** 20 SF, equal orientation	Shell Conditions, HVAC Configuration, House Size, Fuel Price, and Solar Gain follow windows analysis assumptions

4.3.3 Payback

The final step in evaluating cost-effectiveness was to determine the period of time it takes homeowners to recover the increased marginal cost through energy bill savings, or payback. According to the National Association of Home Builders, exterior doors are capable of lasting as long as the home[13] but to be conservative EPA based its analysis on a 30 year lifetime. As with the previous criteria revision, EPA modeled energy savings and payback from replacing one 20 square foot door.

For its preliminary cost-effectiveness analysis, EPA is using manufacturers' best-selling ENERGY STAR qualified doors as a baseline. As with windows, however, the best baseline for the purposes of determining cost-effectiveness of ENERGY STAR criteria is to compare to a code product. EPA is therefore seeking additional data from manufacturers on the incremental cost difference between code doors and those meeting the ENERGY STAR specification so that it can perform additional cost-effectiveness analysis.

Using the data currently available, the best-selling opaque doors meet the proposed ENERGY STAR specification, which means no added costs and no energy savings. For less than half-lite doors, manufacturers indicated that there would be minimal incremental cost, as shown in Table 15. (Again, best-selling doors were used as a baseline due to available data, yielding minimal energy savings and, in some cases, less attractive payback periods.) Energy savings for full-lite doors were marginal and, when modeled, were rounded down to zero by RESFEN so lifetime savings could not be accurately determined.

[13] Seiders, David, et al. February 2007. "Study of Life Expectancy of Home Components." Washington, DC: National Association of Home Builders.

Table 15: Calculation of Simple Payback[14]

Zone	City	Total Marginal Cost ≤ ½-Lite Doors	Annual Energy Cost Savings ≤ ½-Lite Doors	Discounted Lifetime Energy Savings ≤ ½-Lite Doors	Simple Payback ≤ ½-Lite Doors (years)
Northern Zone	Binghamton, NY	$13.00	$2.11	$41.33	7
	Boise, ID	$13.00	$0.74	$14.46	18
	Boston, MA	$13.00	$1.29	$25.26	11
	Chicago, IL	$13.00	$1.11	$21.85	12
	Denver, CO	$13.00	$1.01	$19.77	13
	International Falls, MN	$13.00	$2.02	$39.67	7
	Minneapolis, MN	$13.00	$1.33	$26.04	10
	Missoula, MT	$13.00	$1.15	$22.47	12
	Pittsburgh, PA	$13.00	$1.27	$24.87	11
	Portland, OR	$13.00	$0.87	$17.03	15
North-Central Zone	Kansas City, MO	$13.00	$0.56	$11.03	24
	Lexington, KY	$13.00	$0.58	$11.32	23
	Washington, DC	$13.00	$0.90	$17.64	15
South-Central Zone	Charlotte, NC	$13.00	$0.71	$13.94	19
	Jackson, MS	$13.00	$0.41	$8.01	32
	Los Angeles, CA	$13.00	$0.23	$4.43	57
	Oklahoma City, OK	$13.00	$0.81	$15.85	16
	Sacramento, CA	$13.00	$0.48	$9.33	28
Southern Zone	Houston, TX	$13.00	$0.22	$4.41	59
	Jacksonville, FL	$13.00	$0.28	$5.54	47
	Miami, FL	$13.00	$-0.16	$-3.19	N/A
	Phoenix, AZ	$13.00	$0.42	$8.18	31

4.4 Questions for Stakeholder Feedback

1. Do stakeholders have any data demonstrating that any of the proposed criteria need to be reconsidered?
2. Are there any issues not addressed in this section that have a direct bearing on the criteria levels selected?
3. Are manufacturers willing to volunteer incremental cost data on the difference between a code and an ENERGY STAR qualified door at the various criteria levels?

[14] Source: D&R International, Ltd., 2012. Annual energy cost savings are the difference between the average of multiple simulations of the proposed ENERGY STAR specification and best selling door configuration as indicated by manufacturers, calculated using RESFEN5 assumptions. EPA selected simulations that reflect the range of typical energy consumption of local housing stock for each city. Pricing is estimated by D&R International based on data provided by manufacturers. Lifetime energy savings were calculated over 30 years using a 3% discount rate. The simple payback period is based on marginal cost divided by annual energy cost savings, with no discounting. Payback periods are rounded up to the nearest whole integer.

5 Version 6.0 Draft 1 Criteria for Skylights

EPA's research and analysis indicates that the proposed skylights criteria (see Table 16) would be technologically feasible and provide cost-effective savings for consumers, paying back incremental price premiums in a reasonable period of time. The criteria do not require products to use proprietary technology and do not require consumer to compromise on non-energy performance of the product. Products meeting the criteria are available for sale today while also providing differentiation in the market place for consumers.

Table 16: Draft 1 Criteria for ENERGY STAR Qualified Skylights

Zone	U-Factor	SHGC
Northern	≤ 0.45	≤ 0.35
North-Central	≤ 0.47	≤ 0.30
South-Central	≤ 0.50	≤ 0.25
Southern	≤ 0.60	≤ 0.25

Table 17: Current Criteria for ENERGY STAR Qualified Skylights

Zone	U-Factor	SHGC
Northern	≤ 0.55	Any
North-Central	≤ 0.55	≤ 0.40
South-Central	≤ 0.57	≤ 0.30
Southern	≤ 0.70	≤ 0.30

5.1 Overview

To evaluate the feasibility of the criteria and determine product availability, EPA examined two data sets looking specifically at high-performance (low U-factor) skylights, the performance of various glazing levels, and the performance of various frame materials. Gauging cost-effectiveness involved determining incremental product costs from manufacturer-volunteered data sets, modeling household energy savings for the proposed criteria, and then calculating product payback. All research and analyses were conducted in a manner similar to the previous criteria revision.

