Energy Trust of Oregon
Windows Delphi Panel Study

Prepared for Energy Trust of Oregon

Prepared by Apex Analytics LLC

June 12, 2015

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1. Executive Summary

This report details the results of a Delphi panel study performed for Energy Trust of Oregon's high-efficiency windows measure. Energy Trust has offered incentives to residential homeowners to install higher efficiency windows since 2003, and currently offers a two-tiered incentive for installing high-efficiency windows. The primary goals of the Delphi panel were to help Energy Trust establish a baseline for the current standing of the efficient windows market, understand how the incentives have influenced the current market, and project where the market is headed over the next five years. The focus of the research was on the market for existing residential homes (i.e., not the new construction market). Since Energy Trust is considering shifting the current windows incentives toward a market transformation model (i.e. upstream incentives to manufacturers or retailers), the estimated current market share for high efficiency windows from this study can be used as the baseline (or benchmark) should Energy Trust choose to move towards this alternative approach.

The primary task associated with the Delphi study was to prepare, recruit, and administer a Delphi panel. To prepare for the study, the Apex Analytics (Apex) team reviewed previous evaluation[1] and planning reports[2] and crafted background material for the panelists to review and understand before the panel convened. To recruit experts in the windows field, the Apex team initiated contact with several known entities that provided contacts throughout the windows manufacturing, glass manufacturing, retailer, and government and national windows sectors. The various window experts were first and foremost targeted as regional players within the Pacific Northwest market, and then expanded beyond the Northwest as additional panelists were required and recruited. The Delphi panelists were recruited from October through December of 2014, and offered a financial incentive to participate. The actual panel was conducted in mid-February of 2015. Seven panelists participated.

Given the potentially national scope of the panelists and advances in webinar and survey technology, the Apex team was able to develop a platform that met the requirements of the study. The platform used an online webinar tool (Microsoft Lync), a survey tool that allowed real-time generation of results (SurveyMonkey), and a process that combined the two into a seamless presentation format to allow insights to be generated and discussed.

The key findings from the Delphi panel include the following:

- **Incentive impact on past sales of efficient windows**. Panelists believed that Energy Trust's window incentives have had a substantial impact on the windows market, pushing

[1] Energy Trust of Oregon (April 2014). *Residential Windows Market Research Report.* Portland, OR: Energy Trust. Note that while this report was published in 2014, the findings relate to the windows market in the 2013 calendar year. This report can be found in Appendix C.

[2] [2]The Energy Trust windows measure approval document (located in Appendix D).

approximately 15% of the overall windows market sales from less efficient windows (U-value > 0.30) to the higher efficiency bins (0.26–0.30) in 2013.

- **Current market share**. The current market share for windows shows continued improvement relative to the original 2013 market research estimate – panelists reported an additional 10% of the less efficient market is now believed to have shifted to the higher efficiency windows (U-value < 0.30).
- **Future market share**. Panelists also forecasted where the market is headed through 2020 (both organically, without support, and also with continued support). Panelists believed the market will continue to push market share toward the higher efficiency windows, but there will be an accelerated shift with incentives. Energy Trust support may have the potential to shift 10% of the overall market toward the higher efficiency market share. An important caveat with this finding is the potential for ENERGY STAR to shift its standards during this time frame (which would have a large impact on market share). Also related to ENERGY STAR is its Most Efficient designation for hyper-efficient windows with U-value < 0.20, which shows the market is indeed headed in this direction.
- **Incremental cost**. Only four of the seven panelists provided cost estimates, but incremental costs developed for this study were slightly higher than those estimated during the previous Energy Trust study in 2014. The Delphi baseline window cost (which used the Energy Trust-developed U-value baseline of 0.334) is $13.04/sq ft; the original Energy Trust-based estimate is $12.70/sq ft.
    - The Delphi study found the incremental cost of going from a baseline window (U-value = 0.334) to a high-efficiency window (U-value = 0.28) is $1.43/sq ft.
    - In addition, Energy Trust currently offers an incentive of $1.75/sq ft for the lower tier windows (U-value of 0.28–0.30). This incentive significantly exceeds the incremental cost originally developed for the measures (in 2013, at $1.16/sq ft) and currently developed for this study ($1.43/sq ft).
    - The most frequently cited driver for lowering high-efficiency (U-value < 0.27) window costs was Energy Trust incentives.
- **Market influence**. According to panelists, the most important factors driving the efficient windows market have been:
    - Federal tax credit of $1,500 in 2009 and 2010
    - The ENERGY STAR program and windows specifications
    - Energy Trust removing the requirement for a second weatherization measure to qualify for a windows incentive[1]
    - Energy Trust incentives and support

[1] Energy Trust used to require a second weatherization measure be done at the same time to qualify for a windows incentive (so participants had to do ceiling, wall or floor insulation or air or duct sealing, unless they could verify that all those had already been done).

- **Window quality**. One panelist introduced a new issue that appears to be affecting some of the higher efficiency windows: poor weather-stripping has resulted in testing that shows windows with U-value of 0.27 are really performing as 0.30 or higher because of the significant air leakage (potentially accounting for 50% of the homes' air leakage).

Based on the findings from the Delphi panel, the Apex team has the following recommendations:

- Consider lowering the second-tier efficiency window incentives (currently $1.75) to a value below the estimated incremental costs ($1.43).
- Energy Trust should investigate the air leakage issue further to determine if there are specific manufacturers that are responsible for this issue and to potentially avoid incentivizing these windows. Additionally, Energy Trust should consider window solar heat gain as a component of the window specifications for incentive qualification. Due to the regional climatic differences across Oregon, Energy Trust should consider offering differentiated SHGC windows incentives, since some regions may show net positive energy savings for higher heat gain windows (with low summer cooling load) while other regions would require lower heat gain windows (with higher summer cooling load more than offsetting the winter solar heat gain).
- Energy Trust should consider ongoing research to track and understand the windows market, particularly because market actors are difficult to reach for individual studies. Future research should consider setting up a panel of experts, leveraging the contacts made through this study, and pursuing additional market actors willing to share feedback and insight into the windows market. Energy Trust should also attempt to leverage existing data providers, including Ducker Worldwide, Freedonia Group, or industry trade groups like the American Architectural Manufacturers Association (AAMA), to assess the potential of including Oregon-specific questions to its biannual windows survey.
- Energy Trust has expressed interest in windows with U-value < 0.20. As noted above, ENERGY STAR has initiated a Most Efficient windows specification (started in 2013, with efficiency of U-value 0.20 or lower). Energy Trust should consider adding this measure as part of its window measures if an incentive structure and energy savings prove cost-effective. In addition, coordinating efforts with the ENERGY STAR Most Efficient measures is consistent with Energy Trust market transformation objectives.
- If Energy Trust decides to move forward with a market transformation model for high efficiency windows, the Apex team recommends having all potential partners (retailers, manufacturers) review the findings contained in this report and provide feedback and potentially adjustments to the report findings before the incentives are initiated. With more "skin in the game" partners may be more forthcoming and willing to share market related information.

MEMO

Date: June 12, 2015
To: Energy Trust Board of Directors
From: Marshall Johnson, Residential Program Manager
Erika Kociolek, Evaluation Project Manager
Phil Degens, Evaluation Manager
Subject: Staff Response to Windows Delphi Panel Study

In 2014, Energy Trust worked with an evaluation contractor to interview seven window manufacturers to obtain information about the market share and incremental cost of windows by efficiency bin for 2013. The information obtained through the study proved helpful in revising the Existing Homes program's 2015 windows incentives, which are available to residential homeowners. However, program staff are considering new approaches for promoting high-efficiency windows, which may include midstream or upstream incentives and working more closely with retailers, distributors, and manufacturers to promote high efficiency windows. These are market transformation approaches, and require market data to estimate savings and program impacts. To gather data about the current state of the windows market (specifically, efficiency levels and costs), in 2015, Energy Trust worked with Apex Analytics to convene a Delphi panel consisting of seven windows market actors and experts. Through participating in a webinar, panelists provided estimates of market share and costs of windows by efficiency level in 2015, and their expectations for the future, which could be used to estimate savings in the future.

The webinar format worked well, and proved effective. However, cost information was difficult to obtain, due to market actor reluctance to discuss proprietary information.

The evaluation contractor highlighted that the Existing Homes program's 2015 lower tier for windows ($1.75 per square foot) exceeds the incremental costs developed in the prior 2014 study ($1.16) and this study ($1.43). They recommended changing the incentive so that it does not exceed the incremental costs estimated through these two studies. Energy Trust staff believe that the cost estimates are an indicator, but are by no means perfect. In the Delphi study, panelists commented that the costs from the prior study seemed extremely low and in general, window costs are extremely variable. For the Delphi study, only four actors provided cost information and had "some" or "low" confidence in their estimates. Due to this uncertainty, Energy Trust will not revise the windows incentives for 2016.

In the future, Energy Trust may pursue other methods for obtaining reliable cost information, including having a third-party (such as Ducker) perform data collection activities or gathering quotes from contractors for a representative bundle of residential windows.

2. Introduction

Energy Trust of Oregon (Energy Trust) is an independent nonprofit organization dedicated to helping utility customers benefit from saving energy and generating renewable power. One of Energy Trust's residential offerings provides incentives to single-family residential customers for installing high-efficiency windows. In the fall of 2014, Energy Trust approached Apex Analytics (Apex) to help design and administer a Delphi panel composed of residential windows market actors and experts. The Delphi panel was proposed as an approach that could be used to establish current market penetration for efficient windows and mid-term (five-year) expectations for the windows market.

This report documents the activities and results for the Delphi panel and is organized into the following key sections:

- The Introduction covers the overall goals and objectives for this report, along with a background discussion that serves as an overview and presents details about Energy Trust's windows incentives.
- The Methodology section gives details about the Delphi panel, including panel selection, recruitment, a Web survey, and administration.
- The Findings section presents the results from the Delphi panel.
- The Conclusions and Recommendations section offers overarching highlights from the Findings section and presents actionable recommendations.

2.1 Evaluation Goals and Objectives

Energy Trust is looking to establish a market transformation model for the residential windows market, with the long-term goal of transforming the windows market by moving toward higher efficiency windows as the standard for consumers. The objective of this study is to characterize the local windows market to gain further understanding about the current market (to form a baseline) and how Energy Trust involvement may support the windows market going forward. A secondary objective is to understand how past Energy Trust efforts have affected the windows market. Although panelist feedback in answering defined questions (e.g., market share and costs) is the ultimate goal of the Delphi approach, one of the primary advantages of this approach is that it allows dialogue and engenders valuable insight surrounding these questions and estimates that would not normally be collected using a simple survey design.

The study boosts the breadth of existing Energy Trust residential windows market research. The findings may be used in further helping to establish a model that will assist in identifying barriers or exploiting opportunity to accelerate the adoption and market penetration of cost-effective and energy-efficient residential windows. Additionally, this study is being used to help understand anticipated window costs along different U-value bins, trends in fenestration energy properties and window construction, code

changes, market barriers, and intervention strategies that are needed for substantial changes to occur during the next five years. Some of the key questions that Energy Trust is interested in include the following:

- Understand the current and projected baseline
  - What might the recently studied market share look like in the absence of previous incentive support (i.e., the counterfactual)?
  - Where is the market for high-efficiency windows headed over the next few years?
  - Is Energy Trust support still needed?
  - What will the future windows market look like with and without incentives?
- Understand where window costs are projected to head in five years
- Identify barriers to large-scale consumer adoption
- Determine if it is feasible to lend support for a more aggressive efficiency standard, such as windows with a U-value of 0.20
- Identify any other potential intervention strategies that will spur substantial changes during the next five years

2.2 Background

Between 1997 and 2001, the Northwest Energy Efficiency Alliance (NEEA) helped initiate the Pacific Northwest region's high-efficiency windows efforts with a market transformation model that injected approximately $1.8 million to help drive demand for windows below a U-value of 0.35. NEEA's effort ran in parallel with ENERGY STAR's first efficient window specification of U-value 0.35, initiated between 1998 and 2001. NEEA partnered with regional utilities, window manufacturers, window dealers, the manufactured home industry, and builders across the Northwest to reduce market barriers to ENERGY STAR qualified windows. To build on this initiative, Energy Trust has been offering residential homeowners incentives for installing high-efficiency windows since 2003.

Incentives for high-efficiency windows are offered through Energy Trust's Existing Single Family, Home Performance with ENERGY STAR, and Existing Manufactured Homes programs in Oregon and Washington, along with the Existing Multifamily program (for properties with more than two units in Oregon). The overarching goal of the incentives is to accelerate the adoption and market penetration of cost-effective, energy-efficient residential windows. The specific focus of Energy Trust's windows efforts (and of this study) is on existing homes (windows installed as part of the new residential construction program are defined separately). In addition to the regional- and state-level support for efficient windows by Energy Trust and the Pacific Northwest region, there was also support at the federal level,

with EPA's ENERGY STAR leading the efforts for efficient windows. According to a NEEA long-term monitoring and tracking report (LTMT):[1]

> In 2008, NEEA shared with ENERGY STAR the findings from the 2007 LTMT report, which showed that the penetration of ENERGY STAR windows in the Northwest was nearing 100%. NEEA urged ENERGY STAR to revise the qualification for windows from a U-value of 0.35 to a U-value of 0.30. As of January 4, 2010, ENERGY STAR revised the qualification for windows accordingly. ENERGY STAR qualifications between 2010 and 2014 became 0.30 or less, or 0.31 with a solar heat gain coefficient (SHGC) >= 0.35, or 0.32 with SHGC >= 0.40.

