

# Review of Cost Effectiveness Analysis

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## Background

In July 2012, the U.S. Environmental Protection Agency (EPA) released the *ENERGY STAR® for Windows, Doors, and Skylights Version 6.0 Draft 1 Criteria and Analysis Report* (Draft 1 Report). Section 3.3 of the report describes how EPA collected and analyzed cost data from manufacturers to determine the cost effectiveness of the proposed criteria levels for windows. In February 2013, during the comment period for the Version 6.0 Draft 2 criteria, EPA received questions from stakeholders regarding this analysis. This document is meant to supplement Section 3.3 of the Draft 1 Report, offering clarifications and in-depth descriptions of processes used to determine the payback periods published in the Draft 1 Report. Further, this document contains an additional review of payback periods for products at different cost levels. The Additional Payback Analyses section outlines the results of these analyses and offers revised payback numbers, which reflect the latest specification proposals.

During the Draft 2 comment period, some stakeholders requested more detailed information regarding the cost effectiveness dataset. All the cost data volunteered by manufacturers was provided confidentially to a technical support contractor for EPA. However, EPA has provided the details requested where doing so does not jeopardize the proprietary cost data entrusted to the contractor for aggregation and analysis. EPA appreciates the time and effort invested by those manufacturers who offered private cost data and will continue to protect that data. It is only through these datasets that EPA is able to evaluate the cost effectiveness of various criteria. This document contains the full extent of details EPA is able to disclose while remaining confident that the manufacturers' original cost data is not compromised.

## Overview

The primary metric that EPA uses to determine cost effectiveness is payback (i.e., the length of time it would take a consumer to recoup the additional cost associated with purchasing an ENERGY STAR certified product compared to a standard or code-compliant product). To calculate payback for the Draft 1 Version 6.0 ENERGY STAR for Windows specification, EPA used the following formula:

$$\frac{(IC + MC) \times WPH}{IES} = \text{Payback}$$

Where  $IC$  = Average incremental cost between manufacturers' best-selling Version 5.0 ENERGY STAR window and windows qualifying under the proposed Draft 1 Version 6.0 specification (See Incremental Cost section)

$MC$  = Marginal cost between manufacturers' best-selling Version 5.0 ENERGY STAR window and a code window or the manufacturer's next poorer-performing window (See Marginal Cost section)

$WPH$  = Average number of windows per house (See Windows per House section)

*IES* = Average incremental energy savings per household in a given city (See Incremental Energy Savings section)

*Payback* = Number of years it will take to pay back the consumer’s additional investment (See Payback section)

### Incremental Cost

To collect incremental cost data, EPA contacted all program stakeholders in May 2011 via a broadcast e-mail. In this e-mail, EPA offered manufacturers the opportunity to voluntarily provide the incremental cost of improving the performance of their products to various performance levels. EPA provided a template to manufacturers to assist them in compiling this data (see the Appendix). EPA received 92 incremental price points from eight companies, though 12 data points were excluded from the dataset because either the datasets were incomplete or the ratings were achieved using an attachment product. EPA aggregated the remaining data in an Excel spreadsheet. Data in the spreadsheet included U-factor, Solar Heat Gain Coefficient (SHGC), incremental cost, etc. (see Figure 1: Example of Aggregated Incremental Cost Data). The spreadsheets shown here are for illustrative purposes only and do not include actual data provided by manufacturers.

Figure 1: Example of Aggregated Incremental Cost Data

	A	B	C	D	E	F	G	H	I	J	K
1	Change									Added Cost Over	
2	Company	Frame Material	IG	U-Factor	SHGC	Add Pane	Glass Type	Gas Type	Other	Best Selling	Best-Selling
3	Manufacturer 6	Vinyl	Double	0.40	0.51		Glass Type	Gas Type	Spacer Type	\$0.00	
4	Manufacturer 4	Vinyl	Double	0.40	0.49		Glass Type		Cladding Type	\$20.00	
5	Manufacturer 2	AL Clad Wood	Double	0.36	0.32		Glass Type	Gas Type	Spacer Type	\$0.00	
6	Manufacturer 1	Vinyl	Double	0.32	0.30		Glass Type	Gas Type	Cladding Type	\$0.00	
7	Manufacturer 7	Vinyl	Double	0.32	0.28					\$0.00	Yes
8	Manufacturer 4	AL Clad Wood	Double	0.32	0.28		Glass Type	Gas Type	Spacer Type	\$10.00	
9	Manufacturer 3	Vinyl	Double	0.31	0.28		Glass Type	Gas Type	Spacer Type	\$20.00	
10	Manufacturer 7	AL Clad Wood	Double	0.30	0.27					\$0.00	Yes
11	Manufacturer 6	Vinyl	Double	0.30	0.27					\$0.00	Yes
12	Manufacturer 5	AL Clad Wood	Double	0.30	0.27					\$0.00	Yes
13	Manufacturer 2	AL Clad Wood	Double	0.30	0.26					\$0.00	Yes
14	Manufacturer 5	FG Clad Wood	Double	0.30	0.26					\$30.00	
15	Manufacturer 3	Vinyl	Double	0.30	0.26		Glass Type			\$40.00	
16	Manufacturer 4	FG Clad Wood	Double	0.29	0.25		Glass Type		Spacer Type	\$30.00	
17	Manufacturer 8	Vinyl	Double	0.29	0.25			Gas Type		\$40.00	
18	Manufacturer 2	Vinyl	Double	0.28	0.25		Glass Type			\$50.00	
19	Manufacturer 1	Vinyl	Double	0.28	0.25					\$0.00	Yes
20	Manufacturer 7	Vinyl	Double	0.27	0.25			Gas Type		\$50.00	
21	Manufacturer 8	AL Clad Wood	Double	0.27	0.25		Glass Type			\$60.00	
22	Manufacturer 1	FG Clad Wood	Double	0.27	0.24				Foam	\$70.00	
23	Manufacturer 8	Vinyl	Double	0.26	0.24		Glass Type			\$80.00	
24	Manufacturer 1	Vinyl	Double	0.26	0.23		Glass Type			\$80.00	
25	Manufacturer 2	AL Clad Wood	Triple	0.25	0.22	Add Pane	Glass Type			\$90.00	
26	Manufacturer 7	AL Clad Wood	Triple	0.25	0.22		Glass Type		Foam	\$100.00	
27	Manufacturer 6	Vinyl	Triple	0.24	0.21	Add Pane	Glass Type			\$200.00	
28	Manufacturer 5	Vinyl	Triple	0.24	0.21	Add Pane	Glass Type			\$80.00	
29	Manufacturer 4	Vinyl	Triple	0.23	0.21	Add Pane	Glass Type		Spacer Type; Foam	\$100.00	
30	Manufacturer 6	AL Clad Wood	Triple	0.23	0.20	Add Pane	Glass Type	Gas Type	Spacer Type	\$150.00	
31	Manufacturer 8	Vinyl	Triple	0.22	0.20	Add Pane			Spacer Type	\$250.00	