5.2 Technological Feasibility and Product Availability

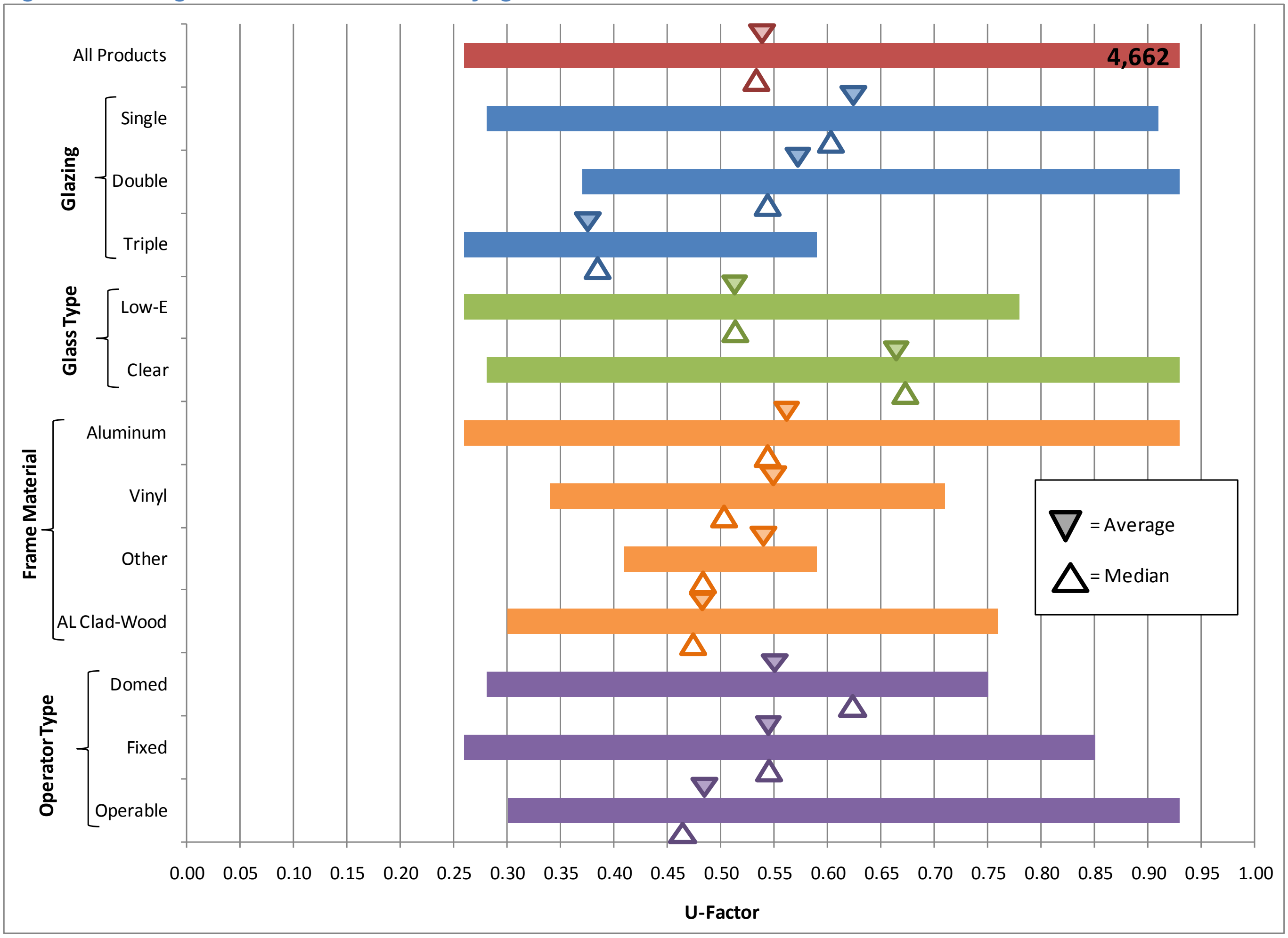
Based on analysis of the NFRC CPD, EPA concluded that the proposed criteria for skylights and tubular daylighting devices (TDDs) are technologically feasible. In addition, research demonstrates that products available for sale can meet these criteria. To set the appropriate skylights criteria, EPA analyzed two datasets: the NFRC CPD and a database of products available for sale. For the TDD analysis, EPA reviewed the NFRC CPD. EPA relied on manufacturer feedback to confirm data points for both products.

5.2.1 NFRC CPD Data Analysis

Similar to the windows and doors analyses, EPA reviewed the skylight product listings in the NFRC CPD, excluding skylights intended for commercial purposes (e.g. structured sheets and roof panels) and skylights from manufacturers no longer marketing these products. In the Framework Document released in October 2011, EPA limited its analysis to glass skylights. Based on stakeholder feedback, EPA has re-incorporated plastic skylights into its analysis, but the addition of these skylights has not altered EPA's overall findings.