Federal support for efficient windows did not end with ENERGY STAR, because various tax credits have been offered for the installation of high-efficiency windows. More recently, as part of the American Reinvestment and Recovery Act of 2009 (the Recovery Act) funding, the federal tax credit was significantly increased in 2009 and 2010 for efficient windows. As of June 1, 2009, only products with both a U-value and SHGC of less than or equal to 0.30 qualify for a tax credit of up to 30% of the product price, up to $1,500. With the increase in both federal and regional support for high-efficiency windows, Energy Trust believed it was time to revisit the measure and the underlying assumptions that were used for cost-effectiveness analysis for the measure. During this same time frame (from 2010 through 2014), Energy Trust offered the following incentives for windows:

- Starting in mid-2010:
  - U-value 0.23–0.30 received an incentive of $2.25/sq ft
  - U-value ≤ 0.22 received an incentive of $3.50/sq ft
- Starting in 2012:
  - U-value 0.26–0.30 received an incentive of $2.25/sq ft
  - U-value ≤ 0.25 received an incentive of $3.50/sq ft

To gather information about the windows market, Energy Trust worked with a third-party contractor to conduct a market research study that was published in 2014 (see Appendix C). The primary purpose of the study was to "inform the development of residential efficient window measure offerings for current (2015) incentives and advise updates to baseline efficiency and incremental measure cost assumptions, if needed." The study objectives were to estimate the average baseline window efficiency rating for products sold in new and existing single-family windows markets, to estimate the average incremental cost of products sold in new and existing single-family windows markets for various efficiency tiers, and to gain manufacturer perspectives on where the residential windows market is headed in the near term

[1]Adapted from Navigant Consulting (2012). *Long-Term Monitoring and Tracking Report on 2011 Activities.* http://neea.org/docs/default-source/reports/long-term-monitoring-and-tracking-report-on-2011-activities.pdf?sfvrsn=18.

(the next 1–2 years). The study interviewed 7 major window manufacturers in the Northwest windows market.

Based on the recent (2014) report for Energy Trust,[1] developed to update the market baseline:

> These [window] measure offerings were screened for cost-effectiveness in 2009 for the 2010 program year using Regional Technical Forum (RTF) assumptions regarding incremental measure cost and an assumed average market baseline efficiency of 0.35.[2] Energy Trust staff had received evidence, both anecdotal and through secondary data, that sales of U-value 0.26–0.30 windows increased rapidly when the cap on the federal tax credit for energy efficient windows was increased to $1,500 by the Recovery Act. Sales have decreased, however, since the cap on the federal tax credit for windows was reduced to $200 in 2011.[3] ENERGY STAR released a draft specification change for windows in July 2012 that showed that the market share of ENERGY STAR windows[4] had reached 81% nationally. ENERGY STAR has since postponed the specification change to January 1, 2015.

Based on findings from the 2014 Energy Trust study, the adjusted weighted average market baseline of replacement windows for existing homes (used by Energy Trust) was calculated as U-value of 0.334.

In an effort to continue pushing the high-efficiency windows market forward and stay ahead of the ENERGY STAR specifications, Energy Trust proposed to change the windows tiers at the beginning of 2015 in anticipation of expected changes to ENERGY STAR windows specifications in 2016 for the Northern climate zone (version 6.0). The effective date for the Northern Zone prescriptive criteria for windows is January 1, 2016 and Table 2-1 below lists the version 6.0 specifications planned for this date.

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[1] Energy Trust of Oregon (April 2014). *Residential Windows Market Research Report.* Portland, OR: Energy Trust.

[2] Energy Trust's 2014 window measures were screened for cost-effectiveness using RTF savings calculated from an assumed average baseline window efficiency of 0.35 and costs from Energy Trust window projects used by the RTF.

[3] http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US43F (note this link is no longer valid).
ENERGY STAR. https://www.energystar.gov/?c=tax_credits.tx_index.

[4] ENERGY STAR's current northern window specification (V5) of U-value greater than or equal to 0.30 went into effect in January 2010, and the draft V6 window specification indicated a move to a minimum efficiency rating of 0.27.
ENERGY STAR for Windows, Doors, and Skylights, Version 6.0 Draft 1 Criteria and Analysis Report (July 2012). http://windowanddoor.com/sites/windowanddoor.com/files/wdfiles_2012/Draft6_V1_Criteria_Analysis_Report-1.pdf.

Table 2-1. Expected ENERGY STAR Version 6.0 Northern Zone Specifications for 2016

U-value	SHGC
<= 0.27	Any
= 0.28	≥ 0.32
= 0.29	≥ 0.37
= 0.30	≥ 0.42

ENERGY STAR has also initiated a windows-based Most Efficient designation. The ENERGY STAR Most Efficient designation was launched in 2013, although the specifications for current (2015) northern zone appear to be the same. The 2015 Most Efficient specifications for the northern zone are windows that meet the current ENERGY STAR criteria (this was version 5 for 2013 and 2014 and is version 6 for 2015 – version 6 specifications are listed above in Table 2-1), exceed the National Fenestration Rating Council (NFRC) performance grade of 15, and have a U-value less than or equal to 0.20 and a SHGC greater or equal to 0.2.

By shifting one year ahead of ENERGY STAR, Energy Trust program staff believe they will have time to better help prepare the Pacific Northwest market for the 2016 changes. In 2015, Energy Trust offers incentives for two tiers of efficient windows[1]:

- U-value 0.28–0.30 receives an incentive of $1.75/sq ft.
- U-value ≤ 0.27 receives an incentive of $4.00/sq ft

[1] For more information please visit http://energytrust.org/residential/incentives/Weatherization/Windows1.

3. Evaluation Methodology

The primary focus of this evaluation was to design and oversee a Delphi panel of windows manufacturers and experts focused on market share and costs of high-efficiency windows. Several subtasks were required to successfully implement the panel:

- Identify, recruit, and confirm the Delphi panel
- Develop and administer a Web survey
- Conduct the Delphi panel

An initial online web survey and the actual Delphi panel tasks were the two primary data collection components associated with this evaluation study. In addition to these data collection efforts, the evaluation team also leveraged the previous 2014 study compiled by Energy Trust that contains a number of similar research questions and objectives to this study. The following sections give a more detailed discussion of the methodology used for data collection and analysis for the primary components.

3.1 Identify, Recruit, and Confirm Delphi Panel

Because the previous windows study was performed by a third-party contractor and promised complete anonymity and privacy for those manufacturers and experts that participated, Energy Trust did not have a contact list to serve as the recruitment sample to contact for participation in this study. As a result, the Apex team began by identifying and contacting potential recruits for this effort. Web searches, phone calls, research papers, and other industry contacts were all leveraged to compile a list of potential candidates. Once the list was compiled the Apex team distributed recruitment emails to potential candidates. The email included details about Energy Trust's windows incentives and the Delphi study. Panelists received an introductory memo that outlined the key attributes of the incentives and results of the recent (2014) study. Candidates were offered an incentive of $350 to participate in the study to help compensate them for their time. The team was able to recruit nine participants.

3.2 Online Web Survey

Apex developed an initial online survey (see Appendix A) for panelists. This survey included all of the planned questions for the Delphi panel. The Apex team believed that this pre-panel survey would help facilitate the actual Delphi for several reasons:

- To help initiate participant feedback
- To help expedite the administration of the panel
- To allow all panelists to start from a more common understanding of the current market
- To give those panelists who either could not attend or failed to attend during the slated time slot a voice so that their responses would count as well

A draft survey guide was prepared for review by Energy Trust Evaluation staff before the survey went live. Staff were also sent a link to test the actual online survey and provided feedback and suggestions for edits to the instrument.

3.3 Conduct Delphi Panel

The Delphi method is an interactive group or panel discussion involving a leader, or facilitator, and a group of experts, or panelists, that are brought together to develop consensus on a particular range of topics. It is an iterative process whereby the facilitator poses various questions to the panelists and asks the panelists to vote or respond to the questions. This allows a review, dialogue, and debate about the summary responses, and enables the panelists to retake the survey question or revise their original responses based on the debate. The technique is often used for forecasting (hence the Oracle of Delphi origins of the name). In the energy efficiency realm, the technique is often used to help evaluate market transformation programs because of their inherent lack of primary or even secondary market data.

For this study, panelists were asked to participate in an online group webinar, answering key research objective questions. During real-time web conferencing, the Delphi team approach was to have the panelists validate their original estimates while making adjustments and developing consensus estimates as needed. Energy Trust and Apex believed that administering the panel using real-time web conferencing would be an effective means of compiling panelist feedback while still allowing group discussions and debate related to the topics as set forth in the template. Advances in webinar and survey software enabled the Delphi team to offer a complete online panel, avoiding travel expenses, travel time, and more complicated logistics. The goal of having a completely online webinar-based Delphi was to have the experience appear seamless and convenient for panelists, but the underlying preparation and logistics behind coordinating the panel required considerable time and resources to ensure a hassle-free and robust panel experience.

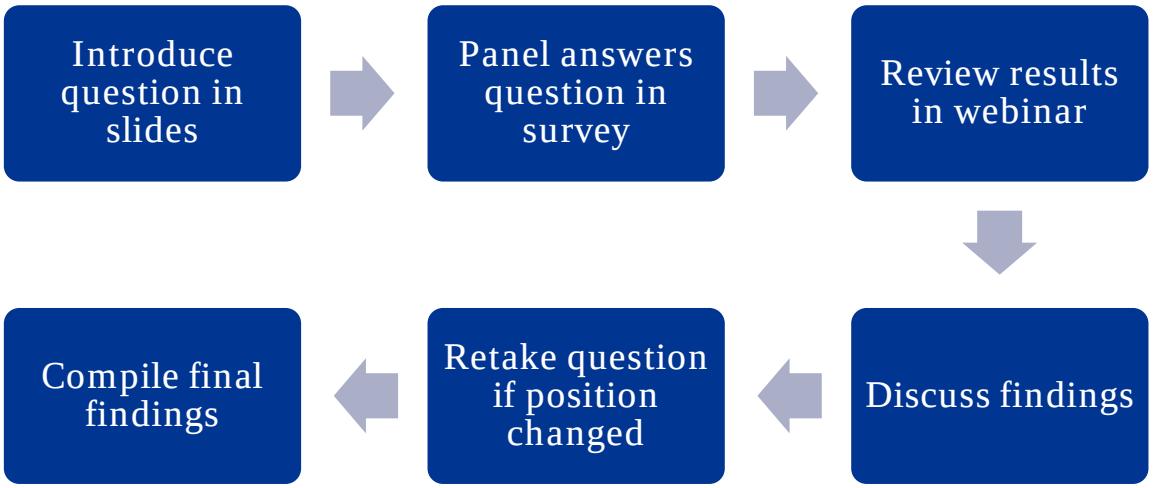
Panelists received instructions on how to connect to the webinar, as well as the survey link to take the real-time survey and the phone number to call. Panelists also received the PowerPoint presentation (see Appendix B) before the meeting as a backup in case they could not connect to the webinar or lost Internet connectivity during the panel. The Apex team decided to use Microsoft Lync webinar software. Lync is a browser-enabled webinar software that allowed the facilitators to display real-time video of them as they led the discussion, privacy settings so that panelists remained anonymous, screen sharing so that panelists could view the presentation, and a chat room that allowed panelists to submit questions as the discussion progressed.

The Apex team reviewed numerous webinar tools, with the ultimate goal of using a single platform to run the webinar and permit screen sharing while also allowing panelists to answer real-time survey questions via the same platform. Unfortunately, although most of the webinar platforms allow simple polling-based surveys (yes/no, multiple choice selection), they do not allow more advanced survey questions to be asked, which was required for this study. SurveyMonkey, an online survey tool accessible via any standard web browser, was the choice for survey administration due to the simple and professional user interface coupled

with enhanced and visually simplified real-time reporting of panelists' responses. Ultimately, the team determined that having two browser windows open would allow participants to navigate easily between the webinar screen and the survey screen (when their responses were required).

The general technique employed for this study followed the most common Delphi method, although a few customized steps were added to allow for a seamless panelist experience. To begin each question or topic, the Delphi facilitators stated and reviewed each question using the PowerPoint presentation and webinar tool and ensured that there were not any questions or concerns related to providing responses. The Delphi facilitators then requested that panelists navigate between the webinar screen and the survey screen and answer the specific survey question being asked. Results were then displayed on the facilitator's screens (webinar) and the discussion about the results of each question on the webinar screen began. Once any debate or discussion was exhausted, panelists were asked to retake the survey question if their opinions had changed during the debate. This process was then repeated for each additional question. Figure 1 presents an overview of this process.