EPA then filtered this data by U-factor and SHGC (less than or equal to the proposed criteria for a given zone), as illustrated in Figure 2 and Figure 3. This process was repeated for each set of proposed criteria.

Figure 2: Example of Applying Number Filters

	A	B	C	D	E	F	G	H	I	J	K
1										Change	Added Cost Over
2	Company	Frame Material	IG	U-Factor	SHGC	Add Pane	Glass Type	Gas Type	Other	Best Selling	Best-Selling
3	Manufa			0.51			Glass Type	Gas Type	Spacer Type	\$0.00	
4	Manufa			0.49			Glass Type		Cladding Type	\$20.00	
5	Manufa			0.32			Glass Type	Gas Type	Spacer Type	\$0.00	
6	Manufa			0.30			Glass Type	Gas Type	Cladding Type	\$0.00	
7	Manufa			0.28						\$0.00	Yes
8	Manufa			0.28			Glass Type	Gas Type	Spacer Type	\$10.00	
9	Manufa			0.28			Glass Type	Gas Type	Spacer Type	\$20.00	
10	Manufa			0.27						\$0.00	Yes
11	Manufa									\$0.00	Yes
12	Manufa									\$0.00	Yes
13	Manufa									\$0.00	Yes
14	Manufa									\$30.00	
15	Manufa									\$40.00	
16	Manufa								Spacer Type	\$30.00	
17	Manufa						Gas Type			\$40.00	
18	Manufa									\$50.00	
19	Manufa									\$0.00	Yes
20	Manufa						Gas Type			\$50.00	
21	Manufa								Foam	\$60.00	
22	Manufacturer 1	FG Clad Wood	Double	0.27						\$70.00	
23	Manufacturer 8	Vinyl	Double	0.26						\$80.00	
24	Manufacturer 1	Vinyl	Double	0.26						\$80.00	
25	Manufacturer 2	AL Clad Wood	Triple	0.25						\$90.00	
26	Manufacturer 7	AL Clad Wood	Triple	0.25					Foam	\$100.00	
27	Manufacturer 6	Vinyl	Triple	0.24						\$200.00	
28	Manufacturer 5	Vinyl	Triple	0.24						\$80.00	
29	Manufacturer 4	Vinyl	Triple	0.23	0.21	Add Pane	Glass Type		Spacer Type; Foam	\$100.00	
30	Manufacturer 6	AL Clad Wood	Triple	0.23	0.20	Add Pane	Glass Type	Gas Type	Spacer Type	\$150.00	

Figure 3: Example of Applying Number Filter to U-Factor Data for Northern Zone

	A	B	C	D	E	F	G	H	I	J	K
1										Change	Added Cost Over
2	Company	Frame Material	IG	U-Factor	SHGC	Add Pane	Glass Type	Gas Type	Other	Best Selling	Best-Selling
3	Manufacturer 6	Vinyl	Double	0.40	0.51		Glass Type	Gas Type	Spacer Type	\$0.00	
4	Manufacturer 4	Vinyl	Double						Cladding Type	\$20.00	
5	Manufacturer 2	AL Clad Wood	Double						Spacer Type	\$0.00	
6	Manufacturer 1	Vinyl	Double						Cladding Type	\$0.00	
7	Manufacturer 7	Vinyl	Double							\$0.00	Yes
8	Manufacturer 4	AL Clad Wood	Double						Spacer Type	\$10.00	
9	Manufacturer 3	Vinyl	Double						Spacer Type	\$20.00	
10	Manufacturer 7	AL Clad Wood	Double							\$0.00	Yes
11	Manufacturer 6	Vinyl	Double							\$0.00	Yes
12	Manufacturer 5	AL Clad Wood	Double							\$0.00	Yes
13	Manufacturer 2	AL Clad Wood	Double							\$0.00	Yes
14	Manufacturer 5	FG Clad Wood	Double							\$30.00	
15	Manufacturer 3	Vinyl	Double	0.30	0.26		Glass Type			\$40.00	
16	Manufacturer 4	FG Clad Wood	Double	0.29	0.25		Glass Type		Spacer Type	\$30.00	
17	Manufacturer 8	Vinyl	Double	0.26	0.25		Gas Type			\$10.00	

Once the filter was applied, the average of the incremental costs for the remaining values was calculated (as shown in Figure 4: Example of Calculating Average Incremental Cost).