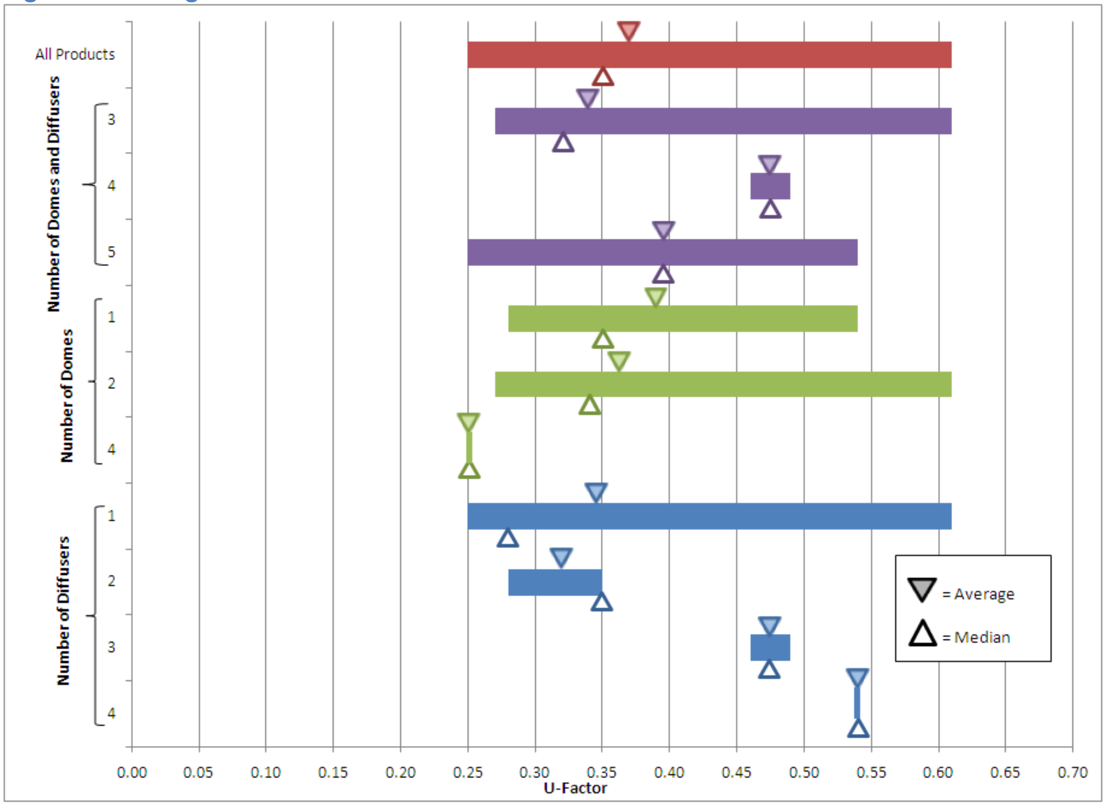
Figure 25 shows the variation in performance for a range of components for CPD skylights. This figure shows a significant performance difference between double- and triple-pane skylights, however, there are double-pane products which are easily able to meet the proposed criteria. This figure also demonstrates that all frame types perform relatively similarly.

Figure 25: Range of Performance for Skylights in the CPD



EPA also reviewed the NFRC CPD data to determine if TDDs could meet the proposed criteria levels set for skylights. Since all TDDs had to be physically tested by March 2012, EPA re-examined the TDD data after that date to ensure that the models were still able to meet the proposed criteria levels. EPA also contacted manufacturers to verify product information because of a number of discrepancies in the CPD values. Figure 26 shows that the average U-Factor performance for TDDs is well below the most stringent skylight U-Factor criterion proposed. Hybrid TDDs (HTDDs) were excluded from the analysis since they are primarily for commercial purposes, but it is worth noting that only one company currently has HTDD listings in the NFRC CPD.

Figure 26: Range of Performance for TDDs in the CPD



5.2.2 Products Available for Sale Analysis

Similar to the windows analysis, EPA collected product data on skylights available for sale to confirm that the skylights in the CPD were an accurate reflection of products sold in the marketplace. (A separate "products available for sale" analysis was not conducted for TDDs because there are so few TDDs available, but EPA directly confirmed TDD product listing and availability with manufacturers.)

To compile this data, EPA first created a list of skylight manufacturers with active residential product lines in the CPD. In contrast to windows, skylight manufacturers are less likely to have skylight specifications published on their websites, but EPA collected and recorded technical specifications and component information for five regional and national manufacturers. Data collected included U-factor, SHGC, VT, operator type, frame type, gas fill, number of panes, and glass tint. Similar to the CPD analysis, skylights used in commercial applications or strictly in conjunction with sun rooms were excluded.

Figure 27 shows that although products available for sale had a narrower range of U-factors than the CPD listings, the percentage of products at various U-factor levels is roughly equivalent. EPA believes this demonstrates that the CPD is generally representative of products available for sale. This distribution also demonstrates that the skylight criteria is in line with EPA's goal of reducing market share, particularly since the ENERGY STAR market share for glass skylights is estimated to be 99%.[15]

[15] Ducker Worldwide LLC, ENERGY STAR Window & Door Tracking Program, 2011, Page 5.

Figure 27: Skylight CPD Versus Products Available for Sale at Different U-Factors

