U.S. Department of Energy
ENERGY STAR Program

Windows, Doors, and Skylights
Revised Draft Criteria and Report

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Executive Summary

On August 6, 2008, the U.S. Department of Energy (DOE) published the *Draft Criteria and Analysis for ENERGY STAR Windows, Doors, and Skylights*. After presenting the *Draft Criteria and Analysis* at the Stakeholder Meeting on August 13, DOE opened a public comment period until November 14.

DOE has reviewed the more than 50 comments submitted during the public comment period and conducted follow-up analysis to address the issues raised by stakeholders. DOE also considered the criteria approved for the 2009 International Energy Conservation Code (IECC) and the criteria set for the 2009-2010 tax credit in the American Recovery and Reinvestment Act of 2009 (ARRA).

On the basis of this analysis, DOE has made several changes to the draft ENERGY STAR criteria:

1. Reduced the number of climate zones to four and returned to geographic zone names
2. Adjusted the windows criteria and limited tradeoffs in the North
3. Adjusted the U-factor for the ≤ ½-lite category of swinging entry doors and changed the Solar Heat Gain Coefficient (SHGC) to match IECC levels
4. Changed skylight criteria based on industry comments and IECC levels
5. Suspended Tubular Daylighting Devices (TDDs) from the program until industry collects a sufficient body of test results
6. Delayed beginning work on criteria for Phase 2 until late Fiscal Year 2009

DOE has also added an additional program requirement for the submission of product shipment data, for which comments were requested in November 2008.

By incorporating these changes, DOE achieves its goals of:

- Re-establishing ENERGY STAR as a differentiator of energy-efficient windows, doors, and skylights by meeting or exceeding code across the United States.
- Increasing national energy savings attributable to ENERGY STAR fenestration. The revised criteria show a potential savings of 9.21 trillion Btu,[1] higher than the 8.5 trillion Btu resulting from the draft criteria (see Table 1).

[1] This savings estimate is conservative, applied only to the NR (No Rating) Northern Zone tradeoff option, as those windows represent the dominant share of the market. The high-gain windows in the two Northern tradeoff options represent a smaller share of the current market (manufacturers estimate less than 5%), but they represent a greater potential for energy savings in a heating-dominated climate.

Table 1: Potential Savings for Revised Draft ENERGY STAR Windows Criteria

	Prescriptive Criteria		
Revised Climate Zone	U-Factor	SHGC	tBtu Saved
North	≤ 0.30 =0.31 =0.32	NR ≥ 0.35 ≥ 0.40	1.97
North-Central	≤ 0.32	≤ 0.40	1.80
South-Central	≤ 0.35	≤ 0.30	4.09
South	≤ 0.60	≤ 0.27	1.35
		TOTAL	**9.21**

NR=No Rating

The criteria development process will proceed as described in Table 2:

Table 2: ENERGY STAR Windows, Doors, and Skylights Criteria Schedule

Public Comment Period	March 11-25, 2009
DOE Reviews Comments	March 25-30, 2009
Final ENERGY STAR Criteria Published	March 31, 2009
Effective Date for Phase 1 Criteria (at least 270 days later)	January 1, 2010
Phase 1 Transition Period Ends All products in distribution chain must be qualified and labeled in accordance with Phase 1 criteria.	March 31, 2010 Earliest possible
Analysis for Phase 2 Begins	Late FY 2009

1 Background

When 28 states surpassed ENERGY STAR requirements by adopting IECC 2003 or more recent editions and ENERGY STAR window market share reached 53 percent, DOE decided the ENERGY STAR criteria for windows, doors, and skylights required revision.

The criteria revision process for windows, doors, and skylights began in the fall of 2007. After in-depth research and analysis, DOE issued the *Draft Criteria and Analysis* in August 2008, followed by a stakeholder meeting for industry feedback. Following this meeting, DOE opened a public comment period ending November 14, 2008. Stakeholders had until December 12, 2008 to comment on the additional program requirements.