Figure 4: Example of Calculating Average Incremental Cost

	A	B	C	D	E	F	G	H	I	J	K
1	Change									Added Cost Over	
2	Company	Frame Material	IG	U-Factor	SHGC	Add Pane	Glass Type	Gas Type	Other	Best Selling	Best-Selling
20	Manufacturer 7	Vinyl	Double	0.27	0.25			Gas Type		\$50.00	
21	Manufacturer 8	AL Clad Wood	Double	0.27	0.25		Glass Type			\$60.00	
22	Manufacturer 1	FG Clad Wood	Double	0.27	0.24				Foam	\$70.00	
23	Manufacturer 8	Vinyl	Double	0.26	0.24		Glass Type			\$80.00	
24	Manufacturer 1	Vinyl	Double	0.26	0.23		Glass Type			\$80.00	
25	Manufacturer 2	AL Clad Wood	Triple	0.25	0.22	Add Pane	Glass Type			\$90.00	
26	Manufacturer 7	AL Clad Wood	Triple	0.25	0.22		Glass Type		Foam	\$100.00	
27	Manufacturer 6	Vinyl	Triple	0.24	0.21	Add Pane	Glass Type			\$200.00	
28	Manufacturer 5	Vinyl	Triple	0.24	0.21	Add Pane	Glass Type			\$80.00	
29	Manufacturer 4	Vinyl	Triple	0.23	0.21	Add Pane	Glass Type		Spacer Type; Foam	\$100.00	
30	Manufacturer 6	AL Clad Wood	Triple	0.23	0.20	Add Pane	Glass Type	Gas Type	Spacer Type	\$150.00	
31	Manufacturer 8	Vinyl	Triple	0.22	0.20	Add Pane			Spacer Type	\$250.00	
32	Manufacturer 6	FG Clad Wood	Triple	0.22	0.19	Add Pane	Glass Type	Gas Type		\$100.00	
33	Manufacturer 4	Vinyl	Triple	0.21	0.19	Add Pane	Glass Type	Gas Type		\$200.00	
34	Manufacturer 3	Vinyl	Triple	0.20	0.18	Add Pane		Gas Type		\$300.00	
35	Manufacturer 3	Vinyl	Triple	0.20	0.18	Add Pane	Glass Type	Gas Type		\$400.00	
36	Manufacturer 1	Vinyl	Triple	0.20	0.17	Add Pane	Glass Type	Gas Type		\$500.00	

Ready 17 of 36 records found Average: \$165.29 Count: 17 Min: \$50.00 Max: \$500.00 Sum: \$2,810.00 100%

Using this method, EPA determined the average incremental costs provided in Table 5 of the Draft 1 Report. As noted in the Draft 1 Report, EPA did not calculate incremental costs for the tradeoff criteria in the Northern Zone, as no manufacturers provided incremental cost data on products meeting the proposed tradeoff criteria.

Table 1 shows the average cost increase over best-selling windows for double-pane products only. EPA excluded triple pane products from its analysis for the reasons highlighted in the Draft 1 Report and detailed in the next section.

**Table 1: Average Incremental Product Costs Across Climate Zones for Draft 1 Version 6.0 Criteria**

Zone	U-Factor	SHGC	Average Cost Increase Over Best-Selling ENERGY STAR Window <sup>1</sup>
Northern	0.27	Any	\$34.00
North-Central	0.29	0.40	\$28.00
South-Central	0.31	0.25	\$21.00
Southern	0.40	0.25	\$13.00

### *Triple-Pane Windows*

Through the ENERGY STAR program, EPA recognizes products that are both highly energy efficient and cost effective in terms of payback. Some manufacturers have expressed concern about the cost effectiveness of products that achieve the proposed specification levels in the Northern Zone, citing the higher cost of triple-pane windows. However, EPA notes that manufacturers can meet the proposed specification using either double- or triple-pane windows. In general, data show that double-pane windows that meet the proposed Northern Zone specification are cost effective for consumers. Feedback that EPA has received from stakeholders confirms that new glass technologies, improvements in frame performance, and/or better spacer performance can help many product lines meet the proposed Northern Zone criteria with double-pane windows.

EPA understands that triple-pane windows are inherently more costly and will result in longer payback periods, making them less cost effective for consumers. Further, including triple-pane products in this analysis would be inconsistent with how cost effectiveness is determined for other ENERGY STAR product categories. Manufacturers may choose to offer more expensive ENERGY STAR products; however, not all of the costs associated with these products are necessarily related to achieving the ENERGY STAR criteria. In the case of windows, triple-pane windows are often high-end products and, as such, may be made from premium materials or offer non-energy features that enhance their appeal and increase their cost. EPA also notes that some triple-pane products far outperform the proposed specification level in the Northern Zone. EPA has not included triple-pane products in the cost effectiveness analysis because manufacturers do not need to rely on this approach to meet the proposed Version 6.0 Northern Zone specification.