Figure 1. Delphi Panel Question Logic



As mentioned previously, panelists received instructions on how to take the online survey before the webinar, which included a deadline for completing the survey. Although multiple reminders were distributed to the group, at the time of the survey deadline, only three participants had logged in to take the survey and only two completed the entire survey. With such a small sample size and low participation rates, the evaluation team decided, with Energy Trust approval, to move forward with the Delphi panel and not require participants to complete the survey. The team determined that the panel would allow sufficient time to review all of the questions and issues that Energy Trust wanted covered.

The Delphi panel was conducted on February 19, 2015, and initiated without any serious technical (IT, connectivity, webinar) issues. The Apex Team managed the Delphi panel and led the discussion while Energy Trust Evaluation staff attended the panel mostly as an observer (Energy Trust representatives helped answer questions about the incentives and study scope when asked). After the Delphi panel the Apex team had a follow-up call with a member of the ENERGY STAR windows group to help place the findings in context and made several attempts to connect with panelists about some of the issues introduced during the panel discussion.

Just before the meeting one participant contacted the Apex team to say that they could not attend because a shift in corporate policy prevented them from participating. This left the panel with a total of eight participants, although early into the panel the Apex team determined that one of the panelists had not called in. As a result, seven panelists ultimately participated in the session. The Apex team sent three follow-up emails offering to have a one-on-one session with the one participant that had not called in. This panelist did not return the three emails and was therefore dropped from the final panelist count, resulting in a total of seven panelists. Because of the requested anonymity of the participants, the Apex team can only disclose that those who participated were a mixture of representatives from windows manufacturers, glass manufacturers, retailers, and technology and industry experts.

4. Findings

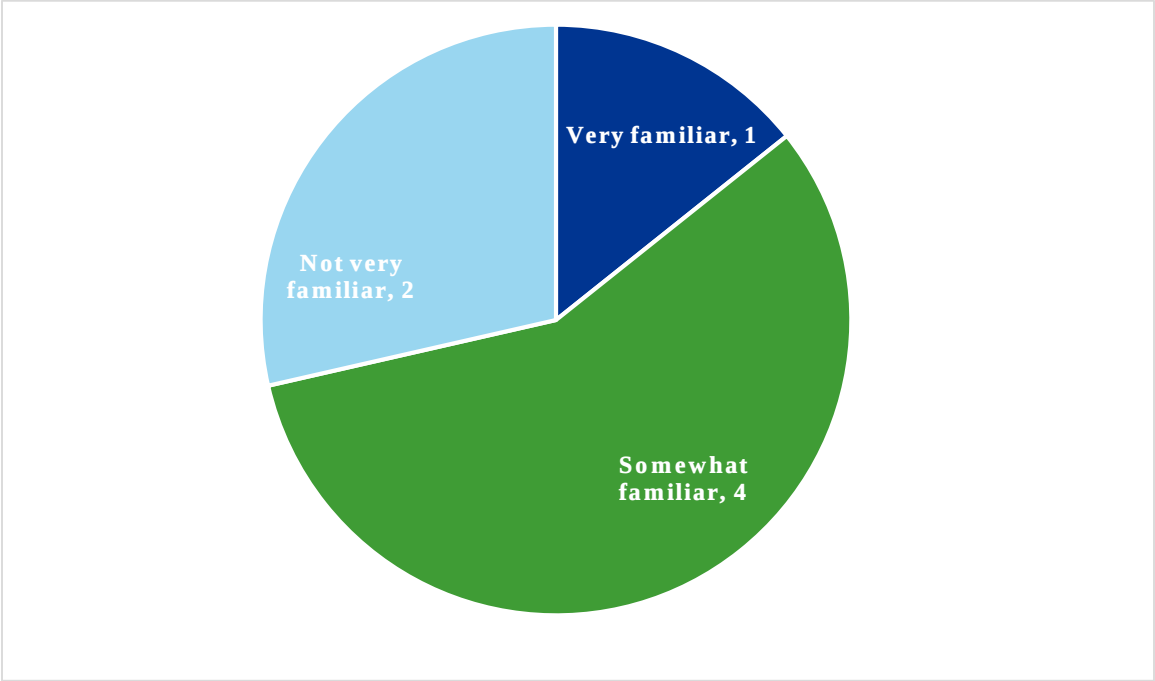
Findings from the Delphi panel are reviewed in the following section. The findings include key highlights surrounding the dialogue that developed for each topic, followed by the results of the survey question (provided in pie or bar charts), and ending with a summary of the results, coalescing the dialogue and survey response into overarching findings. The key areas reviewed in the Findings section include:

- Incentive Familiarity
- Historical Incentive Influence
- Current and Projected Market Share
- Window Costs
- New Technology

4.1 Incentive Familiarity

The Delphi panel began with a few "warm-up" questions to gauge the group's familiarity with Energy Trust's windows incentive offerings for existing homes. The majority of participants (N = 4) were somewhat familiar with the offerings (Figure 2). Two participants were not very familiar with the offerings and one panelist was very familiar. No participants indicated that they were unaware of the offerings.

Figure 2. Response to Survey Question 1: How familiar are you with Energy Trust program for residential high-efficiency windows?

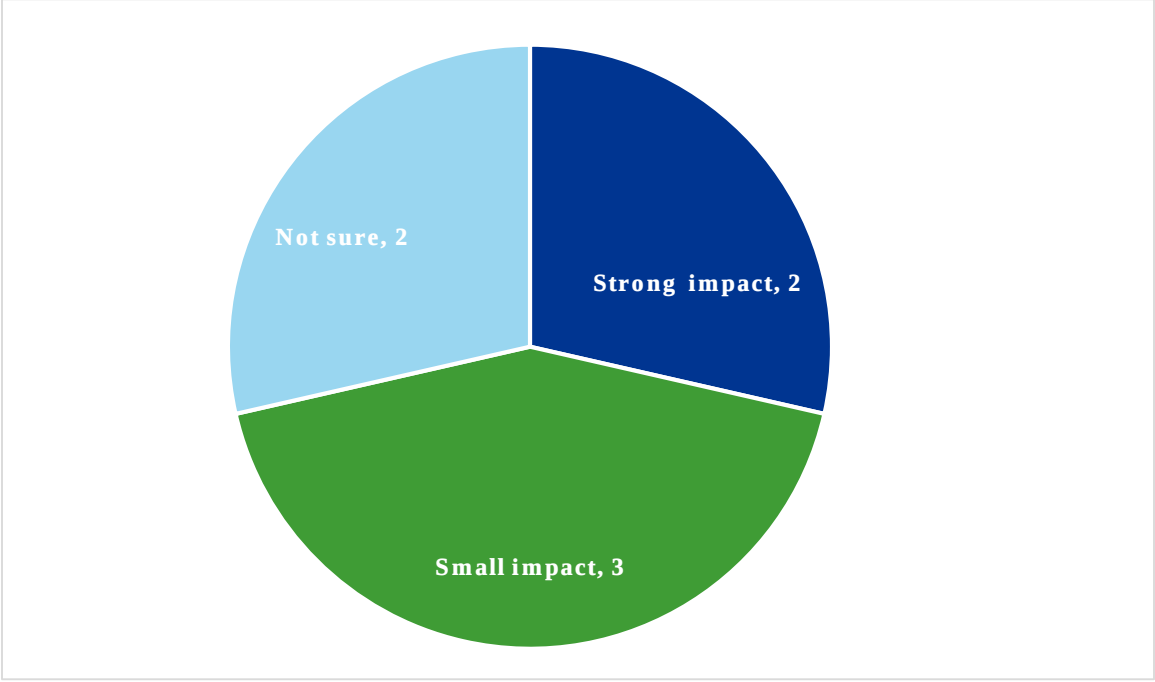


4.1.1 Historical Incentive Influence

The impact of Energy Trust's incentives on the market for efficient windows was asked in two ways: (1) employing a direct solicitation using a scale from "no impact" to "strong impact," and (2) looking at the current market share for windows and estimating the "counterfactual" market share if the incentives had not existed.

Regarding the first approach, the Delphi team asked the panelists the following: "Though the U-factors and incentive amounts have varied over time, Energy Trust has offered incentives for homeowners to install high-efficiency windows since 2003. From your perspective, would you say that the Energy Trust incentives have had an impact on the market share of high-efficiency windows in the Pacific Northwest over the past several years?" Two of the seven panelists believed that the incentives have had a strong impact on the market, three respondents thought the incentives had a small impact, and two respondents were not sure of the impact (Figure 3). None of the respondents thought that the incentives had no impact.

Figure 3. Overall Impact of Incentives on Market Share



The counterfactual program influence approach involved past (2013) incentive performance and the related high-efficiency windows market share, asking the following question:

> Please see the list below [Table 4-1] that shows the Pacific Northwest U-value market share assessment (made in 2013). Each U-value below is followed by their

corresponding estimated market share. Please provide us with what you believe the market share for U-value sales would have been if Energy Trust program support had not been offered over the past several years. Make sure to only place numeric values (no percentage should be included, 10% should be entered as 10, not 0.10).

Table 4-1. Original (2013) Market Share Estimates

U-value	Original (2013) Estimated Market Share
U > 0.35	3%
U 0.31-0.35	41%
U 0.29-0.30	46%
U 0.26-0.28	8%
U < 0.26	2%

Before the panelists started to answer the question, one of the panelists asked whether the market share should represent new construction or retrofit applications (builders versus owners as the target). The Delphi team responded that the ideal response would be for existing (retrofit/remodel) applications but understood that it is difficult enough to identify the overall market let alone the retrofit versus new construction market share; as a result, panelists could focus on the overall market. Furthermore, one panelist stated the belief that the $1,500 federal tax credit was by far the biggest stimulus to get to U-value 0.30 and below, saying that it was really responsible for jump-starting the shift to the higher efficiency windows. The other panelists agreed with this assessment and it was unanimous that the federal tax credit really drove the market to U-value 0.30 and below.

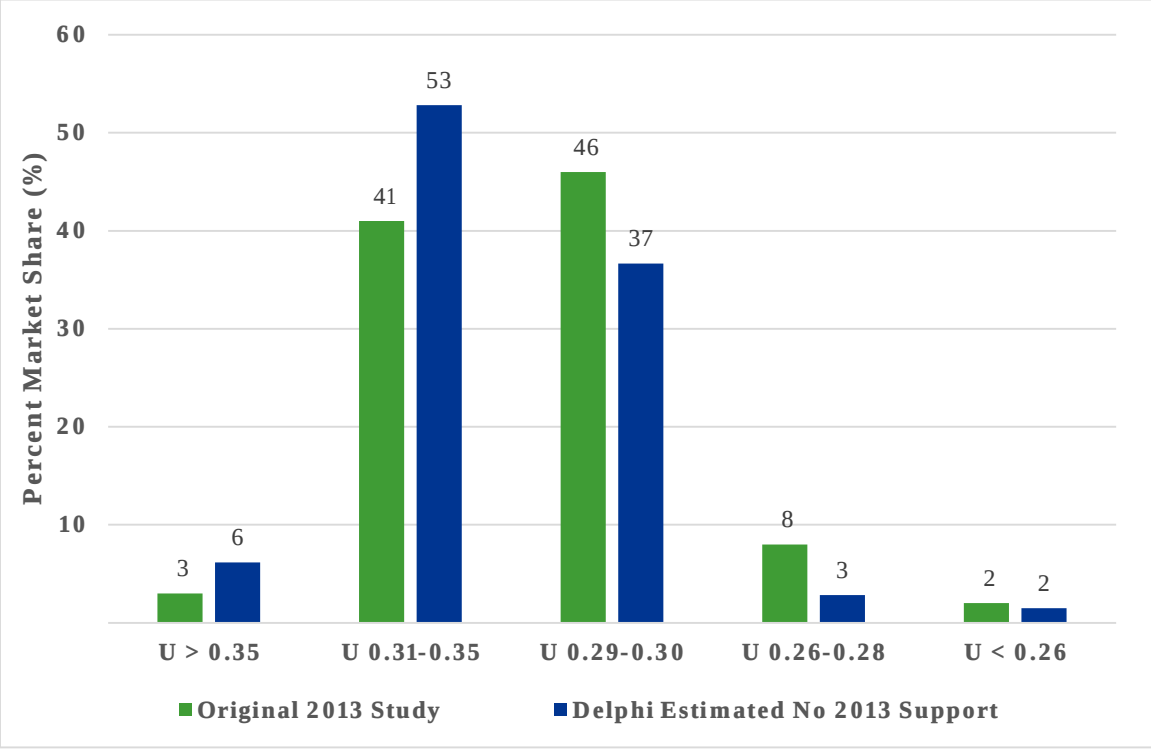
Another panelist mentioned that during the same time, Energy Trust dropped its second measure requirement for windows,[1] and that this also had a significant impact on the efficient windows market share. All panelists agreed that besides these two primary factors, Energy Trust incentives and program support for high-efficiency windows also had a positive impact on the windows market. One panelist pointed out that Energy Trust offered "continued support," and if Energy Trust had not offered the support *after* the federal credit was withdrawn, the market would have lost momentum and reverted back to the pre-tax credit market share. From this discussion, the Apex team came to the following conclusions:

[1] Energy Trust previously required a second weatherization measure to be done at the same time to qualify for a windows incentive (so a participant had to do ceiling, wall or floor insulation, or air or duct sealing, unless they could verify that all those had already been done). Energy Trust discontinued that requirement in May 2011**.** Once Energy Trust removed that requirement, the number of windows projects submitted for incentives went up dramatically.