DOE typically incorporates feedback from industry stakeholders into the criteria revision process to get firsthand information on the feasibility and benefits of the criteria changes under consideration. During the current revision, DOE also needed to consider two

changes in the regulatory arena that occurred since the publication of the *Draft Criteria and Analysis*:

- Finalization of the 2009 IECC criteria
- Establishment of specific energy performance criteria in the renewed tax credit for fenestration products

During the public comment period on the *Draft Criteria and Analysis* ending November 14, associations, manufacturers, Energy Efficiency Program Sponsors (EEPS), and other interested parties submitted more than 50 comments. DOE reviewed the comments and identified the major issues stakeholders recommended for review:

- Criteria in the North
- The separate zone in the Pacific Northwest
- Criteria in the South
- Doors
- Skylights
- Tubular Daylighting Devices (TDDs)
- Phase 2

DOE has also made changes to the additional program requirements proposed in November 2008.

In September of 2008, the International Code Council (ICC) finalized the 2009 IECC, whose levels exceed those of ENERGY STAR in several regions. ENERGY STAR must consider the stringency of IECC levels when evaluating which criteria will yield savings above prevailing building codes. This is particularly true in the wake of the passage of the American Recovery and Reinvestment Act of 2009 (ARRA); because the law requires states to adopt the most recent code and enforce it to receive additional state energy grants, states are likely to adopt the 2009 IECC more quickly than they might have otherwise.

On February 17, 2009, President Obama signed into law ARRA, which extends and revises the tax credit for windows, doors, and skylights. While the previous tax credit for fenestration products applied to ENERGY STAR qualified products, the new tax credit specifies energy performance criteria, a maximum 0.30 U-factor and maximum 0.30 SHGC, for the entire country, regardless of climate zone. DOE considered this fact when reviewing ENERGY STAR criteria levels across the country.