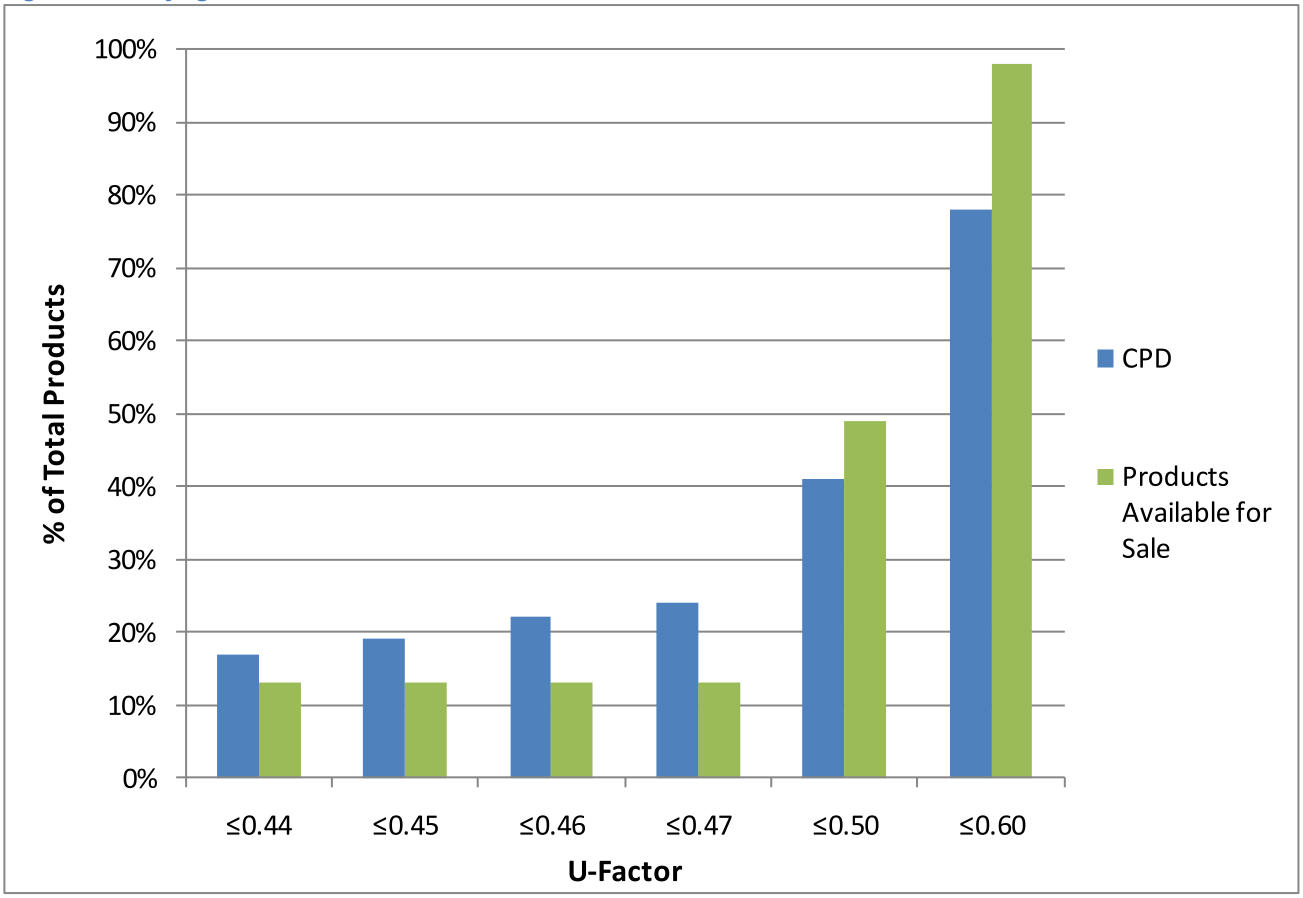
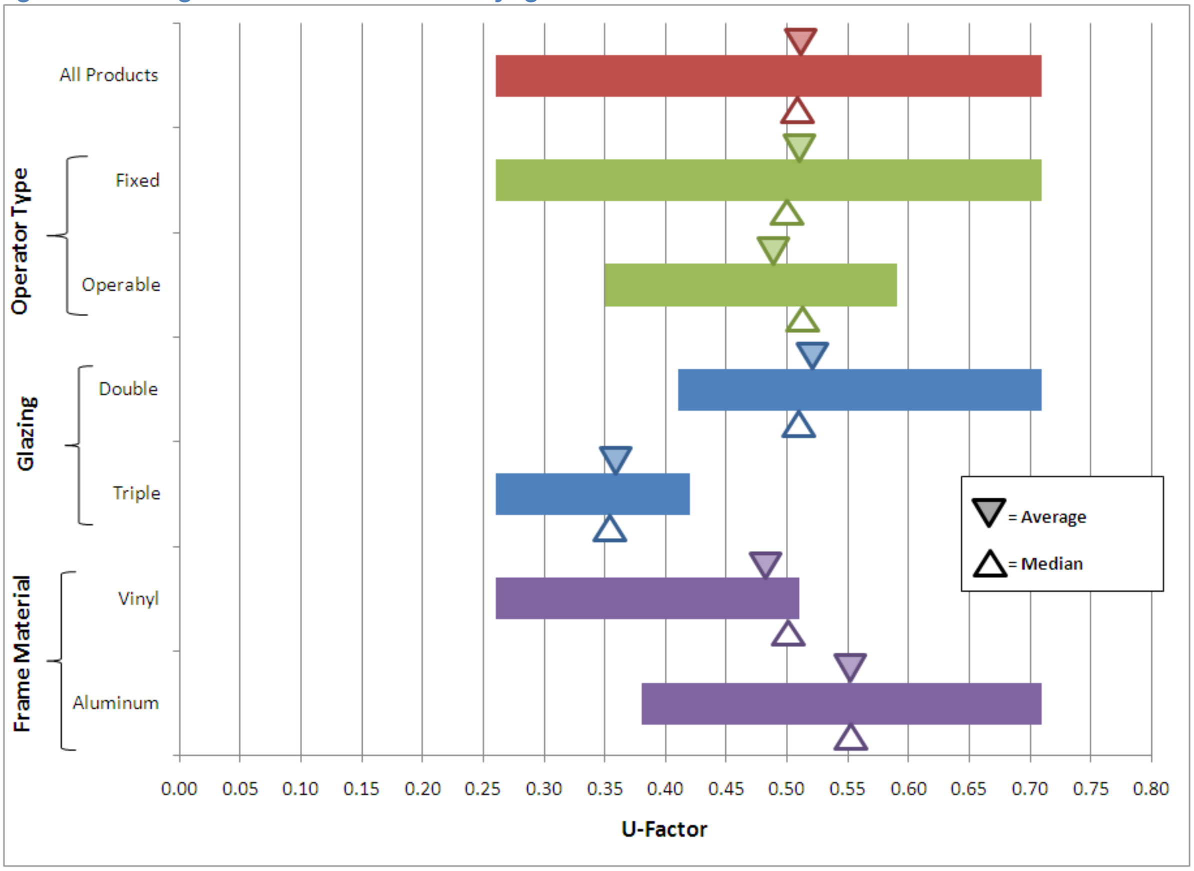