- The federal tax credit drove the market forward and had the most significant impact on high-efficiency windows, but this support was a brief boost and without sustained support the market would have reverted back to the less efficient tiers.
- Energy Trust incentives served as the sustained support for high-efficiency windows and helped maintain demand in the high-efficiency windows market.

The results of the first question, asking what the market would have looked like in 2013 in the absence of Energy Trust incentives, are shown in Figure 4. When the results were displayed to the group, a discussion began about the various U-value groupings and their associated market share. One panelist mentioned that the high U-values (> 0.35) would not have been significantly affected because of operator type (double hung and slider) and/or frame material (wood or wood-clad). These windows are inherently higher U-value with little choice because of particular house/architecture types. This panelist believed that it would be the middle categories in which the incentives would have the most significant impact. Another panelist disagreed and believed that there are some, but more limited, options for the less efficient windows (U-value > 0.35) class. Based on the Delphi survey results, panelists agreed that Energy Trust incentives had some degree of influence on all efficiency categories.

Figure 4. Original 2013 Efficient Windows Market Share Relative to Delphi Panel Estimate Assuming No Energy Trust Incentive Support



Based on the discussion and the summary of the panelists' responses to historical market share and incentive influence, the Apex team concludes that:

- The original estimated market share (from the 2014 study) for the least efficient tier (U-value > 0.35) windows was most likely low. All panelists placed this share at approximately 6% (it was originally half that, at 3%). This estimate mirrors the Pacific Northwest non-ENERGY STAR market share of 5% that Ducker reported in 2013[1] (assuming that Ducker survey respondents mistakenly believed the cutoff for ENERGY STAR to be U-value 0.35).
- Panelists believed that the 2013 incentives had a substantial influence on the windows market, having moved the market from the lower efficiency (U-value > 0.30) bins to the higher efficiency bins (U-value 0.26–0.30): 15% of the lower efficiency market share was shifted to the higher efficiency, incentive-qualified market.
- The highest efficiency tier (U-value < 0.26) was not influenced by the incentives, and is likely represented by a highly price inelastic consumer segment that is influenced more by consumer preference and architectural requirements rather than by price.
- The impact of the 2013 incentives based on panelist feedback was to have shifted sales from an average efficiency of 0.32 to 0.31.

After establishing historical market share and incentive influence, and having received valuable feedback from the panelists about the market, the Delphi team moved the discussion to the next Delphi objective, the current and projected market share.

4.1.2 Current and Projected Market Share

The next set of Delphi questions shifted the discussion toward current (2015) and projected market share by U-value of the windows market. As noted above in section 2.2 (background), in an effort to continue pushing the high-efficiency windows market forward and stay ahead of the ENERGY STAR specifications, Energy Trust proposed to change the windows tiers at the beginning of 2015 in anticipation of expected changes to ENERGY STAR windows specifications in 2016 for the Northern climate zone (version 6.0). Therefore the remaining Delphi questions were focused on the new U-value bins and are different than those previously discussed in section 4.1.1 (historical influence). The current market share question was:

> Planned Energy Trust program support for 2015 includes incentives of $4.00/sq ft for products with a U-value of 0.27 and less, and $1.75/sq ft for products with a U-value between 0.28 and 0.30. Because the U-value bins are changing, we would like to understand where you believe the current market stands (beginning of 2015) based on these new U-value bins. The list below [Table 4-2] will help us assess recent Pacific Northwest window market share by U-value for 2015. Please provide us with your best estimate for the current 2015 Pacific Northwest market share.

[1] Ducker Worldwide (December 2014). *ENERGY STAR Window & Door Tracking Program Triple Glazing Market Assessment.* Troy, MI: Ducker.

The next Delphi questions then shifted the discussion toward the future, asking panelists about their expectations for the mid-term projections of the windows market (five years out until 2020) both with and without Energy Trust incentives:

> Given your response above to current market share, we would also like to understand where you believe market share is headed over the mid-term (the next 3 to 5 years). The list below [Table 4-2] will help us assess projected Pacific Northwest U-value-based window market share over the next several years. Please provide us with your best estimate for expected market share [for question 5: ASSUMING CONTINUED PROGRAM SUPPORT; for question 6: ASSUMING NO PROGRAM SUPPORT]. To remind you, 2015 program support includes incentives of $4.00/sq ft for products with a U-value 0.27 and less, and $1.75/sq ft for products with a U-value between 0.28 and 0.30. Please use your responses from the lists above to help guide your projections below.

Table 4-2. List of U-value bins for Panelists to Enter Estimated Market Share

U-value
U > 0.35
U 0.31-0.35
U 0.28-0.30
U 0.25-0.27
U 0.20-0.24
U < 0.20

Discussion Regarding the Current and Projected Market Share

The discussion proceeded with a panelist asking Energy Trust staff whether this question again related to the overall market. Energy Trust staff clarified that the incentives are focused on existing single-family (and small multifamily homes with fewer than four[1] units). Energy Trust also reported that the program offers different incentive structures for new homes, and these other programs are not windows-centric but are interested in the overall efficiency score of the home. In addition, Energy Trust clarified that the multifamily program is different. Given the differences in the multifamily and the new construction market, the Delphi

[1] It should be noted here that four units were originally understood to be part of the incentives but after the Delphi panel concluded, Energy Trust staff clarified it was only up to two units. The Apex team does not believe this has any impact on the estimates due to the relatively high uncertainty around the point estimates regardless coupled with the very small portion of the residential market between two and four unit housing.

team indicated that the panelists should try to focus responses on existing (remodel and retrofit) single-family homes.

Panelists agreed that it would be considerably more difficult to collect data on existing homes alone, with so many shifts in the market and types of residential construction. According to the panelists, several other factors have come into play with respect to the windows markets. These factors are very different now relative to five years ago: (1) there was a shift in residential construction (mostly attributable to the downturn in the housing market) that occurred in 2008 toward multifamily housing; and (2) there was considerably less focus on single-family specification builds and a shift more toward custom homes. Another panelist commented that new construction is really code-driven as well, with the Delphi and Energy Trust team responding that new construction is a different program with different incentives than those being investigated here. Once again, Energy Trust staff helped explain that existing home window replacement should be the focus. The Delphi team reiterated that it is understood that it can be difficult to isolate existing versus new homes for characterizing the windows market.

At this point in the discussion panelists referred to ENERGY STAR's role in the market. A panelist stated that "national figures for ENERGY STAR are quite high, with a preponderance of the ENERGY STAR cutoff (U-value = 0.30). ENERGY STAR is a driver here as well for this." A different panelist chimed in, speaking to the initial results, and stated that if the discussion is focusing only on replacement windows, the initial results (the market share by U-value) shown are a little low for the U-value 0.28–0.30 group. The panelist went on to express the belief that if the discussion is including all construction, it is fairly representative of the market as a whole. This panelist then mentioned that ENERGY STAR and the federal tax credit, coupled with Energy Trust incentives, all contributed to the high U-value 0.28-0.30 market share, though the panelist believed that the summary value being displayed in the webinar was potentially a little low. Another panelist agreed, and mentioned that many consumers end up with windows around U-value 0.30, but they add "decoratives" (i.e., grids, bars, trim, muntins), which would shift the efficiency level to U-value 0.31 or higher. This panelist went on to say that most products are indeed within the 0.29–0.31 range. The discussion concluded with a panelist stating that "with better glazing then you can easily reach 0.27, but ultimately it is the frame material that is a big driver in all of this."

Panelists were unsure of how the reported market share is calculated and asked if it is calculated by sales weighting, or is it calculated using a weighted average based on size, or just sale of everything (overall area unit sales)? A panelist stated that most windows are bought as window packages with a range of U-values across three of these U-value categories[1]. This panelist wanted to know what methodology was used previously and what will be used here. The Delphi team responded that it is indeed important that the logic used is the same and that the focus here should be on simplicity, focusing simply on the overall number of windows and using just number of units. Along similar lines, another panelist stated that the window

[1] This feedback is affirmation that many in this market have a hard time generalizing about its products. Everything is custom, there are a range of efficiency levels, and efficiency is not at the forefront of the goals of the market.

companies "don't really track the U-value sales and are not in energy business." This panelist went on to say that windows either do or do not make it into higher U-value bins, and therefore wanted to know if Energy Trust is being biased toward fixed casement and awning windows[1]. The Delphi team responded that it plans to use best metric available, which is to simply use estimates for single unit sales.

A different panelist mentioned that all manufacturers now offer a low-e argon option, and if taking into account the glass package, operator type, and material type, a very large percentage goes out with low-e and argon. This would place those units at U-value 0.30 or less (at the low-end, at U-value 0.27 or at the high-end, [including decoratives in glass] at U-value 0.32). Another panelist agreed with this statement, saying that these ranges are seen in every level, and when changing the glass, fill, and material, there will be a range in ultimate U-value efficiency. The first panelist recommended that it would be ideal to do an area-weighted average with the "efficiency bar" set in the middle between slider and grills (falling well over the efficiency specification) with fixed windows (falling well under the efficiency specification). This will produce an area-weighted average with the package of technologies. The biggest trade-offs are between glass and frame selection in dealing with windows and efficiencies. This panelist concluded that if one looks at the actual U-value of a window, the same window potentially could also have variation simply based on the NFRC rating.

At this point, the Delphi team tried to steer the conversation toward higher efficiency windows and asked specifically: What can be done to shift toward U-value 0.30 and lower? Is it more money or styles, or does money not have enough of an influence? The first panelist to speak up, responding rather quickly to this question, reported that the market shifted "overnight" from an average of U-value 0.35–0.30 directly as a result from the federal tax credit. This panelist then stated "Yes, to answer your question, money can absolutely drive the market." According to another panelist, the tax credit even helped shift big box and DIY home improvement stores to mostly stocking U-value 0.30 windows, and that the manufacturers were really following the demand. Other incentives "added fourth surface low-e; if not for Energy Trust money, there would not have been the drive to do that. If the demand isn't there then they [the manufacturers] won't offer the product." This panelist believes that Energy Trust incentives have been very valuable in driving technology, but that there is a point with technology (currently at about U-value 0.25 and below) where there are too many drawbacks relative to benefits for pushing this technology.

Another panelist introduced the market transformation aspect related to incentives. This panelist mentioned that by offering rebates, the market definitely shifts as a result, but the more important question is whether the market *remains* at the improved level. This panelist believed that it is very important to design incentives that would encourage market transformation (effectively a structural change), so that there is no reverting back to the original less-efficient market. This panelist concluded by stating that

[1] Since fixed casement and awning windows tend to be lower U-value products, they would not qualify for Energy Trust incentives, by virtue of being products with lower efficiency ratings.

anything Energy Trust can do to encourage a more permanent shift is worthwhile; otherwise, that money is wasted.

The Delphi team then shifted the conversation and asked how the industry can transition to triple-pane packages from the current double-pane packages to get to the lower U-value 0.20 efficiency. One panelist suggested that Energy Trust look into manufacturers that are currently marketing single-pane, NFRC-rated low-e storm windows that are half the cost of replacement windows in any of these categories. This panelist believed that this will definitely have an impact on the market, and that it will offer roughly the same performance of full retrofits. Another panelist brought up the European market, where there are some entire regions in which the market is triple-pane, and that nothing but cost is limiting the transition to this as well for the United States. This panelist believes that this is the critical path to higher efficiency windows and that Energy Trust can play a role. Another panelist brought up the fact that this would require a significant and costly transition for the manufacturers to attain this goal, although European attention to framing has already brought this down to U-value 0.25 and below.

To jump-start the conversation about projections, the Delphi team asked the panelists their thoughts on market share in the near future, and stated "It looks like the trend, based on your responses, is that the incentives are having an impact in pushing sales below the 0.30 value." The first panelist to speak up stated "just an observation, but I find it hard to believe that the level of incentive Energy Trust is offering wouldn't have an impact; the question in my mind is what part of the market it will cannibalize?" The Delphi panel responded by reviewing the summary statistics for this question and indicated that the results showed that the U-value 0.28-0.35 range will lose market share to the more efficient products. A new panelist spoke up and mentioned that ENERGY STAR is going to be the "proverbial bull in the china closet": if ENERGY STAR drops the U-value specification below 0.27, then these numbers (results of the survey questions) will be skewed and any shift in ENERY STAR will affect the U-value 0.25-0.27 windows market. The Delphi team stressed that the focus of the responses for this Delphi should be based on the world as we now know it, but agreed that shifts to ENERGY STAR specifications or federal building code are indeed wild cards.

As the conversation about market share projections was winding down, one panelist introduced a fairly contentious issue—potentially poor weather-stripping of some windows. This panelist argued that about 0.03 of U-value is lost with poorly sealed windows (going from a U-value 0.27 to 0.30 window). The panelist stated that these poorly manufactured windows end up being responsible for half the air leakage of the home through the weather-stripping. The panelist wanted to reiterate that the effect of air-leakage differences has the equivalent impact as the U-value differences with windows from different manufacturers that meet the same criteria. If windows have poor weather-stripping, that places the window performance back into a considerably higher U-value category. The panelist stated that certification laboratories "just test houses as they are built" and the tests show this issue to be a serious fault in the certification efforts and that "actual testing on homes did show this."