2 Revisions to Draft ENERGY STAR Criteria and Analysis

Figure 1: Revised Draft ENERGY STAR Climate Zone Map

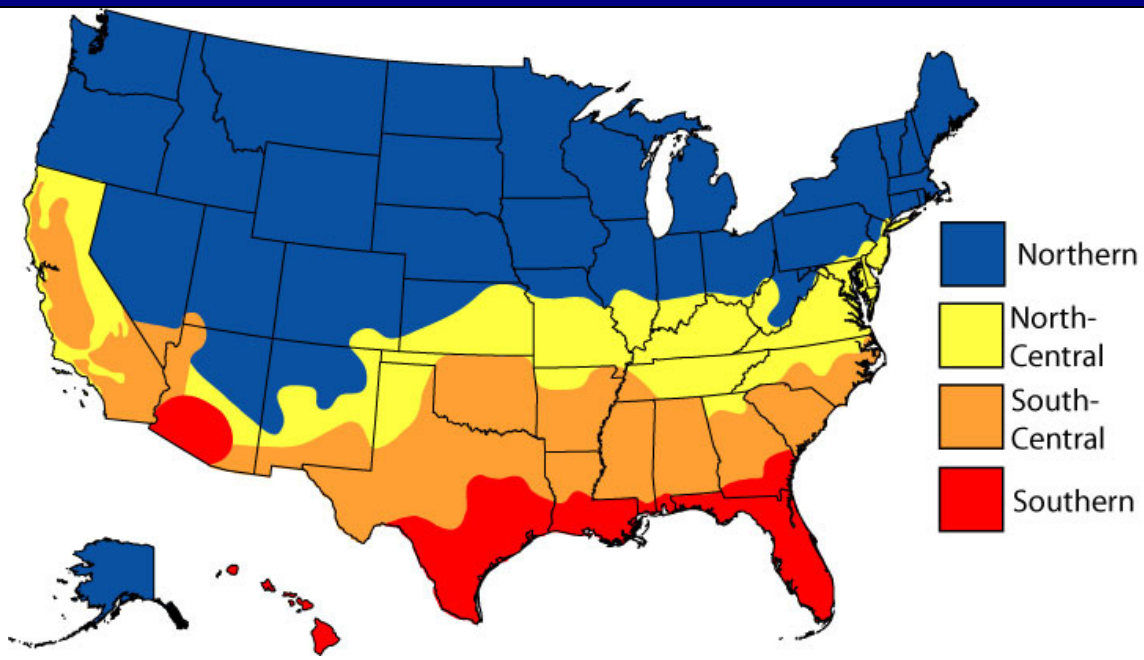

Table 3: Revised Draft ENERGY STAR Windows Criteria

	Draft Criteria Proposal – Phase 1		Final 2009 IECC		Revised Criteria Proposal – Phase 1	
Proposed Climate Zone	U-Factor	SHGC	U-Factor	SHGC	U-Factor	SHGC
ES5a	≤ 0.30	≤ 0.55	≤ 0.35	NR	N/A	N/A
Northern	Tradeoffs	Tradeoffs	≤ 0.35	NR	≤ 0.30 =0.31 =0.32	NR ≥ 0.35 ≥ 0.40
North-Central	≤ 0.33	≤ 0.40	≤ 0.35	NR	≤ 0.32	≤ 0.40
South-Central	≤ 0.35	≤ 0.30	≤ 0.40	≤ 0.30	≤ 0.35	≤ 0.30
Southern	≤ 0.50	≤ 0.25	≤ 0.65/0.50	≤ 0.30	≤ 0.60	≤ 0.27

NR=No Rating

2.1 Revised ENERGY STAR Climate Zone Map

The climate zone map proposed in the *Draft Criteria and Analysis* followed the contours of the IECC climate zones everywhere but in California and the Pacific Northwest. DOE sought closer alignment with the IECC climate zones because the IECC is the dominant energy code manufacturers consider when distributing product. Because California maintains its own energy code, Title 24, DOE followed Title 24 boundaries. At the request of the Northwest Energy Efficiency Alliance (NEEA), Zone ES5a had a different set of prescriptive windows criteria to exceed the stringent building codes effective in certain parts of that region. To reduce complexity for manufacturers and consumers, DOE combined several of the IECC and Title 24 zones for a total of six proposed ENERGY STAR climate zones in the *Draft Criteria and Analysis*.

Stakeholders raised several concerns about the map proposed in the *Draft Criteria and Analysis* and suggested solutions:

- The criteria levels proposed in Zones ES5 and ES4 are too similar to warrant separate zones, and additional zones complicate the current four-zone system. The Window and Door Manufacturers Association (WDMA) and the American Architectural Manufacturers Association (AAMA) jointly proposed an alternative map that combined the two zones and ES5a, among other changes.
- The establishment of a "by-request" zone in the Pacific Northwest sets a precedent for the creation of additional zones based on stakeholder request and the introduction of too much complexity for the consumer.
- The use of numeric nomenclature for the climate zones causes confusion with IECC zone numbers. Stakeholders suggested returning to the geographic designations used in the current ENERGY STAR map.

Responding to these stakeholder comments, DOE made the following changes to the ENERGY STAR climate zone map (see Figure 1):

- Combined the proposed Zones ES5 and ES4 into one zone because both zones can benefit from the same criteria;
- Re-integrated Zone ES5a into the standard Northern Zone, as the 0.30 U-factor option now meets the incentive requirements of the NW utilities; and
- Returned zone nomenclature to geographic designations to avoid confusion with IECC zone numbers.

2.2 Revised Windows Criteria

2.2.1 Revised Criteria in the North

In the *Draft Criteria and Analysis*, three climate zones composed the heating-dominated northern region of the United States: Zones ES5, ES5a, and ES4. In Zones ES5 and ES4, the proposed windows criteria were based on minimum aggregate annual energy performance rather than a prescriptive U-factor, and were accompanied by U-factor and SHGC caps. Zone ES5a included the four states of the Pacific Northwest and Alaska. At the request of the Northwest Energy Efficiency Alliance (NEEA), Zone ES5a had a different set of prescriptive windows criteria to exceed the stringent building codes effective in certain parts of that region.