Note: In response to stakeholder inquiry, EPA has provided information about the incremental cost data for triple-pane windows that can achieve the Draft 1 U-factor in the Northern Zone in the detailed comment response document for windows.

### **Marginal Cost**

EPA typically uses the cost differential between ENERGY STAR and the Federal minimum standard when evaluating payback. However, because there is no Federal standard for windows, EPA uses the International Energy Conservation Code (IECC) as the baseline for cost effectiveness evaluation. EPA asked manufacturers to report the cost differential between their best-selling ENERGY STAR qualified window and an IECC 2009-compliant window or their next-poorer performing window. The 2009 IECC is

<sup>1</sup> Based on data provided by manufacturers, the average best-selling ENERGY STAR qualified window had a U-factor of 0.30 and an SHGC of 0.28.

the prevalent model code used in the United States, with 31 states having adopted IECC 2009 or a code with equivalent performance.

Most manufacturers that responded to EPA’s request indicated that they did not offer code windows (i.e., windows that just meet code requirements) or that they offered code windows for about the same cost as their current best-selling ENERGY STAR Version 5.0 windows. In both instances, this makes the marginal cost effectively \$0. However, to take a conservative approach, EPA excluded these data points from its original analysis. This left only one data point (\$20), which represented the incremental upgrade cost from the manufacturer’s next-poorer performing window (double-pane clear) and its best-selling ENERGY STAR window. This is the marginal cost that EPA used in its original analysis.

As noted earlier, the marginal cost is added to the incremental cost (described in the previous section) to arrive at the total cost differential between “code” and the proposed Version 6.0 specification. For the purposes of this document, this cost differential is called the “total additional cost per window.” EPA previously referred to this cost differential as “total marginal cost per window” (see Table 8 in Section 3.3.3 of the Draft 1 Report). Stakeholder comments indicated that there may have been some misinterpretation of the terms used to describe these various costs. To clarify, Table 2 outlines the incremental cost, marginal cost, and total additional cost per window for each climate zone. Note that marginal cost does not vary by climate zone because the best-selling ENERGY STAR Version 5.0 product for most manufacturers qualifies in all climate zones.

**Table 2: Incremental, Marginal, and Total Additional Costs for Each Climate Zone**

<b>Zone</b>	<b>Incremental Cost (IC) ENERGY STAR Version 5 to 6 (Draft 1)</b>	<b>Marginal Cost (MC) “Code” to ENERGY STAR Version 5</b>	<b>Total Additional Cost per Window (IC + MC)</b>
Northern	\$34.00	\$20.00	\$54.00
North-Central	\$28.00		\$48.00
South-Central	\$21.00		\$41.00
Southern	\$13.00		\$33.00

## Windows per House

The number of windows per house is calculated based on the assumptions used in the household energy savings analysis (described in the next section). For the household energy savings assumptions, EPA uses four houses with sizes based on the Residential Energy Consumption Survey (RECS) data. There are two existing houses, a one-story house with 1,700 sq. ft. and a two-story house with 2,600 sq. ft. For the new houses, EPA uses a one-story house with 1,700 sq. ft. and a two-story house with 2,800 sq. ft.

EPA assumes that window area in each house is equal to 15% of floor area (see Table 3: Calculation of Average Number of Windows per House). The total window area is divided by the area of a single window (15 sq. ft. or 3 ft. by 5 ft.) to calculate a total number of windows for each house. Averaging these results, EPA arrived at 22 windows per house.

**Table 3: Calculation of Average Number of Windows per House**

House	Floor Area (sq. ft.)	Window Area (% of Floor Area)	Window Area per House (sq. ft.)	Area per Window (sq. ft.)	Number of Windows per House
1	1,700	15%	255	15	17
2	2,600		390		26
3	1,700		255		17
4	2,800		420		28
					Average = 22

## Incremental Energy Savings

EPA calculated incremental savings for 22 cities across the four ENERGY STAR climate zones and all IECC climate zones. EPA estimated energy savings by simulating whole-house energy consumption in the RESFEN 5 software<sup>2</sup> and then replacing an entire set of windows with products at the proposed new specification levels. EPA modeled typical one- and two-story detached single-family houses for each climate zone, with some features remaining static across all climate zones. “Typical” features (listed below) used are based on IECC and Lawrence Berkeley National Laboratory (LBNL) methodologies.

- Electric heat pump or gas furnace, with central air conditioning
- Window area equal to 15% of floor area (based on RECS data) with equal orientation of windows on each wall to normalize for any differences in savings from orientation
- Electric rates based on average of 2010-2011 Energy Information Administration’s (EIA) average annual residential fuel prices for each representative state<sup>3</sup>
- Natural gas rates based on average of 2011 monthly residential data for each state<sup>4</sup>
- RESFEN 5 typical solar gain, which represents a statistically average solar gain reduction for a typical house using factors of overhang, obstructions, and interior shading

For the cost effectiveness baseline, EPA modeled clear double-pane windows (Window 311, as described in LBNL’s Window Library, for the Northern Zone). Savings were determined for existing and new construction houses, with housing shell conditions defined by RESFEN 5 for existing houses and IECC 2009 for new houses (each modified for its respective climate zone). House sizes were based on data from the 2005 RECS as outlined in Table 4: House Size Assumptions for Existing and New Homes.