A new panelist spoke up to defend window manufacturers and stated that windows are tested and certified to meet air-leakage specifications (per North American Fenestration Standards [NAFS], NFRC requirements,

and International Energy Conservation Code [IECC] requirements) and that there are code citations for air-leakage requirements. Another panelist then reiterated that a defect in weather-stripping could mean that Energy Trust is, in effect, accepting windows that do not meet code. The Delphi team asked whether this is an issue with the quality of the actual windows or of the installation. The panelist indicated that it is not the installation but it is the window manufacturing. Another panelist believed that if this air-leakage issue is true, the standards are, in effect, "driving efficient windows products to the bottom of the barrel rather than top of the barrel." Because of time constraints (there were only 20 minutes left of the Delphi panel at this point), the Delphi team drew this discussion to a close by suggesting a follow-up discussion with individual panelists regarding the significance and prevalence of this issue.

Findings and Conclusions Regarding the Current and Projected Market Share

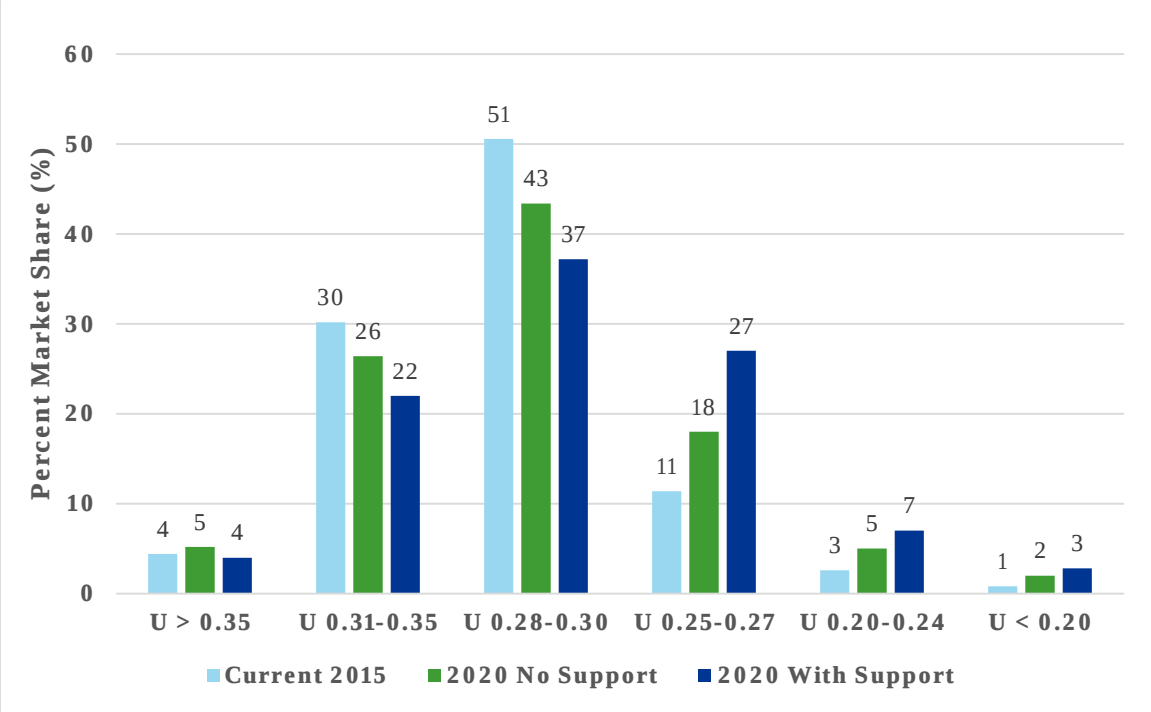
From this discussion, the Apex team came to the following conclusions:

- Summarizing and distilling the windows market into a very generalized U-value market share is very difficult, even for windows experts and market actors.
- Panelists agreed there was no doubt that Energy Trust incentive support for windows has had a positive and significant impact on the efficient windows market, helping to accelerate the shift towards higher efficiency windows.
- ENERGY STAR has had and will continue to have a major impact on the windows market, and projections reported by panelists will be irrelevant if ENERGY STAR specifications change between now and 2020.
- U-value is not the only fenestration-based driver for home efficiency – solar heat gain and air leakage are two major issues that Energy Trust should factor into their incentives.
- There are other products currently available in the market, including low-e storm windows, which panelists believe could be a cost-effective alternative for Energy Trust to consider.

The results from the current and projected market share questions, which incorporate the new Energy Trust designation of window tiers, are included in Figure 5.[1]

[1] During the initial review of the detailed results after the Delphi panel, the Apex team noticed that one panelist's responses were significantly different from the others for all of the U-value groups. This panelist provided an extremely high percentage of products sold in the highest U-value group and no products in the higher efficiency (lower U-value) groups. Because the summary statistics included only seven responses, a single outlier response had a fairly significant impact on the findings, especially on the low and high end of the U-value groupings. As a result, the Apex team decided to remove the market share responses from this respondent in the overall average reported in the figure above. If the team had retained this panelist's market share estimates, the lower and higher U-value groups would have been widely different than the validated values as reported by Ducker and ENERGY STAR.

Figure 5. Current (2015) and Projected (2020) Market Share With and Without Energy Trust Incentive Support



A few observations are included here relating to the results of these market share questions:

- The U-value 0.35 and greater windows market share are fairly static. Per feedback received during the Delphi panel, this window group will be in demand regardless of programs, incentives, and ENERGY STAR. As one panelist stated: "The high U-values (> 0.35) are not much impacted because of operator type (double hung and slider) and/or frame material (wood or wood-clad). These windows are inherently higher U-value. As a homeowner [these windows types] are what they get, with no choice because of house/architecture type."
- Incentives will primarily cannibalize the mid-range efficient windows of U-value 0.28 and greater, and will drive demand to the lower U-value 0.25–0.27 range. Even the higher efficiency U-value 0.20–0.24 range will increase with incentive support.
- Windows with U-value < 0.20 will be marginally affected by any incentive. This is constrained by technology and cost.
- The trend, regardless of incentives, is definitely shifting toward higher efficiency windows. This is partially attributable to the ENERGY STAR program. Energy Trust incentives appear to accelerate the market trend toward efficiency.
- The panelist response to market share did shift slightly between the first and second iteration of the projections (both with and without Energy Trust incentive support):
    - Panelists shifted greater market share toward the U-value 0.28-0.30 away from the higher efficiency U-value 0.25–0.27 group for the projections without support.

- Panelists shifted greater market share toward the U-value 0.28-0.30 and 0.31-0.35 groups away from the higher efficiency U-value 0.25-0.27 and 0.20–0.24 groups for the projections with support.

After establishing current and projected market share, and having received valuable feedback from the panelists about the market drivers, the Delphi team moved the discussion to the next Delphi objective, the window costs.

4.1.3 Window Costs

Estimating the incremental cost of moving toward higher efficiency windows has been extremely difficult in the past for several reasons: (1) the lack of retailer-based market data; (2) the lack of willingness to provide survey responses and their accuracy; and (3) the isolation of the value of moving between U-value groups (exclusive of other window options and features). The next set of Delphi questions asked panelists the following:

> The lists below [Table 4-3] will allow us to assess overall Pacific Northwest market share average unit retail window cost (per square foot). Can you please provide your understanding of where you believe the market now stands (2015) and where you expect the unit cost (per square foot) to shift over the next several years? First we will begin with where retail costs now stand. Next we are interested in where costs will be in 2017, and finally where they will be in 2020.

Table 4-3. List of U-value bins for Panelists to Enter Estimated Cost

U-value
U > 0.35
U 0.31-0.35
U 0.28-0.30
U 0.25-0.27
U 0.20-0.24
U < 0.20

Discussion Regarding Window Costs

The first panelist to comment noted that these costs[1] (the ones from the previous 2014 study) seem really low ($100 for a 12-sq-ft window), saying that there is no way this is right. Energy Trust staff agreed, and stated that part of the reason for conducting the Delphi panel was to get better cost estimates. The incremental costs between the U-value bins are the most important aspect of the costs. Another panelist noted that within the same product line there could be a pricing factor of three, from bottom to top of the line, so summarizing overall costs is difficult to track. The ENERGY STAR windows group member that the Apex team spoke with confirmed this, and stated that costs for the same window could be a factor of ten ($150 window on the low end to a $1,500 window on the high end)[2]. Another panelist noted that they could not respond to the cost questions because of the highly sensitive nature of product pricing and costs. Finally, another panelist noted that the combination of frame material, glazing, and operator can all have an impact on the price range, from a low of $10/sq ft up to $30/sq ft.

Ultimately only four of the seven panelists were willing and able to provide cost estimates. For the cost estimates, the Delphi facilitators asked panelists to rate their confidence level (one representing very low confidence and five representing very high confidence). Of the four who responded, three indicated being "somewhat confident" (a level of three) in their estimates; one panelist had low confidence (a level of one). In reviewing the panelist cost responses, the Apex team believes that three of the four Delphi panel members were most likely representing wholesale costs and not retail costs to the end-use consumer, because they were benchmarking their estimates against the wholesale costs provided by Apex from the prior study.

Findings and Conclusions Regarding the Window Costs

An overview of the final Delphi-based estimated incremental costs is shown in Figure 6. The largest jump in relative incremental costs occurs once the windows efficiency drops below the U-value of 0.30 (2015 estimates show only a $0.33 jump in square foot cost going from 0.35 to 0.31-0.35, but a $1.09 jump in per square foot costs from U-value of 0.31-0.35 to 0.28-0.30). Based on feedback received from conversations with a member of the ENERGY STAR windows group, coupled with the review of the results of the Delphi panel, it is clear that there is a tipping point for incremental costs in current and anticipated windows sales: this tipping point appears to be around the U-value 0.27 efficiency (which is the midway point between 0.25 and 0.30). Between U-value 0.30 and 0.25, the rate of change between U-value bin incremental costs increases significantly. An analysis of window manufacturer cost data, based on conversations with a member of the ENERGY STAR windows group, showed that payback (based on energy savings relative to incremental cost) was best around the U-value 0.27, and that anything below U-value 0.27 showed a

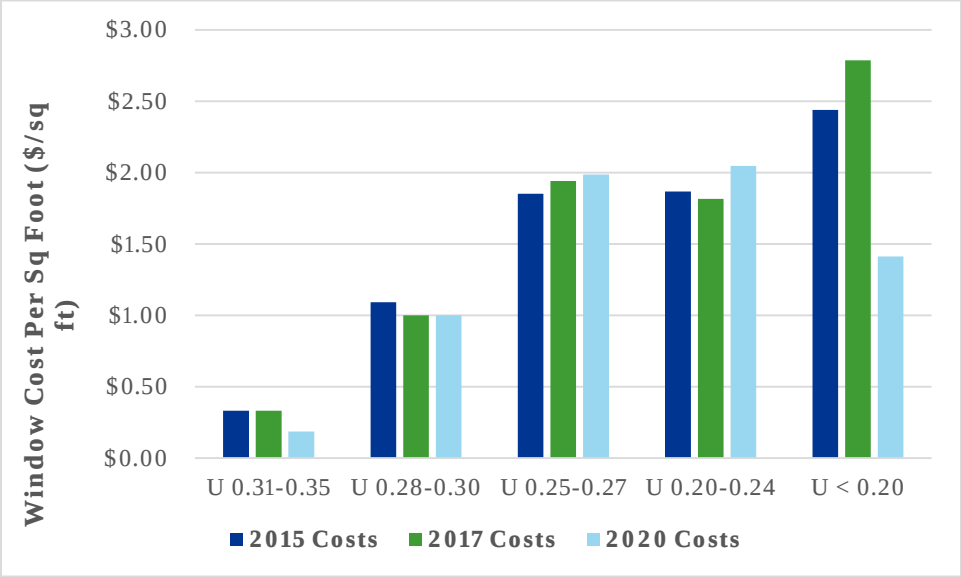
[1] Original study costs that were shown to panelists are included in Appendix C.

[2] The Apex team had a lengthy discussion with a member of the ENERGY STAR windows group after the Delphi to help place the findings in context.

relatively steep increase in cost with payback exceeding the benchmark given for windows. Another interesting finding from the incremental cost data is the U-value 0.20 group, with the information in Figure 6 highlighting panelists' belief that incremental costs for the ultra-efficient windows group will decline by 2020.

The Apex team made several cost adjustments and weighted responses to estimate the final incremental retail costs (final costs are displayed in Figure 6). First, for the three respondents who benchmarked their estimates to the wholesale price, the Apex team used the retail-to-wholesale adjustment factor developed in the Energy Trust memo approval document[1] (a 1.41 multiplier). Second, the individual responses were weighted based on the panelists' confidence levels (those with lower confidence were weighted less and those with higher confidence were weighted more). Finally, the overall adjusted and weighted estimates were compared to Energy Trust's estimates of installed cost (assuming 50% of the installed cost to be labor and installation cost). The Delphi-based baseline (using the measure approval document U-value baseline of 0.334) is therefore $13.04 per square foot, and the original measure approval document-based estimate is $12.70.