Stakeholders expressed the following concerns about the draft criteria for Zones ES5, ES5a, and ES4:

- The tradeoffs proposed in Zones ES5 and ES4 were too complex and too similar in the two zones. The majority of comments proposed eliminating the tradeoffs in the North.
- Windows qualifying for the criteria proposed for Zone ES5a were not cost-effective to produce.
- The criteria, especially for Phase 2, might lead to greater sales of high-gain windows, which, if sold in large quantities, might increase peak demand in the summer.

The revised tax credit specifies a maximum U-factor and maximum SHGC of 0.30. Although the tax credit applies across the United States, DOE considered it most closely when reviewing the proposed criteria for the North, the zone that would most benefit from the application of this low U-factor.

Meeting or exceeding code is a minimum requirement for ENERGY STAR criteria, and ICC set the final 2009 IECC prescriptive criteria for the regions corresponding to ES5, ES5a, and ES4 at a maximum U-factor of 0.35 and No Rating for SHGC.

In revising the draft criteria for the northern climates, DOE considered its original analysis, stakeholder comments, the newly enacted federal tax credit, and final 2009 IECC prescriptive criteria.

DOE's revised criteria consolidate the three northern zones (ES5, ES5a, and ES4) into a single zone and greatly simplify tradeoffs, as requested by stakeholders. DOE tightened the U-factor criterion to the 0.30 level of the tax credit to ensure ENERGY STAR intersects with the tax credit. To maximize the number of products qualifying in this zone at the 0.30 maximum U-factor, DOE set no SHGC criterion rather than carry over the tax credit's SHGC maximum. The majority of windows in the market meeting the 0.30 U-factor, however, will also meet the tax credit's 0.30 SHGC level, because the

median SHGC for products with U-factors $\leq$ 0.30 is 0.27. [2] The revised tax credit of 30%, up to $1500 total, will help cover the cost of producing windows that qualify for the credit.

DOE has retained limited tradeoffs in this new Northern Zone, in recognition of the benefits of higher solar gain where orientation and conditions are optimal. Tradeoffs will further increase the range of available products and the number of manufacturers able to offer qualifying products, while yielding roughly equivalent annual energy performance.

The energy savings analysis in the *Draft Criteria and Analysis* revealed that in the North, a 0.01 increase in U-factor produces equivalent energy performance to a 0.05 increase in SHGC. DOE used this relationship to establish the proposed revised tradeoff levels: setting the tax credit criteria of 0.30 U-factor and 0.30 SHGC as the base case, the minimum required SHGC in the revised tradeoffs rises 0.05 to balance a 0.01 rise in U-factor. The two alternative criteria specify U-factors of 0.31 and 0.32 (see Table 3), while allowing the minimum SHGC to rise to 0.35 and 0.40 respectively. Windows with those specific U-factors and the corresponding SHGCs or higher will qualify.

DOE anticipates the new criteria will likely result in somewhat lower peak load in the North, as the majority of sales will be low-e windows that qualify for the tax credit. Windows qualifying for the tax credit will have average SHGCs somewhat lower than current ENERGY STAR qualified products, and thus the net impact will likely be a somewhat lower net aggregate summer peak load.

2.2.2 Revised Criteria in the South

The criteria proposed for the South in the *Draft Criteria and Analysis* were a maximum U-factor for ES1 of 0.50, the level proposed for IECC 2009, and a maximum SHGC of 0.25, to exceed the proposed IECC level and maintain solar control in the South. DOE felt that ICC's proposal for a 0.50 maximum U-factor in IECC 2009 would excessively harm manufacturers and promised to relax its U-factor to the level finally approved by ICC or to 0.60, whichever was more stringent.