Figure 28 illustrates that in the products available for sale analysis fixed and operable products perform similarly while there is a significant jump in performance when moving from a double- to a triple- pane skylight.

Figure 28: Range of Performance for Skylights Available for Sale



5.2.3 *Market Impact*

In setting the skylights criteria, EPA considered whether the proposed criteria were technologically feasible and whether qualifying skylights would be available. Figure 29 shows that approximately 17% of the skylights in the CPD would meet the U-factor and SHGC requirements in the Northern Zone, 18% in the North-Central and South Central Zones, and 27% of products would be able to meet the requirements in the Southern Zone.

Figure 29: Distribution of CPD Skylights by U-Factor and SHGC

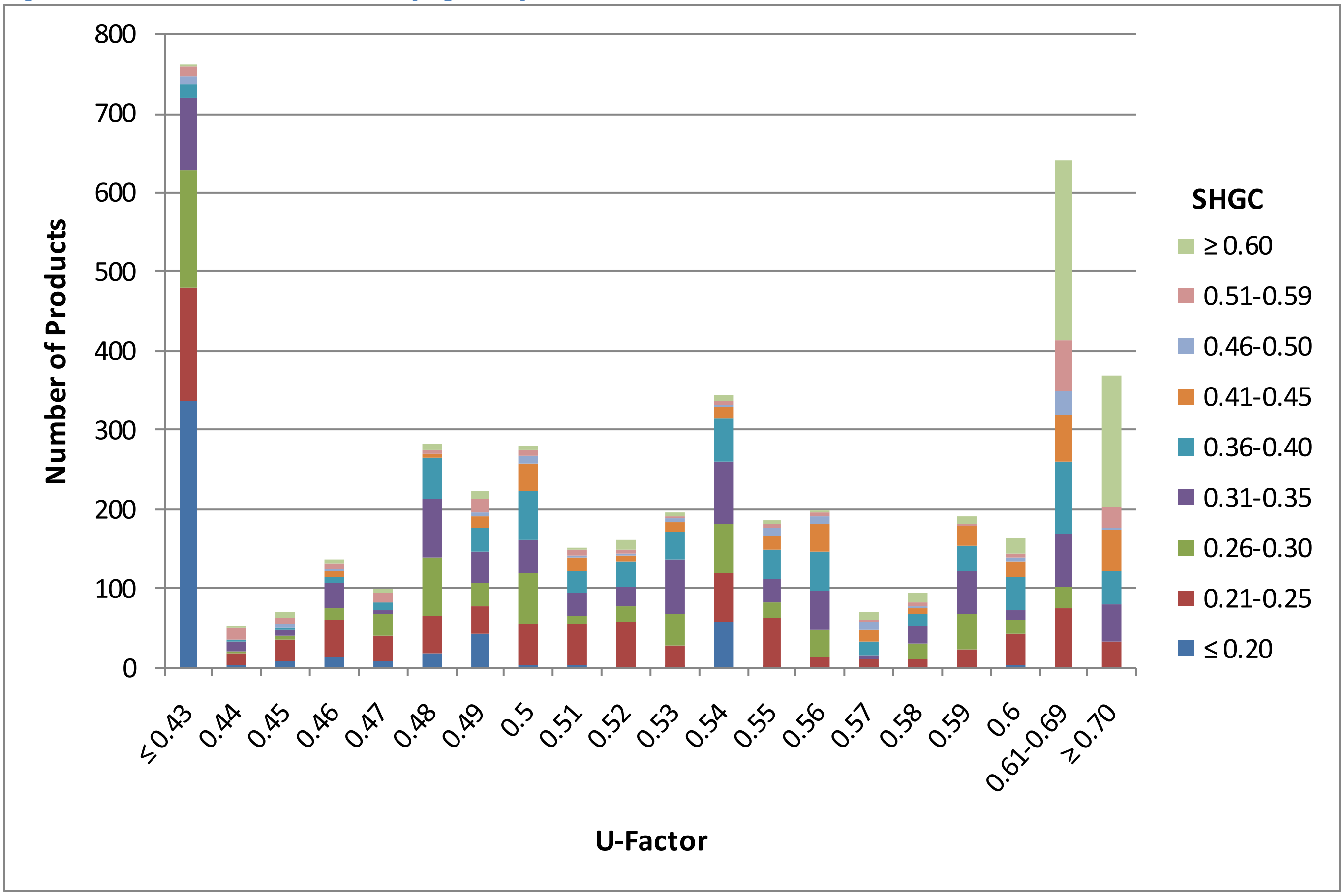
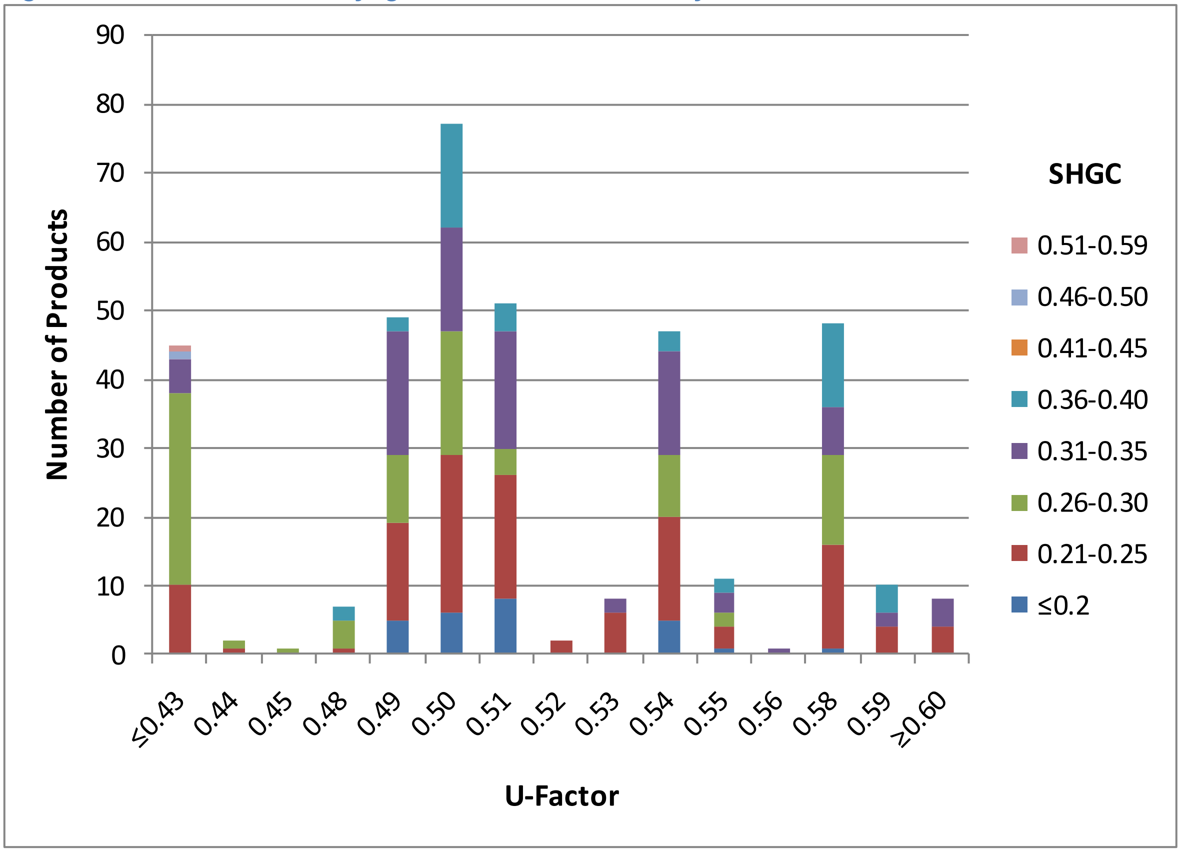