**Table 4: House Size Assumptions for Existing and New Homes**

	Size
<b>Existing</b>	1700 SF (1-Story) with Slab Foundation
	2600 SF (2-Story) with Basement Foundation
<b>New</b>	1700 SF (1-Story) with Slab Foundation
	2800 SF (2-Story) with Basement Foundation

For the purposes of modeling, EPA used the criteria outlined in Table 5 below. The selected criteria mirror those modeled by LBNL for the aggregate national savings analysis as outlined in Section 3.4 of the Draft 1 Report. These simulations resulted in the annual incremental energy savings presented in Table 8 of the Draft 1 Report.

<sup>2</sup> <http://windows.lbl.gov/software/resfen/resfen.html>

<sup>3</sup> [www.eia.gov/](http://www.eia.gov/)

<sup>4</sup> Ibid.

Table 5: Draft 1 Criteria (as modeled) for each ENERGY STAR Climate Zone

ENERGY STAR Zone	City	IECC Zone	Draft 1 Criteria (as modeled)
Northern	Binghamton, NY	6	U-factor 0.27 SHGC 0.27
	Boise, ID	5	
	Boston, MA	5	
	Chicago, IL	5	
	Denver, CO	5	
	International Falls, MN	7	
	Minneapolis, MN	6	
	Missoula, MT	6	
	Pittsburgh, PA	5	
	Portland, OR	4	
North-Central	Kansas City, MO	4	U-factor 0.29 SHGC 0.27
	Lexington, KY	4	
	Washington, DC	4	
South-Central	Charlotte, NC	3	U-factor 0.31 SHGC 0.25
	Jackson, MS	3	
	Los Angeles, CA	3	
	Oklahoma City, OK	3	
	Sacramento, CA	3	
Southern	Houston, TX	2	U-factor 0.40 SHGC 0.25
	Jacksonville, FL	2	
	Miami, FL	1	
	Phoenix, AZ	2	

## Payback

Payback is calculated using the formula described in the Overview section. In summary:

$$\frac{(IC + MC) \times WPH}{IES} = \text{Payback}$$

Where  $IC$  = \$13-34 depending on climate zone (see Table 2)

$MC$  = \$20 (remains the same across the climate zones)<sup>5</sup>

$WPH$  = 22 (remains the same across the climate zones)

$IES$  = Varies depending on city

Using Binghamton, New York, as an example, the completed formula would be:

$$\frac{(\$34 + \$20) \times 22}{\$158.33} = 7.5 = \text{Payback (in years)}$$

<sup>5</sup> Most manufacturers' best-selling ENERGY STAR Version 5.0 qualifies in all climate zones.

Note that EPA chose a conservative approach by calculating simple payback, which does not include many factors that could result in shorter payback periods, such as the time value of money and the likely increase in energy costs. Estimated payback results for each city are provided in Table 8 of the Draft 1 Report.

Many stakeholders have expressed concerns about the national average payback of 13 years presented in the Draft 1 Report. Though EPA presented this national average payback to document that the proposed new specifications meet the ENERGY STAR guiding principle of achieving payback for the consumer within the lifetime of the product, EPA believes that this statistic has limited utility as a yardstick for the cost effectiveness of the proposed criteria. The 13-year national payback number is the average of the zonal payback averages, which were calculated by averaging the payback periods across the cities in each climate zone. Additionally, the 13-year national average is based on the Draft 1 criteria, which have since been revised in two climate zones. Finally, the Draft 1 Report payback periods are based on a series of conservative assumptions to ensure that payback within the lifetime of the product could be achieved in high-cost, low-savings scenarios.

## Additional Payback Analyses for the Final Draft Specification

For the Final Draft, EPA is proposing updated specifications from Draft 2 as shown in Table 6.

**Table 6: Changes from Draft 2 to Final Draft Specification for ENERGY STAR Windows**

Zone	U-Factor	SHGC
Northern	≤ 0.27	Any
Tradeoffs	= 0.28	≥ 0.32
	= 0.29	≥ 0.37
	= 0.30	≥ 0.42
North-Central	≤ 0.30 <sup>6</sup>	≤ 0.40
South-Central	≤ 0.30 <sup>7</sup>	≤ 0.25
Southern	≤ 0.40	≤ 0.25

In this section, EPA provides additional cost effectiveness analysis on the Final Draft specification being proposed. Specifically, EPA re-evaluates some of its assumptions with respect to cost, calculates payback periods for a variety of cities in all zones under the Final Draft specification, and evaluates payback periods over a range of U-factors for the Northern Zone.

### Revised Payback Analysis

In its initial analyses, EPA chose a series of very conservative assumptions to confirm that in the majority of instances (even with higher-cost products), consumers would be likely to see a return on their investment within the lifetime of the product as described in the *ENERGY STAR Products Program Strategic Visioning and Guiding Principles* document. Having confirmed that this was the case across a wide variety of scenarios, EPA has now evaluated the payback delivered by the Final Draft specification

<sup>6</sup> North-Central Zone U-factor maximum was 0.29 in the Draft 2 specification.