Figure 6. Current (2015) and Projected Incremental Retail Costs[2]



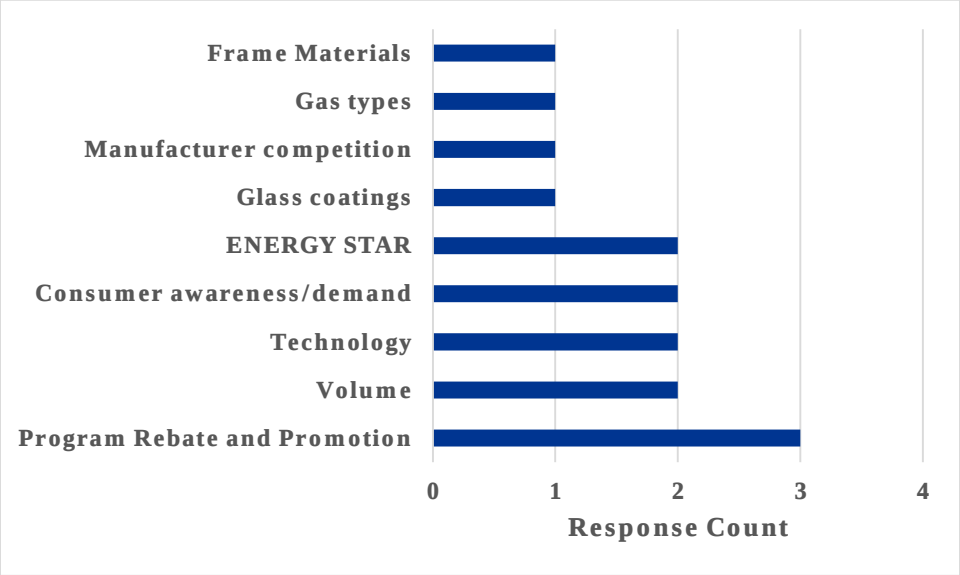
The Delphi team also asked the panelists what they believed were the three biggest drivers for a decrease in the cost of U-value 0.27 and lower windows. Since the discussion was focused around retail costs, the Delphi

[1]The Energy Trust windows measure approval document (found in Appendix D, which indicates approval of the measure) included a review of the actual installed cost of windows for incentivized projects. The analysis showed that the 25th percentile cost of an installed baseline efficiency (U-value = 0.334) window to be approximately $25. This was across all qualified window types and sizes.

[2] Note that the incremental costs displayed here are incremental between each bin, so going from 0.31-0.35 to 0.28-0.27 you would need to add the 0.31-0.35 plus .028-0.3 plus 0.25-0.27.

team assumed the panelist response were based on retail costs, so incentives would be responsible for lowering the price on the downstream side while manufacturer-based costs would drop cost on the upstream side. The most frequently cited drivers were program rebates and promotions[1], followed by ENERGY STAR, consumer awareness and demand, technology, and volume. The panelist responses are tabulated in Figure 7 and may include up to three responses per panelist.

Figure 7. Primary Drivers for High Efficiency (U-value 0.27 and Lower) Cost Reduction



A few observations are included here relating to the results of these window costs questions:

- Similar to and even more pronounced than market share, summarizing and generalizing window costs is very difficult. With so many options (window type, frame type, glass, gas, features), panelists conveyed the significant magnitude for the range of window costs.
- Some panelists questioned the cost-effectiveness once you pass the mid-range efficiency (lower than 0.28, one tends to see a significant increase in price without the associated increase in thermal comfort and energy savings).

4.1.4 New Technology

The final question of the Delphi panel touched on new technology and when panelists believed new windows technology would be commercially available at a competitive price and with more than 1% of market share. The question panelists received was:

[1] It should be noted that when the question was asked, the panel had been talking a lot about incentive influence, so respondents may have been primed to answer this question as indicated by the responses.

Please review the table of new window technologies below [Table 4-4] and provide the year when you expect them to be generally available at a competitive price and have a greater than 1% share of the market.

Table 4-4. New Technology List for Year Available

Technology
Photochromatic Glass
Electrochromatic Glass
Aerogel Insulated Glass
LED Integrated Glass
PV Integrated Glass
Other (Specify)

At this point in the Delphi panel time was running short and the Delphi team decided to have respondents provide answers to this question but move on to final thoughts, recommendations, and feedback. Due to the lack of dialogue with this section the Apex team has decided to show the findings from the question but is not able to include any discussion or feedback from the Delphi panel. The results of the final question are below in Table 4-5. Of note is that one panelist indicated both photochromatic and electrochromatic glass being either currently (2015) available or available next year (2016). All other panelists placed the timeline for these window technologies closer to 2020 (for electrochromatic) or beyond to 2025 (photochromatic). Another panelist indicated that PV glass is currently available (2015) at a competitive price. The majority of panelists placed the availability at 2020 and beyond for most of the window technologies.

Table 4-5. Expected Availability of New Window Technologies at Competitive Price and > 1% Market Share

Technology	Count of Panelists by Year Technology Available					
	2015-2019	2020	2025	2030	2050	2100
Photochromatic	1	1	3	1		1
Electrochromatic	1	4		2		
Aerogel insulate	1	1		2	2	
LED-integrated glass		1		3	2	1
PV Integrated glass	1		2	3	1	

The Apex team included an “other” category for additional technologies that panelists believed could be viable in the near-to-mid-term. Three panelists provided a response to the “other” category. Two of the three mentioned vacuum glazing and European style framing, while one panelist entered “SHGC tradeoffs” and integrated shading with insulating value.

5. Conclusions and Recommendations

There were a number of important conclusions and recommendations from the Delphi panel, as summarized below.

Study Design and Data Collection

Overall, the Delphi panel was a successful undertaking. Feedback from panelists was that it was a "great process," and that the only weakness was "figuring out the technology at first but it worked well." Strengths of the panel session included being able to administer a Delphi panel remotely, using the latest technology, which helped meet Energy Trust's policy of not paying for panelist travel and time expenses and avoid panelists having to travel and add to the inconvenience of panelist participation. The technology also allowed real-time feedback, where responses were collected and summarized immediately. The technology enabled follow-up discourse surrounding the summary responses. Allowing panelists to contribute anonymously also may have prompted some panelists to speak up and debate where they might have stayed silent in an in-person setting.

There were also several weaknesses of the panel, including lower participation rates than anticipated and identifying a date and time slot that would work for 12 people (including Apex, Energy Trust, and panelists). Although the technology was found to be a strength of the panel, the anonymity of the webinar may have allowed some participants to remain silent, and there was not the real-time, in-person pressure to contribute. This may have prevented some panelists from contributing, allowing them to listen in but not actively participate. In addition, some panelists were hesitant to share their insights or cost data because of corporate policy. Finally, two of the panelists had limited knowledge of Energy Trust's incentives.

As mentioned in the Findings section, panelists proved difficult to recruit, because of availability, corporate policy, or a lack of established relationships with both Energy Trust and Apex Analytics. Furthermore, there were panelists that were willing to participate but not able to share market share or cost data because of corporate policy.

In addition, one of the primary reasons the Delphi panel was necessary is the lack of reliable, comprehensive, and current windows market data. The lack of data is often the "Achilles heel" of market transformation programs, specifically on evaluation efforts focused on estimating incentive impacts. Without primary data availability and actual retail sales data, Energy Trust is forced to rely on more anecdotal and secondary sources of market share and cost data. A few alternative resources could be beneficial to Energy Trust and are worth contacting to assess the potential of additional research or data collection specific to the Oregon market.

Recommendation: It would be in Energy Trust's interests to develop and foster relationships and contacts with various regional windows and glass manufacturers, retailers, and other industry experts for future

reference and insight. Energy Trust should leverage the existing contacts that were made for this Delphi panel and continue efforts to establish new contacts with market actors. The goal is to increase the accessibility and availability of these actors for future incentive design changes and recommendations. Establishing and maintaining relationships is especially important should the incentive structure be shifted towards an upstream oriented market transformation type of offering.

Future research should include establishing an ongoing panel of experts, leveraging the contacts made through this study. In addition, Energy Trust should pursue additional market actors who are willing to share feedback and insight into the windows market. Energy Trust should consider reaching out to Ducker and inquiring about the cost of having Ducker perform add-on data collection items specific to the Oregon windows market (the specific report is "*ENERGY STAR Window & Door Tracking Program Triple Glazing Market Assessment*"). Another idea would be to reach out to other program administrators to assess if and how they are able to leverage market data. The document at http://www.efficientwindows.org/utilityincentiveswindows.pdf is a good place to start.

Past, Present, and Future Market Share

The Findings section showed that Energy Trust's incentives had a relatively strong influence on the market share, although a more exact attribution estimate was not part of this effort, nor can a retrospective value necessarily be generated from this study since the focus was to establish current and projected baseline which should be used to help inform current and future windows incentive offerings. Panelists indicated that the previous incentive efforts (in 2013) showed 15% of the less efficient market share in 2013 was shifted toward the efficient (incentive-qualified) market. Panelists also believe that by 2020 the highly efficient market (U-value < 0.27) will gain approximately 10% of the share because of incentives and activities (although partially at the cost of losing the U-value 0.28–0.30 market share). The results will help Energy Trust understand future efforts to quantify impact and influence in the market over the next five years. In addition, one of the underlying assumptions about the market share and cost projections in this study was that the ENERGY STAR specifications would not change between now and 2020. If the ENERGY STAR specifications do change, and are made either more or less stringent, that will have an impact on the realized efficient market share relative to what was projected in this study.

Recommendation: Energy Trust may seek to leverage the current and projected market share findings in this report to serve as the foundation for any future impact or attribution efforts. Although these values should be referred to as the baseline market conditions, changes in ENERGY STAR specifications, federal building code, economic drivers underlying the housing market, and the economy as a whole may alter the projections reported here. Furthermore, Energy Trust should be sure to track ENERGY STAR specifications and maintain contact with the ENERGY STAR windows division, which furnished feedback for this study and expanded Energy Trust's understanding of the windows market. Adjustments made to the incentives based on feedback and updates may be required if warranted.

Incremental Costs

The incremental costs were the most difficult values to develop through the Delphi panel. That was the question that resulted in the lowest response rate, either because of uncertainty surrounding costs, panelist unfamiliarity with the retail market, or corporate policy that precluded panelist response. There also appeared to be some confusion about the wholesale, retail, and incremental cost aspects of the underlying assumptions. Ultimately the Delphi team reiterated that the focus for this study on costs should be on the incremental cost difference between U-values. The incremental costs developed for this study are slightly higher than the Energy Trust findings from the previous 2014 study.

One issue that arose during the review of the Energy Trust incremental cost development from the previous study and the measure approval document was the fact that the current lower tier window incentives ($1.75) currently exceed the incremental costs ($1.16) developed in the previous study and measure approval document. The incentives also exceed the estimated incremental costs for the lower tier windows based on this study ($1.43).

Recommendation: Unless a more detailed and comprehensive data source becomes available (that includes window retail costs exclusive of the installation/labor costs), Energy Trust may choose to use the incremental costs as reported in this report for its cost-effectiveness assumptions. Energy Trust should reconsider offering an incentive that exceeds the incremental cost of the lower-tiered windows. As an alternative, Energy Trust may want to consider shifting this incentive and offering an even lower incentive for single-pane low-e storm windows (see next paragraph for details).

Other Issues for Efficient Windows

Several side discussions toward the end of the panel focused on issues outside of U-value efficiency that could have a significant impact on the overall efficiency of windows or fenestration properties of homes. One of the negative issues that was mentioned was air leakage, and the claim by one of the panelists that testing showed that some manufacturers were currently offering high-efficiency (low U-value) windows, but they are manufactured with poorly integrated weather sealing. This poor weather sealing had the effect of shifting the U-value of the window approximately by 0.03 (from U-value 0.27 to 0.30 window). On the positive side, there was also a (albeit brief) discussion on the solar heat gain, and that ENERGY STAR recognizes the trade-offs between U-value and SHGC. Another panelist mentioned that there are trends to integrate add-on systems as retrofits, with some newer options having built-in shading and insulating devices as well. Several manufacturers are currently offering single-pane, NFRC-rated, low-e storm windows that are half the cost of replacement windows in any of the U-value categories with roughly the same performance.[1] This panelist believed these products will have a significant impact on the market.

[1] Larsen (http://www.larsondoors.com/storm_windows/) and Indow (http://www.indowwindows.com/).

Recommendation: Energy Trust should investigate the alleged air-leakage issue further to assess and identify the prevalence. ENERGY STAR relies on the NFRC testing and certification for air leakage and certifies the windows based on this and other parameters. Integrating ENERGY STAR qualifications as a component of the incentives makes sense and could avoid this issue. Furthermore, if Energy Trust decides to keep the lower-tier windows measure, it may make sense to align the incentive's lower-tier windows with ENERGY STAR specifications and include the additional restrictions of higher SHGC. Finally, single-pane storm windows may in fact be a viable option or measure alternative that Energy Trust can offer for future incentive modifications.