Figure 30 demonstrates that 13% of the products available for sale meet the proposed criteria in the Northern Zone, 11% in the North-Central Zone, 16% in the South Central Zone, and 38% in the Southern Zone.

Figure 30: Distribution of Skylights Available for Sale by U-Factor and SHGC



5.3 Cost-Effectiveness

To determine cost-effectiveness, EPA examined incremental product costs volunteered by manufacturers and calculated household energy savings for upgrading to ENERGY STAR. The methodologies and results are described below.

5.3.1 Incremental Product Costs

EPA contacted manufacturers last year and extended an invitation to directly participate in the criteria revision process by volunteering incremental cost data to achieve various levels of thermal performance. EPA requested basic product data for best-selling ENERGY STAR qualified skylights and the added cost to consumers to achieve 0.01 incremental improvements in U-factor and SHGC. Based on this data, EPA arrived at the incremental costs provided in Table 18.

Table 18: Best-Selling Skylight and Average Cost Increase to Reach Version 6.0 Specification

	Best-Selling Specification		Proposed Specification		
Zone	**U-Factor**	**SHGC**	**U-Factor**	**SHGC**	**Average Cost Increase**
Northern	0.55	0.40	0.45	0.35	$0 - $20
North-Central			0.47	0.30	$0 - $20
South-Central	0.57	0.30	0.50	0.25	$20 - $40
Southern	0.70	0.30	0.60	0.25	$20 - $40

EPA also invited TDD manufacturers last year to directly participate in the criteria revision process by volunteering cost data. Since there are a limited number of TDD models, considering incremental pricing did not make sense, so EPA looked at pricing depending on the size of the TDD. EPA believes this pricing is in-line with pricing for skylights and TDDs can be cost effective at the criteria levels that have been proposed.

5.3.2 Household Energy Savings

Skylight energy savings are based on simulations of whole-house energy consumption using RESFEN 5.0 software.[16] Energy savings are estimated by adding 10 square feet of skylight to the models while keeping all other variables from the windows models constant. Assumptions are provided in Table 19. Results of the household energy savings analysis for skylights are provided in the next section.