Stakeholders' primary concern in this zone was the very low SHGC would reduce transmission of visible light. Based on final approved levels for the 2009 IECC and stakeholder concerns, DOE revised the draft criteria in the South as follows:

- Relaxed the SHGC to 0.27. DOE's research confirmed industry's observation that about half of solar energy is visible light[3] and SHGC levels below 0.25 reduce visible light. DOE does not want to encourage the production of windows that provide less visible light. Maintaining the 0.25 SHGC proposed in the *Draft Criteria and Analysis* would mean the average SHGC of most products would fall

[2] D&R International, Ltd., 2008. Analysis of 62 window manufacturers from 2008 Top 100 Manufacturers from *Window & Door Magazine* (February 2008) and ENERGY STAR Windows, Doors, and Skylights partners.

[3] John Carmody, Stephen Selkowitz, Dariush Arasteh, and Lisa Heschong. *Residential Windows*. Third Edition. New York, NY: W.W. Norton & Company, 2007. Page 43.

below 0.25. By relaxing the SHGC to 0.27, DOE expects the mean SHGC of qualifying products to be 0.25 or 0.26, near the 0.27 level.

- Relaxed the U-factor to 0.60, as promised in the *Draft Criteria and Analysis*, because the IECC set the maximum U-factor for this region at 0.65.

2.2.3 Revised U-Factor in the North-Central Zone

DOE lowered the U-factor in the North-Central Zone from the originally proposed 0.33 to 0.32 to remain consistent with the more stringent levels proposed in other climate zones.

2.3 Revised Criteria for Swinging Entry Doors

DOE proposed separate criteria for swinging entry doors in the *Draft Criteria and Analysis* that vary by glazing area rather than climate zone. DOE selected three glazing categories and proposed U-factors based on the potential energy performance of those categories. Because the proposed criteria applied for all climate zones, DOE specified an SHGC maximum of 0.30 to balance the negative impacts of solar gain in the South with the positive benefits of solar gain in the North.

Stakeholders' major concern with the criteria for swinging entry doors was the comparatively greater stringency of the U-factor requirement ($\leq$ 0.25) for the $\leq$ ½-lite category compared to the > ½-lite category. Given the ratio of slab to glass, to be consistent with the > ½-lite level of 0.32, the $\leq$ ½-lite U-factor should be a maximum of 0.27 or 0.28.

Some stakeholders felt that the 0.30 maximum SHGC was unnecessary or should at least be phased in to reduce the need for expensive product redesign.

DOE concurred with stakeholder analysis on the $\leq$ ½-lite category and adjusted the U-factor criterion accordingly. SHGC maxima were maintained for all door categories, because the final 2009 IECC includes a 0.30 maximum in its three southernmost zones.

Table 4: Revised Draft ENERGY STAR Criteria for Swinging Entry Doors

Glazing	Draft Criteria Proposal - Phase 1		Draft Criteria Relative to IECC 2009		Revised Criteria Proposal - Phase 1	
	U-Factor	SHGC	U-Factor	SHGC	U-Factor	SHGC
Opaque	$\leq$ 0.21	NR	Exceeds code in all zones		$\leq$ 0.21	NR
$\leq$ ½-Lite	$\leq$ 0.25	$\leq$ 0.30	Exceeds code in all zones	Meets Code	$\leq$ 0.27	$\leq$ 0.30
> ½-Lite	$\leq$ 0.32	$\leq$ 0.30	Meets code in ES4, ES5, & ES5a	Meets Code	$\leq$ 0.32	$\leq$ 0.30

NR=No Rating

2.4 Revised Criteria for Skylights

The *Draft Criteria and Analysis* proposed new criteria for skylights that would encourage superior product performance and maximize potential savings.

Stakeholders expressed concerns over the technological feasibility of the criteria and the accuracy of the National Fenestration Rating Council (NFRC) Certified Product Directory (CPD). Cross-checking with industry records confirmed irregularities in the original dataset, for example the data used for the analysis included test skylights. Stakeholders recommended specific criteria levels that corresponded to the corrected product inventory.