Hyper-Efficient Windows

One of the objectives for the Delphi was related to questioning the support for windows with U-value at or below 0.20. Panelists agreed that costs for these windows are very high, with the majority of the offerings at this level of efficiency requiring triple-pane glass, which is a large component of the cost. Although cost and technology are barriers to the hyper-efficient windows market, ENERGY STAR has moved in this direction with the development of the Most Efficient designation. The ENERGY STAR Most Efficient windows must meet or exceed U-value 0.20. The ENERGY STAR partner website[1] lists the manufacturers and models that meet these strict criteria.

Recommendation: Though the market for these hyper-efficient windows is small, and barriers steep, Energy Trust should consider offering incentives to help support these windows if a cost-effective offering can be developed. Communication with members of ENERGY STAR could help move this effort forward. The hyper-efficient windows market may be the ideal candidate for upstream incentives should Energy Trust move in that direction and provided the offerings are cost-effective.

Market Transformation

Energy Trust has indicated their interest in potentially shifting the current downstream window incentives towards a more upstream or market transformation type of incentive structure. In fact, one of the primary objectives of this study was to help inform and establish a market baseline with which to benchmark current market saturation of efficient windows for future evaluation and impact efforts. The Achilles heel of market transformation programs has been the difficulty in assessing market influence mostly attributable to the lack of detailed and applicable baseline with which to understand the true impacts of the "hidden" incentives.

Recommendation: If Energy Trust decides to move forward with a market transformation model for high efficiency windows, the Team recommends having all potential partners (retailers, manufacturers) review the findings contained in this report and provide feedback and potentially adjustments to this reports findings before the incentives are initiated. With more "skin in the game" partners may be more forthcoming and willing to share market related information.

[1] https://www.energystar.gov/index.cfm?c=most_efficient.me_index.

A. Delphi Original Web-based Survey (extract from Sogo)

*** Required Information**

page 1

Thank you for taking the time to participate in this Northwest residential windows study. Your insights and feedback will help Energy Trust of Oregon refine its programs to support high-efficiency windows in the Northwest windows market. The information you provide will be kept confidential to the extent permitted by law. All responses will be reported in aggregate and individual comments will not attributed to any respondent. Please read through the following sets of questions, and should you have any questions about the survey (either technical or related to content) feel free to contact Noah Lieb at Apex Analytics at 303.590.9888 x103.

page 2

*** 1. Important notice before you begin the survey: DO NOT USE YOUR BROWSERS NAVIGATION (BACK/FORWARD) BUTTONS - ONLY USE THE SURVEY TOOL BACK BUTTON. Please enter your panelist ID that you were provided. If you misplaced or need your panelist ID please email the Apex team (Noah's email is noahl@apexanalyticsllc.com) or call Noah at 303.590.9888 ext. 103.** (Enter your answer in "X######X" format where # is number)

_____
_____

page 3

2. Q1: Are you aware that Energy Trust offers incentives for residential high-efficiency windows? (Select one option)

- ◯ Yes
- ◯ No, not aware of the program

[Display this comment only if answer to Q#2 is No, not aware of the program]

Energy Trust has offered incentives for high-efficiency windows since 2003. Energy Trust currently offers incentives for two tiers of efficient windows: - U-Value 0.26-0.30 (incentive = $2.25/sq ft) - U- Value = 0.25 (incentive =$3.50/sq ft)

3. Q1A: How familiar are you with Energy Trust program for residential high-efficiency windows? (Select one option) [Answer this question only if answer to Q#2 is Yes]

- ◯ Very familiar with the program
- ◯ Somewhat familiar with the program
- ◯ Not very familiar with the program

[Display this comment only if answer to Q#3 is Somewhat familiar with the program OR Not very familiar with the program]

Energy Trust has offered incentives for high-efficiency windows since 2003. Energy Trust currently offers incentives for two tiers of efficient windows: - U-Value 0.26-0.30 (incentive = $2.25/sq ft) - U- Value = 0.25 (incentive =$3.50/sq ft)

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4. Q2: Though the U-values and incentive amounts have varied over time, Energy Trust has offered incentives for homeowners to install high-efficiency windows since 2003. From your perspective, would you say that the Energy Trust incentives have had an impact on the market share of high-efficiency windows in the Pacific Northwest over the past several years? (Select one option)

- ◯ Yes, it has definitely had a strong impact on market share
- ◯ Yes, though it has likely had a relatively small impact on market share
- ◯ No, it has not impacted the market share of high-efficiency windows

◯ Not sure/Don't know

5. Q2A: Can you please explain why you believe Energy Trust incentives have not had an impact on the market share of high efficiency windows? [Answer this question only if answer to Q#4 is No, it has not impacted the market share of high-efficiency windows]

_____
_____

6. Q3: Please see the table below that shows the Pacific NorthWest U-value market share assessment (made in 2013). Each U-value below is followed by their corresponding estimated market share [in brackets]. Please provide us with what you believe the market share for U-value sales would have been if Energy Trust program support had not been offered over the past several years. Make sure to only place numeric values (no % should be included) and that you check the bottom row to ensure the market share sums to 100. [Answer this question only if answer to Q#4 is Yes, it has definitely had a strong impact on market share OR Yes, though it has likely had a relatively small impact on market share]

> 0.35 [3%]	____
.31-.35 [41%]	____
.29-.30 [46%]	____
.26-.28 [8%]	____
< .26 [2%]	____
Total	100

page 5

7. Q4: How important will incentives like those offered by Energy Trust be for increasing the market share of high-efficiency windows in the near term (next five years)? In 2015, Energy Trust will be offering $1.75 per square foot for U-Value 0.28 – 0.30 and $4.00 per square foot for U-Value 0.27 and lower. (Select one option)

- ◯ These type of incentives are critically important
- ◯ These incentives do have a role in helping support the market, but are not critical to increasing the market share of high-efficiency windows
- ◯ Incentives are no longer necessary to advance the market share of high-efficiency windows

8. Q4A: Can you please explain why you feel program support is no longer necessary? [Answer this question only if answer to Q#7 is Incentives are no longer necessary to advance the market share of high-efficiency windows]

_____
_____

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9. Q5: Planned Energy Trust program support for 2015 includes incentives of $4.00 per square foot for products with a U-factor of 0.27 and less, and $1.75 for products with a U-factor between 0.28 and 0.30. Because the U-value bins are changing, we would like to understand where you believe the current market stands (in 2014) based on these new U-value bins. The table below will help us assess current Pacific Northwest window market share by U-value for 2014. Please provide us with your best estimate for current 2014 Pacific Northwest market share.

> 0.35	____
0.31-0.35	____
0.28-0.30	____
0.25-0.27	____
0.20-0.24	____
< 0.20	____
Total	100

10. Q6: Given your response above to current market share, we would also like to understand where you believe market share is headed over the mid-term (the next three-to-five years). The table below will help us assess projected Pacific Northwest U-value based window market share over the

next several years. Please provide us with your best estimate for expected market share with ASSUMING NO PROGRAM SUPPORT after 2014. Use your responses from the table above to help guide your projections below.

> 0.35	____
0.31-0.35	____
0.28-0.30	____
0.25-0.27	____
0.20-0.24	____
< 0.20	____
Total	100

11. Q7: Now we would also like to know your opinion on the expected mid-term (next three-to-five years) market share ASSUMING CONTINUED PLANNED PROGRAM SUPPORT after 2014. To remind you, 2015 program support includes incentives of $4.00 per square foot for products with a U-factor of 0.27 and less, and $1.75 for products with a U-factor between 0.28 and 0.30. Please use your responses from the tables above to help guide your projections below.

> 0.35	____
0.31-0.35	____
0.28-0.30	____
0.25-0.27	____
0.20-0.24	____
< 0.20	____
Total	100

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12. Q8: What do you feel will be the strongest drivers of an increase in 0.27 or lower U-value market share over the next 5 years?

(a)

_____
_____

page 8

13. Q9: What do you feel will be the three strongest drivers of a decrease in the cost of 0.27 or lower U-value windows?

(a)

_____
_____

page 9

14. Q10: Please review the table of new window technologies below and provide when you expect them to be generally available at a competitive price and have a greater than 1% share of the market.

(a)	Photochromic (Select one option)
	○ 2015 ○ 2016 ○ 2017 ○ 2018 ○ 2019 ○ 2020 ○ By 2025 ○ Pipedream
(b)	Electrochromatic (Select one option)
	○ 2015 ○ 2016 ○ 2017 ○ 2018 ○ 2019

	○ 2020 ○ By 2025 ○ Pipedream
(c)	Aerogel insulated (Select one option)
	○ 2015 ○ 2016 ○ 2017 ○ 2018 ○ 2019 ○ 2020 ○ By 2025 ○ Pipedream
(d)	LED integrated glass (Select one option)
	○ 2015 ○ 2016 ○ 2017 ○ 2018 ○ 2019 ○ 2020 ○ By 2025 ○ Pipedream
(e)	PV integrated glass (Select one option)
	○ 2015 ○ 2016 ○ 2017 ○ 2018 ○ 2019 ○ 2020 ○ By 2025 ○ Pipedream

15. Q11: Are there any other technologies not listed above that you feel should be included (especially to reach the U-value of 0.20)? We are interested in technologies aside from fourth surface double pane or triple pane. Please include the year that you expect technology to be viable.

_____
_____

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16. Q12: Are there any other comments or relevant market details that you would like to share with us that we can bring up as a discussion topic during the Delphi panel discussion?

_____
_____

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The next step in this process will be to inform us of your availability to schedule the Delphi panel discussion. Please indicate the date/times that you are available out of the available slots below (NOTE: time below is PACIFIC (PST)) and we will follow-up with you regarding the final date and time for the Delphi panel. As a reminder, please review the materials that have been provided to you and be prepared for a lively discussion about the windows market!

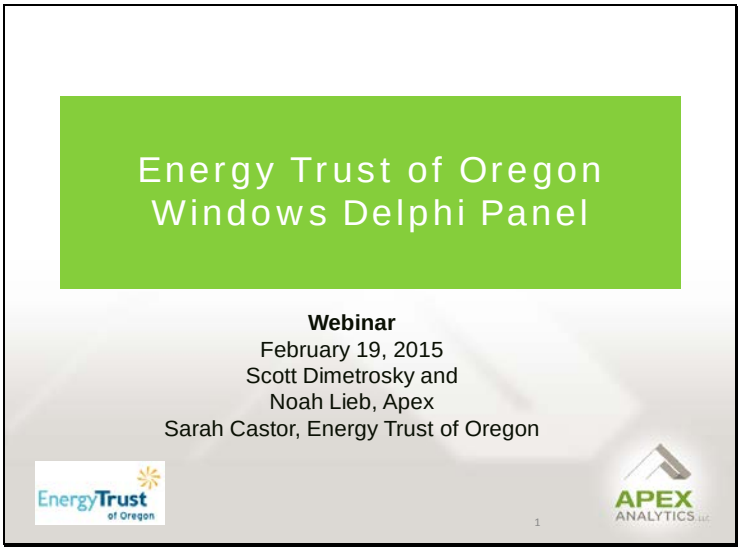
17. Morning Session

	9:00 AM	10:00 AM	11:00 AM
(a) Mon Dec 8	☐	☐	☐
(b) Tues Dec 9	☐	☐	☐
(c) Wed Dec 10	☐	☐	☐
(d) Thurs Dec 11	☐	☐	☐
(e) Fri Dec 12	☐	☐	☐
(f) Mon Dec 15	☐	☐	☐
(g) Tues Dec 16	☐	☐	☐
(h) Wed Dec 17	☐	☐	☐
(i) Thurs Dec 18	☐	☐	☐
(j) Fri Dec 19	☐	☐	☐

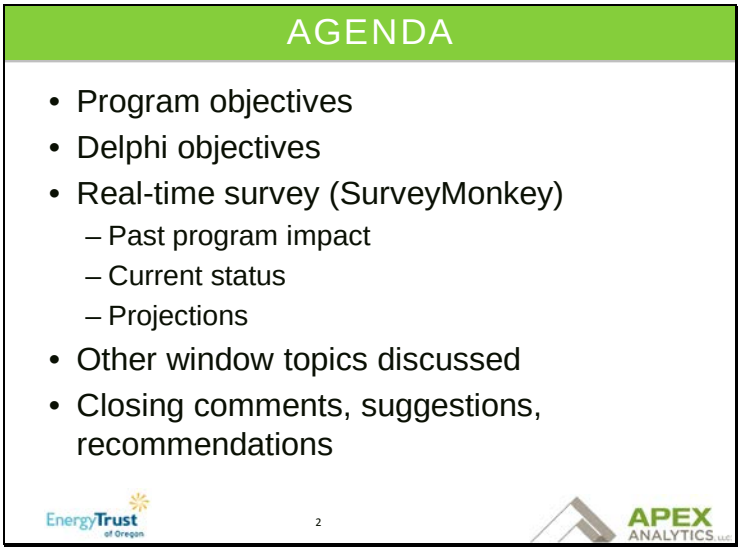
18. Afternoon Session	1:00 PM	2:00 PM	3:00 PM
(a) Mon Dec 8	☐	☐	☐
(b) Tues Dec 9	☐	☐	☐
(c) Wed Dec 10	☐	☐	☐
(d) Thurs Dec 11	☐	☐	☐
(e) Fri Dec 12	☐	☐	☐
(f) Mon Dec 15	☐	☐	☐
(g) Tues Dec 16	☐	☐	☐
(h) Wed Dec 17	☐	☐	☐
(i) Thurs Dec 18	☐	☐	☐
(j) Fri Dec 19	☐	☐	☐

B. Delphi Panel Presentation

Slide 1



Slide 2



Slide 3

PROGRAM OBJECTIVES

- Accelerate the adoption and market penetration of cost-effective and energy efficient residential windows
- Focus on existing buildings
- Explore opportunities

EnergyTrust of Oregon

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APEX ANALYTICS, LLC

Slide 4

DELPHI OBJECTIVES

- Understand current and projected baseline
  - What might the recently studied market share look like in absence of prior program support? (i.e., the counterfactual)
  - Where is the market for high-efficiency windows headed over next few years?
  - Is program support still needed?
  - What will the future windows market look like with and without program support?
- Develop incremental costs
- Identify barriers
- Is it feasible to lend program support for a more aggressive efficiency standard, such as windows with a U-Factor of 0.20?