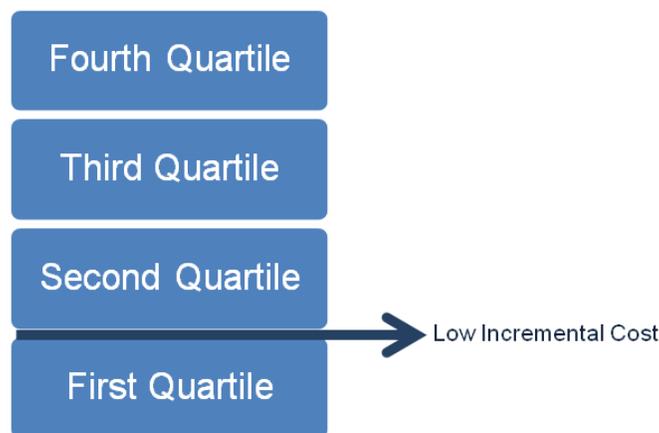
<sup>7</sup> South-Central Zone U-factor maximum was 0.31 in the Draft 2 specification.

with a focus on lower and average cost products (as is done for the other ENERGY STAR product categories).

EPA's initial approach analyzed the average (mean) of the incremental costs provided by manufacturers. Products requiring substantial, expensive upgrades to meet the criteria were averaged in with high-performing products that might require only minor modifications to meet the criteria. To evaluate the potential effect of this conservative approach, EPA revisited the original source data to calculate low incremental cost for the same changes.

To calculate low incremental cost for the dataset, EPA sorted the incremental costs from highest to lowest and then divided the dataset into fourths, or quartiles. The first quartile represents the products with the lowest incremental costs. "Low incremental cost" refers to the value between the first and second quartiles, or the median of the lower half of the data set. Figure 5 illustrates this concept. This basic statistical approach prevents potential skewing of the dataset were an average of all the values in the first quartile to be used. Due to the nature of how this statistic is determined, EPA cannot provide the specific value identified because it is tied to one product from one manufacturer.

**Figure 5: Explanation of Low Incremental Cost**



As noted in the Marginal Cost section, most manufacturers indicated no marginal cost between their current, best-selling ENERGY STAR window and their next poorer-performing window. One manufacturer indicated a cost of \$20, so EPA used this marginal cost in the original analysis to be conservative. However, it may be more accurate to consider paybacks associated with a \$10 or a \$0 marginal cost because most manufacturers with whom EPA discussed this issue (both in 2011 and more recently) indicated they had no marginal cost. EPA considered these two marginal cost options for the revised payback analysis.

To approximate low-cost products, EPA used the low incremental cost and marginal costs of \$0 and \$10. As shown in Table 7, this results in two sets of total additional costs per window. These two values were averaged together to arrive at the low-cost product approximation. To approximate average-cost products, EPA used the average incremental cost and marginal costs of \$0 and \$10. The average incremental cost is the mean of all the incremental cost data as explained in the Incremental Cost section. As shown in Table 7, this results in two sets of total additional costs per window. These two values were averaged to arrive at the average cost product approximation.

**Table 7: Approximation of Low- and Average-Cost Products**

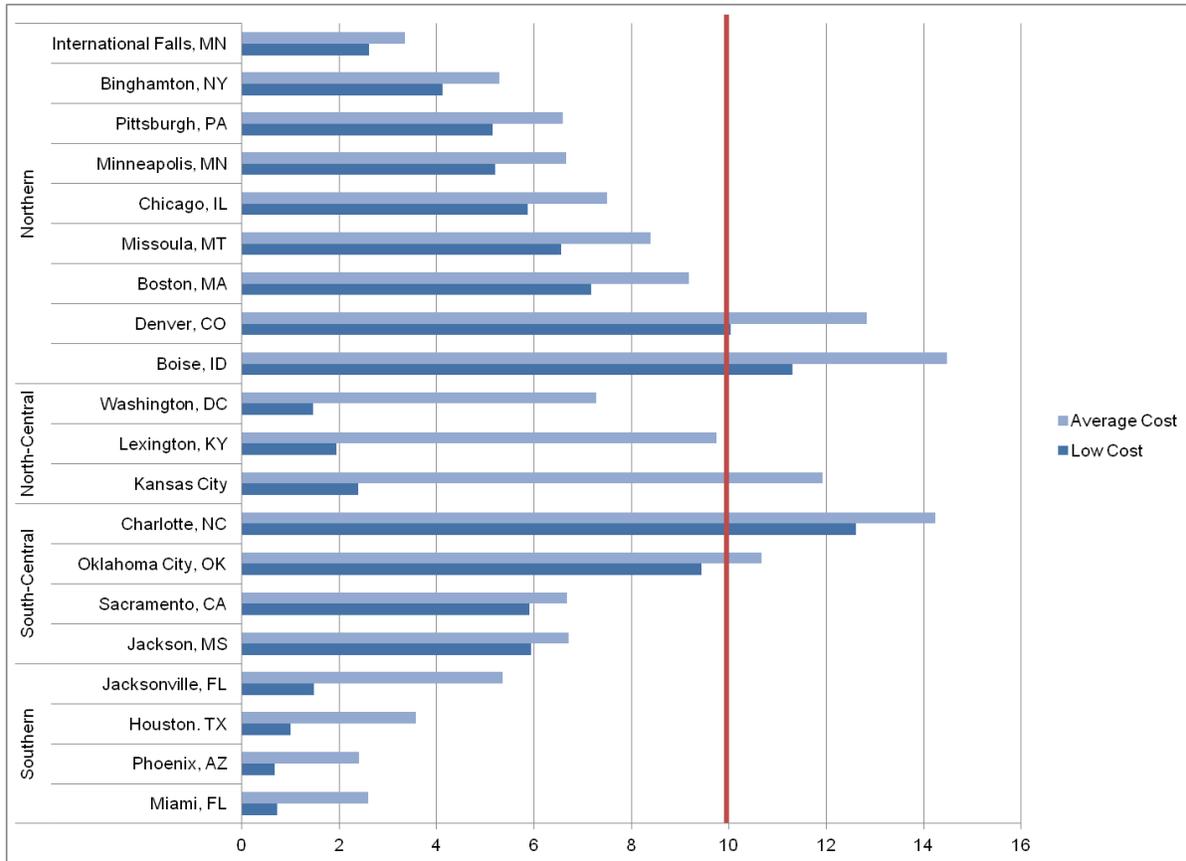
<b>Products Approximated</b>	<b>Incremental Cost (IC)</b>	<b>Marginal Cost (MC)</b>	<b>Total Additional Cost per Window (IC + MC)</b>
Low-Cost	Low	\$0	Low + \$0
	Low	\$10	Low + \$10
Average-Cost	Average	\$0	High + \$0
	Average	\$10	High + \$10