Table 19: Assumptions for Skylights Household Savings Analysis

IECC	*ES*	*Cities[1]*	*Best Selling*	*Proposed*	*Component Areas*	*Variables*
1	1	Miami, FL	U-Factor 0.70 SHGC 0.30	U-Factor 0.60 SHGC 0.25	**Windows** 15% of floor area, equal orientation **Skylights** 10 SF	Shell Conditions, HVAC Configuration, House Size, Fuel Price, and Solar Gain follow windows analysis assumptions
2	1	Phoenix, AZ				
2	1	Houston. TX				
2	1	Jacksonville, FL				
3	2	Los Angeles, CA	U-Factor 0.57 SHGC 0.30	U-Factor 0.50 SHGC 0.25		
3	2	Jackson, MS				
3	2	Oklahoma City, OK				
3	2	Charlotte, NC				
3	2	Sacramento, CA				
4	3	Washington, DC	U-Factor 0.55 SHGC 0.40	U-Factor 0.47 SHGC 0.30		
4	3	Kansas City				
4	3	Lexington, KY				
4	4	Portland, OR		U-Factor 0.45 SHGC 0.35		
5	4	Chicago, IL				
5	4	Boston, MA				
5	4	Pittsburgh, PA				
5	4	Denver, CO				
5	4	Boise, ID				
6	4	Missoula, MT				
6	4	Minneapolis, MN				
6	4	Binghamton, NY				
7	4	International Falls, MN				

5.3.3 Payback

To evaluate cost-effectiveness, EPA then determined payback. Typical window lifetime is 20-30 years[17] so EPA assumed skylights would have a comparable lifetime and based its analysis on a 25 year lifetime. Since 99% of glass skylights are ENERGY STAR qualified[18], EPA assumed that this represents

[16] http://windows.lbl.gov/software/resfen/resfen.html

[17] Seiders, David, et al. February 2007. "Study of Life Expectancy of Home Components." Washington, DC: National Association of Home Builders.

[18] Ducker Worldwide LLC, ENERGY STAR Window & Door Tracking Program, 2011, Page 5.

accurate baseline energy consumption for its analysis. EPA also assumed that the typical home has 10 square feet of skylights replaced, or approximately 1.5 skylights.

Table 20: Calculation of Simple Payback[19]

Zone	City	Annual Energy Cost Savings	Discounted Lifetime Energy Savings	Total Marginal Cost [Low / High]	Simple Payback [Low / High] (years)
Northern Zone	Binghamton, NY	$4.48 (0%)	$77.99	$0 / $20	0 / 7
	Boise, ID	$1.60 (0%)	$27.88	$0 / $20	0 / 19
	Boston, MA	$2.82 (0%)	$49.17	$0 / $20	0 / 11
	Chicago, IL	$2.53 (0%)	$44.08	$0 / $20	0 / 12
	Denver, CO	$2.30 (0%)	$40.05	$0 / $20	0 / 13
	International Falls, MN	$4.32 (0%)	$75.29	$0 / $20	0 / 7
	Minneapolis, MN	$2.96 (0%)	$51.46	$0 / $20	0 / 11
	Missoula, MT	$2.44 (0%)	$42.49	$0 / $20	0 / 13
	Pittsburgh, PA	$2.88 (0%)	$50.08	$0 / $20	0 / 11
	Portland, OR	$1.49 (0%)	$25.86	$0 / $20	0 / 21
North-Central Zone	Kansas City, MO	$1.05 (0%)	$18.33	$0 / $20	0 / 29
	Lexington, KY	$1.28 (0%)	$22.33	$0 / $20	0 / 24
	Washington, DC	$1.78 (0%)	$30.91	$0 / $20	0 / 17
South-Central Zone	Charlotte, NC	$1.21 (0%)	$21.00	$20 / $40	25 / 50
	Jackson, MS	$0.85 (0%)	$14.89	$20 / $40	36 / 71
	Los Angeles, CA	$0.47 (0%)	$8.18	$20 / $40	64 / 128
	Oklahoma City, OK	$1.41 (0%)	$24.60	$20 / $40	22 / 43
	Sacramento, CA	$1.02 (0%)	$17.74	$20 / $40	30 / 59
Southern Zone	Houston, TX	$0.87 (0%)	$15.21	$20 / $40	35 / 69
	Jacksonville, FL	$0.92 (0%)	$16.09	$20 / $40	33 / 65
	Miami, FL	$0.35 (0%)	$6.14	$20 / $40	86 / 171
	Phoenix, AZ	$1.33 (0%)	$23.16	$20 / $40	23 / 46

5.4 Questions for Stakeholder Feedback

1. Do stakeholders have any data demonstrating that any of the proposed criteria need to be reconsidered?
2. Are there any issues not addressed in this section that have a direct bearing on the criteria levels selected?

[19] Source: D&R International, Ltd., 2012. Annual energy cost savings are the difference between the average of multiple simulations of the proposed ENERGY STAR specification and best selling skylight configuration as indicated by manufacturers, calculated using RESFEN5 assumptions. EPA selected simulations that reflect the range of typical energy consumption of local housing stock for each city. Lifetime energy savings were calculated over 25 years using a 3% discount rate. Pricing is estimated by D&R International based on data provided by manufacturers. Due to insufficient pricing data, the low/high range represents changes to EPA's pricing assumptions – all other inputs were held constant. The simple payback period is based on marginal cost divided by annual energy cost savings, with no discounting. Payback periods are rounded up to the nearest whole integer.

6 Next Steps

The publication of this report marks the beginning of the second formal comment period for the Version 6.0 criteria revision. At the midpoint of this comment period is the public stakeholder meeting. EPA anticipates releasing a second draft of the criteria before the end of the year, followed by a third comment period and the publication of the final criteria in March 2013. The implementation date of the Version 6.0 criteria is slated for January 1, 2014.

6.1 Stakeholder Feedback

The Agency welcomes stakeholder comments on all topics related to this specification revision, especially with regards to specific questions posed in this report. Please send comments by Friday, September 28, 2012, to windows@energystar.gov.

6.2 Stakeholder Meeting

EPA plans to have a stakeholder meeting and concurrent webinar approximately 30 days after the release of this report. Shortly after the release of this report, EPA plans to provide a tentative agenda and details on date and location of this meeting.