Analysis of a corrected dataset supported industry's position on availability and feasibility. In response to the new data, stakeholder comments, and approved criteria levels for the 2009 IECC, DOE made the following changes to the draft skylight criteria:

Table 5: Revised Draft ENERGY STAR Skylight Criteria

Climate Zone	Draft Criteria Proposal – Phase 1		IECC 2009		Revised Criteria Proposal - Phase 1	
	U-Factor	SHGC	U-Factor	SHGC	U-Factor	SHGC
Northern	≤ 0.50	NR	≤ 0.60	NR	≤ 0.55	NR
North-Central	≤ 0.55	≤ 0.40	≤ 0.60	NR	≤ 0.55	≤ 0.40
South-Central	≤ 0.55	≤ 0.30	≤ 0.60	≤ 0.30	≤ 0.57	≤ 0.30
Southern	≤ 0.55	≤ 0.30	≤ 0.75	≤ 0.30	≤ 0.70	≤ 0.30

NR=No Rating

2.5 Criteria for Tubular Daylighting Devices

DOE did not establish criteria for TDDs in the *Draft Criteria and Analysis*. At that time, a physical test procedure existed for TDDs, but NFRC determined the approved simulation method did not accurately model product performance. DOE deferred setting ENERGY STAR criteria for these products until there was a sufficient body of physical test results on which to determine relative performance.

As of the date of this report, no additional test results are available, and DOE has no choice but to suspend TDDs from the ENERGY STAR program pending the availability of a sufficient body of test results. DOE will monitor the situation with NFRC and will revisit the status of TDDs in the ENERGY STAR program if it receives such test results and can determine relative performance.

3 Phase 2

The *Draft Criteria and Analysis* included a proposal for a Phase 2 of the criteria revision, set to go into effect approximately four years after Phase 1. DOE proposed criteria levels for windows, doors, and skylights and described the research it had collected to date.

A majority of stakeholders commenting on Phase 2 suggested the start be delayed.

Stakeholders raised concerns about product availability and cost to produce products meeting Phase 2 criteria levels. Since it is still three to four years until the likely effective date for these criteria, DOE is postponing finalization of these criteria to allow for additional data collection and analysis. The Department will begin research on a Phase 2 proposal in late FY 2009.

4 Additional Program Requirements

In November 2008, DOE proposed three additional program requirements for partners of ENERGY STAR for Windows, Doors, and Skylights:

1. Adding the full CPD number to the NFRC temporary label, so consumers can locate complete product and performance data
2. Resetting ENERGY STAR product criteria for windows, doors, and skylights to IECC criteria if the code moves beyond ENERGY STAR before the next ENERGY STAR criteria revision
3. Providing shipment data for ENERGY STAR qualified products so DOE can monitor the program's progress and evaluate its results

DOE determined that adding the full CPD number to the NFRC temporary label would be operationally difficult, and given the severity of the fines imposed for inaccurate labeling, it is not feasible to implement this proposed requirement in the current economic climate.

The Energy Policy Act of 2005 (EPAct 2005) requires ENERGY STAR to offer a public comment period on any proposed criteria revisions. Therefore, the proposed requirement to temporarily reset ENERGY STAR windows, doors, and skylights criteria to more stringent levels set by building codes before the next ENERGY STAR criteria revision does not meet the intent of the legislation.

Several stakeholders lodged strenuous objections to the proposed shipment data reporting requirement, fearing possible disclosure of this sensitive data and expressing concern about the time and technology required for collecting and reporting. On the other hand, stakeholders acknowledged DOE cannot calculate energy savings without aggregated shipment data.

Stakeholders proposed that, rather than reporting the information directly to DOE or its contractor, the data be reported to and aggregated by Ducker Research and published by AAMA and WDMA in an expanded *Study of the U.S. Market for Windows, Doors, and Skylights*. Discussion on this alternative is ongoing, and DOE will announce its decision in time to coordinate with the next study.