EPA then used the process outlined in the Incremental Energy Savings section to recalculate the incremental energy savings for each city<sup>8</sup> and calculated the payback period in years. Payback periods based on lower- and average-cost products are more consistent with how cost effectiveness is evaluated for other ENERGY STAR product categories.

As Figure 6 indicates, average-cost products offer payback periods of less than 10 years in all but five cities and payback periods of less than seven years in half of the cities for which EPA performed energy savings analysis. Low-cost products offer payback periods of less than 10 years in all but three cities and payback periods of less than seven years in all but five cities for which EPA performed energy savings analysis.

<sup>8</sup> Los Angeles, California, and Portland, Oregon, were excluded because low annual heating and cooling costs for those cities limit the potential for energy savings. Portland was also excluded because the Pacific Northwest has local codes that far exceed the model code for the climate and energy efficiency program sponsors offer rebates for high-performance windows in that region that will offset incremental costs.

Figure 6: Payback (in years) for Low- and Average-Cost Products Meeting the Final Draft Specification

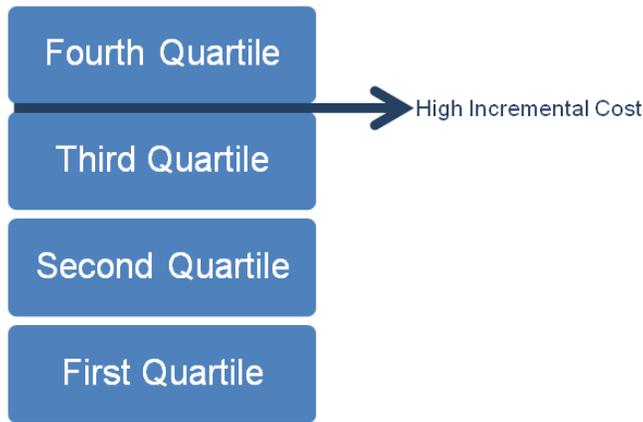


### Evaluation of Various Criteria Levels in the Northern Zone

Some stakeholders have suggested that payback periods might be shorter in the Northern Zone if the U-factor were raised, while others suggested that a lower U-factor for the Northern Zone could offer shorter payback periods. Based on this feedback, EPA performed additional payback analyses for a range of U-factors for the Northern Zone (0.25 to 0.29). EPA also considered making no change to the current U-factor maximum of 0.30 in the Northern Zone. However, making no change does not recognize the better-performing products in the market that are cost effective for consumers. Therefore, EPA did not include the U-factor level of 0.30 in this evaluation.

To evaluate the proposed criteria level in the Northern Zone against other options, EPA used the conservative marginal cost estimate (\$20) with low, average, and high incremental costs. The calculation of low incremental cost is described in the Revised Payback Analysis section. The mean incremental cost is the average of all incremental cost data points. To calculate high incremental cost for the dataset, EPA sorted the incremental costs from highest to lowest and then divided the dataset into fourths, or quartiles. The fourth quartile represents the products with the highest incremental costs. “High incremental cost” refers to the value between the third and fourth quartiles, or the median of the upper half of the data set. Figure 7 illustrates this concept. This basic statistical approach prevents potential skewing of the dataset were an average of all the values in the fourth quartile to be used. Due to the nature of how this statistic is determined, EPA cannot provide the specific value identified because it is tied to one product from one manufacturer.