6.3 Revised Timeline

Table 21 is a duplication of Table 1 for ease of reference. Details on the tentative timeline are provided in Section 1.2.2.

Table 21: Tentative Timeline for Criteria Revision

Tentative Timeline	
Draft 1 Criteria and Analysis Report	July 2012
Stakeholder Meeting	August 2012
Comment Period	July – September 2012
Draft 2 Criteria and Analysis Report	December 2012
Comment Period	January 2012
Publish New Program Requirements	March 2013
Criteria Take Effect	January 1, 2014

Glossary

> ½-lite	ENERGY STAR classification for a door with > 29.8 percent glazing (based on NFRC 100-2010). Includes ¾-lite and fully glazed doors.
≤ ½-lite	ENERGY STAR classification for a door with ≤ 29.8 percent glazing (based on NFRC 100-2010). Includes ¼- and ½-lite doors.
¼-lite	Descriptor for a door with < 13.6 percent glazing (based on NFRC 100-2010). See also ≤ ½-lite.
½-lite	Descriptor for a door with > 13.6 percent, but < 29.8 percent glazing (based on NFRC 100-2010). See also ≤ ½-lite.
¾-lite	Descriptor for a door with >29.8 percent, but < 36.4 percent glazing (based on NFRC 100-2010). See also > ½-lite.
Certified Products Directory	A database containing fenestration that has received certification authorization from an NFRC-approved Inspection Agency.
CPD	See Certified Products Directory.
Door	A sliding or swinging entry system designed for and installed in a vertical wall separating conditioned and unconditioned space in a residential building. See also opaque, ≤ ½-lite, > ½-lite, sliding entry door, and swinging entry door.
Dynamic glazing	Any window, door, or skylight that has the fully reversible ability to change its performance properties, including U-factor, SHGC, or Visual Transmittance. This includes, but is not limited to, electrochromic glass systems that can be tinted in response to an electronic control signal or environmental change and fenestration with operable blinds or shades positioned between glass panes.
EEPS	See Energy Efficiency Program Sponsor.
Energy Efficiency Program Sponsor	Electric or gas utilities, state agencies, and other regional groups that sponsor programs to promote the sale of energy-efficient products and adoption of energy conservation measures.
Fenestration	Products that fill openings in a building envelope, including windows, doors, and skylights, designed to permit the passage of air, light, and/or people.
Fully glazed	Descriptor for a door with > 36.4 percent glazing (based on NFRC 100-2010). See also > ½-lite.
Gap width	The distance between two adjacent glazing surfaces.
Glazed	Descriptor for a fenestration product containing glass.
Glazing	Glass used in a fenestration product.
IECC	See International Energy Conservation Code.
IG Unit	See Insulating Glass Unit.
IGU	See Insulating Glass Unit.
Insulating Glass Unit	A preassembled unit, comprising panes of glass, which are sealed at the edges and separated by dehydrated space(s).
International Energy Conservation Code	A building energy code published by the International Code Council.
LBNL	See Lawrence Berkley National Laboratory.
Lite	A pane of glass used in fenestration.
Low-e coating	Microscopically thin metal, metal oxide or multilayer coating, deposited on a glazing surface to reduce its thermal infrared emittance.

Low-emissivity coating	See Low-e coating.
National Fenestration Rating Council	A non-profit organization that administers the only uniform, independent rating and labeling system for the energy performance of windows, doors, and skylights.
NFRC	See National Fenestration Rating Council.
Opaque	ENERGY STAR classification for a door with no glazing (based on NFRC 100-2010).
Peak load	The maximum daily, weekly, or seasonal electric load.
Residential building	A structure used primarily for living and sleeping that is three stories or less in height and not governed by commercial building codes.
SHGC	See Solar Heat Gain Coefficient.
Skylight	A window designed for sloped or horizontal application in the roof of a residential building, the primary purpose of which is to provide daylighting and/or ventilation. May be fixed or operable. See also Tubular Daylighting Device.
Sliding glass door	A system that contains one or more manually operated panels that slide horizontally within a common frame.
Solar Heat Gain Coefficient	The ratio of the solar heat gain entering the space through the fenestration product to the incident solar radiation. Expressed as a value between 0 and 1.
Spacer	The component that separates and maintains the space between the glazing surfaces of insulating glass.
Swinging door	A system having, at a minimum, a hinge attachment of any type between a leaf and jamb, mullion, or edge of another leaf or having a single, fixed vertical axis about which the leaf rotates between open and closed positions.
Swinging entry door	See Swinging door.
TDD	See Tubular Daylighting Device.
Tubular Daylighting Device	A non-operable skylight primarily designed to transmit daylight from a roof surface of a residential building to an interior ceiling surface via a conduit. The product consists of an exterior glazed weathering surface, a light transmitting tube with a reflective inside surface, and an interior sealing surface, such as a translucent ceiling panel.
Tubular skylight	See Tubular Daylighting Device.
U-factor	The heat transfer per time per area and per degree of temperature difference, which when multiplied by the interior-exterior temperature difference and by the projected fenestration product area yields the total heat transfer through the fenestration product due to conduction, convection, and long wave infra-red radiation. Expressed in units of Btu/h•ft^2•ºF.
VT	See Visible Transmittance
Visible Transmittance	The ratio of visible radiation entering the space through the fenestration product to the incident visible radiation, determined as the spectral transmittance of the total fenestration system, weighted by the photopic response of the eye, and integrated into a single dimensionless value. Weighted by a standard solar spectrum.
Window	An assembled unit consisting of a frame/sash component holding one or more pieces of glazing functioning to admit light and/or air into an enclosure and designed for a vertical installation in an external wall of a residential building.