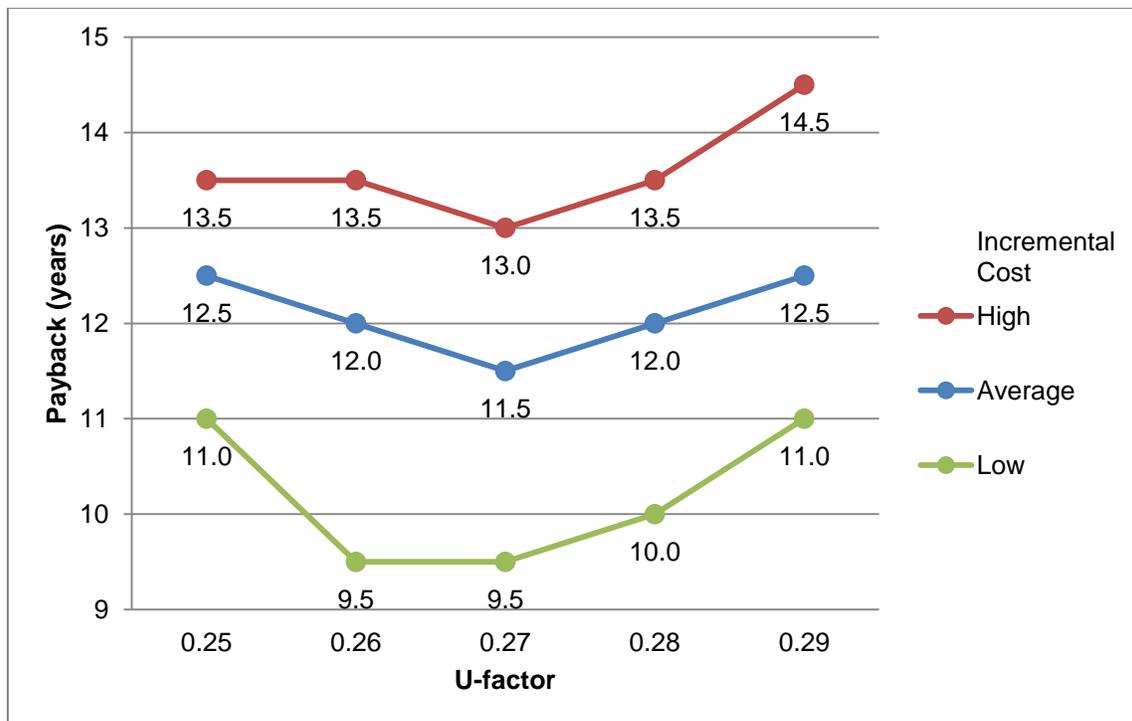
Figure 7: Explanation of High Incremental Cost



EPA then calculated the incremental energy savings for each U-factor level and each city in the Northern Zone<sup>9</sup> using the method outlined earlier in this document. The formula outlined in the Overview section was applied to each city using the expanded incremental costs and revised incremental energy savings. EPA then averaged the city paybacks to determine an average payback period for the Northern Zone for each combination of U-factor and incremental cost.

Figure 8 shows the results of this analysis. A U-factor maximum of 0.27 in the Northern Zone offers a shorter payback period than other considered U-factor criteria at any price point when using a conservative marginal cost estimate of \$20.

Figure 8: Payback for Various U-factors and Incremental Costs in the Northern Zone with \$20 Marginal Cost



<sup>9</sup> Portland, Oregon, was excluded because low annual heating and cooling costs for that city limit the potential for energy savings. Additionally, the Pacific Northwest has local codes that far exceed the model code for the climate and energy efficiency program sponsors offer rebates for high-performance windows in that region.

## Conclusion

EPA has provided this review of the cost effectiveness analysis in an effort to respond to commenter concerns expressed in response to the Draft 2 Version 6.0 specification. EPA has provided additional details and data to the extent possible where doing so does not breach the confidentiality of manufacturers' data.

EPA performed additional analysis on cities across multiple climate zones using low- and average-cost products to determine payback periods for the proposed final draft specification. This analysis shows that average-cost products offer payback periods of less than 10 years in all but five cities and payback periods of less than seven years in half of the cities for which EPA performed energy savings analysis. Low-cost products offer payback periods of less than 10 years in all but three cities and payback periods of less than seven years in all but five cities for which EPA performed energy savings analysis.

In addition, EPA evaluated payback periods for a range of U-factors in the Northern Zone. This analysis shows that, with a conservative marginal cost of \$20, a U-factor maximum of 0.27 offers better payback than other criteria levels considered by EPA or proposed by stakeholders during the most recent comment period at low, average, and high incremental price points.

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Appendix

Form used by manufacturers to compile incremental cost data.

	Performance		Primary Components								Size
	U-Factor	SHGC	Foam-Filled?	IG Type	IG Size	Glass Type 1	Glass Type 2	Glass Type 3	Gas Fill	Spacer	
Best-Selling ENERGY STAR Qualified Window											
Improvements in U-Factor	U-Factor	SHGC	Change cells below as necessary								Added cost over best-selling
Window A1	-0.01										
Window A2	-0.02										
Window A3	-0.03										
Window A4	-0.04										
Window A5	-0.05										
Window A6	-0.06										
Window A7	-0.07										
Window A8	-0.08										
Window A9	-0.09										
Window A10	-0.10										
Improvements in SHGC	U-Factor	SHGC	Change cells below as necessary								Added cost over best-selling
Window B1		0.27									
Window B2		0.26									
Window B3		0.25									
Window B4		0.24									
Window B5		0.23									
Window B6		0.22									
Window B7		0.21									
Window B8		0.20									
Window B9		0.19									
Window B10		0.18									
Window B11		0.17									
IECC 2012 Zone 2 Criteria	U-Factor	SHGC	Change cells below as necessary								
Window C1	0.40	0.25									