EnergyTrust of Oregon

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APEX ANALYTICS, LLC

Slide 5

HOW WILL THIS WORK?

- Review each question here in presentation / webinar
- Navigate between this webinar screen and the survey screen
- Answer individual survey question
- Discuss the results of each question in webinar screen
- Retake survey question after discussion
- Rinse and repeat

EnergyTrust of Oregon 5 APEX ANALYTICS, LLC

Slide 6

QUESTIONS ONE & TWO

- "Warm-up questions"
- Simple questions to understand familiarity with ETO windows program and impacts on efficient window market share
- Allows us to work out any kinks to this process

EnergyTrust of Oregon 6 APEX ANALYTICS, LLC

Slide 7

QUESTION THREE

U-Factor Tier	Relative Market
> 0.35	3%
.33 to .35	26%
.31 to .32	15%
.29 to .30	46%
.26 to .28	8%
< .26	2%

Please see the list below that shows the Pacific Northwest U-factor market share assessment (made in 2013). Each U-factor below is followed by their corresponding estimated market share [in brackets]. Please provide us with what you believe the market share for U-factor sales would have been if Energy Trust program support had not been offered over the past several years. Make sure to only place numeric values (no % should be included, 10% should be entered as 10, not 0.10).

EnergyTrust of Oregon

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APEX ANALYTICS, LLC

Slide 8

QUESTION FOUR

Planned Energy Trust program support for 2015 includes incentives of $4.00 per square foot for products with a U-factor of 0.27 and less, and $1.75 for products with a U-factor between 0.28 and 0.30. Because the U-factor bins are changing, we would like to understand where you believe the current market stands (beginning of 2015) based on these new U-factor bins. The list below will help us assess recent Pacific Northwest window market share by U-factor for 2015. Please provide us with your best estimate for current 2015 Pacific Northwest market share.

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APEX ANALYTICS, LLC

Slide 9

QUESTION FIVE & SIX

Given your response above to current market share, we would also like to understand where you believe market share is headed over the mid-term (the next three-to-five years). The list below will help us assess projected Pacific Northwest U-factor based window market share over the next several years. Please provide us with your best estimate for expected market share with ASSUMING (WITH/WITHOUT) PROGRAM SUPPORT after 2014. Use your responses from the table above to help guide your projections below.

EnergyTrust of Oregon 9 APEX ANALYTICS, LLC

Slide 10

QUESTIONS SEVEN → ELEVEN

The lists below will allow us to assess overall Pacific Northwest market share average retail unit window cost (per square foot). Can you please provide your understanding of where you believe the market now stands (2015) and where you expect the unit cost (per square foot) to shift over the next several years? First we will begin with where retail costs now stand.

- Next we would like your expectation for where retail costs will be in two years, in 2017?
- Finally, we would like your expectation for where retail costs will be by 2020?

What do you feel will be the three strongest drivers of a decrease in the cost of 0.27 or lower U-factor windows?

On a scale from 1 to 5, where 1 is very low confidence and 5 is high confidence, how much confidence do you place on these cost estimates?

EnergyTrust of Oregon 10 APEX ANALYTICS, LLC

Slide 11

QUESTIONS SEVEN → ELEVEN

U-Factor Tier	Market Share Weighted Average Cost ($)
> 0.35	$7.94
.33 to .35	$8.21
.31 to .32	$8.68
.29 to .30	$9.00
.26 to .28	$9.59
< .26	$11.31

EnergyTrust of Oregon 11 APEX ANALYTICS, LLC

Slide 12

QUESTION TWELVE

Please review the list of new window technologies below and provide when you expect them to be generally available at a competitive price and have a greater than 1% share of the market

EnergyTrust of Oregon 12 APEX ANALYTICS, LLC

Slide 13

OTHER WINDOW TOPICS DISCUSSED

- What other emerging technologies might window manufacturers utilize in the future to provide a more robust and cost effective product offering, especially to reach the U-factor of 0.20? We are interested in technologies aside from fourth surface double pane or triple pane?
- Is it feasible to lend program support for a more aggressive efficiency standard, such as windows with a U-factor of 0.20?
- Barriers and opportunities?

EnergyTrust of Oregon 13 APEX ANALYTICS, LLC

Slide 14

RECOMMENDATIONS

- Please provide recommendations, feedback, comments
- Checks will be in mail – please email Noah with address

EnergyTrust of Oregon 14 APEX ANALYTICS, LLC

Slide 15

CONTACT INFO

- Apex Phone
  - 303.590.9888
- Scott Dimetrosky (x101)
  - scottd@apexanalyticsllc.com
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  - noahl@apexanalyticsll.com
- Sarah Castor (503.445.7619)
  - sarah.castor@energytrust.org

EnergyTrust of Oregon

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APEX ANALYTICS, LLC

C. Previous Windows Report

Residential Windows

Market Research Report

Prepared by:
Adam Shick
Energy Trust of Oregon

In collaboration with:
Paul Sklar, Energy Trust of Oregon
Gary Curtis Consulting, LLC

April 18th, 2014

Introduction

This report summarizes research findings from window manufacturer interviews that were conducted from October – November 2013 by an independent contractor for the Energy Trust of Oregon (ETO). The contractor was hired to perform market research on the residential windows market in the Northwest. Due to problems unrelated to the Energy Trust contract, the final report summarizing research findings was not completed by the contractor. However, the contractor provided sufficient information for Energy Trust staff to develop a research report. As a result, the research findings presented here reflect the primary research (interviews) conducted by the independent contractor and response interpretation and summarization completed by Paul Sklar and Adam Shick, members of ETO's planning staff. This report documents the research project's goals, methods, findings, and additionally its shortcomings.

Background

Energy Trust currently offers incentives for two 'tiers' of efficient windows[1];

- U-Value 0.26-0.30 (incentive = $2.25/sq ft)
- U- Value ≤ 0.25 (incentive =$3.50/sq ft)

These measure offerings, which will remain active throughout 2014, were screened for cost effectiveness in 2009 for the 2010 program year using Regional Technical Forum (RTF) assumptions regarding incremental measure cost and an assumed average market baseline efficiency of 0.35[2]. The primary purpose of this report is to review these assumptions for continued relevance and update them if needed. Prior to and consecutive with this research, Energy Trust staff has received evidence, both anecdotal and through market actors, that sales of 0.26-0.30 windows increased rapidly when the cap on the federal tax credit for energy efficient windows was increased to $1,500 by the American Recovery and Reinvestment Act of 2009, but have been seen to decrease since the cap on the federal tax credit for windows was reduced to $200 in 2011[3]. One such market actor, ENERGY STAR, released a draft specification change for windows in July 2012 which showed that the market share of ENERGY STAR

[1] For more information please visit http://energytrust.org/residential/incentives/Weatherization/Windows1

[2] Energy Trust's 2014 window measures were screened for cost-effectiveness using RTF savings calculated from an assumed average baseline window efficiency of 0.35 and costs from ETO window projects used by the RTF.

[3] http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US43F
https://www.energystar.gov/?c=tax_credits.tx_index

windows[1] has reached 81% nationally. ENERGY STAR has since postponed the specification change to January 1st, 2015, but even with this delay, the planned revision indicates a need to review of ETO's baseline assumptions.

To better inform our understanding of the market baseline, ETO engaged the services of Gary Curtis (contractor), an independent contractor and well-known Northwest US windows market expert, in the fall of 2013 to collect primary research data on window sales by efficiency level (U-value), average incremental cost, and availability of residential windows for the new and existing homes markets[2]. The contractor was at the time beginning work on separate but related windows market research on behalf by NEEA. Consequently, ETO was able to add additional research questions onto the interview questionnaire developed by NEEA that were expected to provide answers to ETO's market research questions.

Goals and Objectives

The primary purpose of Energy Trust's market research was to inform the development of residential efficient window measure offerings for 2015 programs and advise updates to baseline efficiency and incremental measure cost assumptions, if needed.

The research project's objectives were to;

- Interview 12-15 major window manufacturers in the Northwest region windows market
- Estimate the average baseline window efficiency rating for products sold in new and existing single-family windows markets
- Estimate the average incremental cost of products sold in new and existing single-family windows markets for various efficiency tiers
- Gain manufacturer perspectives regarding where the residential windows market is headed in the near term (the next 1-2 years)

[1] ENERGY STAR's current northern window specification of U-value greater than or equal to 0.30 went into effect Jan. 2010, and the draft V6 window spec indicated a move to a minimum efficiency rating of 0.27; http://windowanddoor.com/sites/windowanddoor.com/files/wdfiles_2012/Draft6_V1_Criteria_Analysis_Report-1.pdf

[2] Manufacturer data provided by the contractor did not provide adequate information to separate the new and existing homes window markets

Methods

ETO relied on primary data collection, conducted by an independent contractor, for the windows market assessment. The contractor attempted to interview as many window manufacturers as possible so that interview data could represent as large a portion of the market as we could access. The window manufacturers that were approached for interviews and the persons contacted for those interviews were determined at the sole discretion of the contractor, since the contractor's industry connections and relationships, in addition to an assurance of confidentiality, were the primary factor in the window manufacturer's agreement to participate in this research project.

An interview guide was developed by the contractor and a subcontractor (Kelly Whitty), with input, suggestions, and review by ETO staff and Charlie Stephens at NEEA. The final interview guide contains primarily quantitative research questions, and is shown in Appendix 2 of this report.

The interview questions for ETO's research objectives asked each manufacturer to describe the percent of total windows sales and the average incremental cost of windows in each of the following U-value efficiency rating tiers[1];

- ≥ 0.35
- 0.33 to 0.35
- 0.31 to 0.32
- 0.29 to 0.30
- 0.26 to 0.28
- ≤ 0.25

Manufacturers also provided self-reported data on their overall market share in the Northwest and in Oregon, which were used for weighting manufacturer responses and calculating the (weighted) average baseline efficiency in the market. Manufacturers lastly provided information about the availability and variety of operator types in each of the efficiency tiers shown above.

Manufacturer interviews were conducted over the phone from October-November 2013, but since responses to some interview questions required manufacturers to perform calculations and/or gather sales data, those questions were sent to the manufacturers prior to the telephone interviews to allow adequate time for necessary calculations and/or data collection. Such responses were collected using electronic versions of the interview guide.

[1] Manufacturers were asked to answer for the last 12 months, Q3-2012 through Q3-2013

Responses collected during the telephone interviews were recorded on paper by the contractor then entered in a summary spreadsheet for further analysis. This manual data entry step underwent QC by Energy Trust staff. Interview responses without attribution to the individual or specific distributor are provided in Appendix 1.

The contractor completed interviews with seven major window manufacturers operating in the Northwest from October to November 2013 that represented 74.5% of the total window sales in the regional windows market. Although the research plan called for 12-15 manufacturer interviews, repeated follow-up communications and requests for interviews were unfortunately not effective in increasing manufacturer participation in the research project.

Findings

Energy Trust was provided with self-reported manufacturer interview data by the contractor which covered the overall market share, percent of windows sales by efficiency category, and incremental cost by efficiency category, for each manufacturer. These data were then used by ETO staff to calculate market share weighted average; (1) incremental costs by efficiency category, (2) relative market share by efficiency category, and (3) the overall baseline efficiency in the market.

Since all seven window manufacturers interviewed were either unable to provide more granular market share data for sales in Oregon only, or indicated that sales patterns in Oregon were consistent with the rest of the region, the above calculations were performed for the regional market only.

Relative market share for each efficiency category is shown below in Table 1, and is calculated for any efficiency category *k* as;

$$\frac{\sum_{j=1}^{7} Market\ Share_j * Pecent\ of\ Sales_{jk}}{\sum_{j=1}^{7} Market\ Share_j}$$

Where *j* is the index of interviewed manufacturers

Table 1: Percent of Sales by Efficiency Tier

U-Value Tier	Relative Market Share
> 0.35	2.78%
.33 to .35	26.25%
.31 to .32	15.05%
.29 to .30	45.87%
.26 to .28	7.91%
.25 or lower	2.15%
Total	**100.00%**

As shown above in Table 1, nearly 56 percent of total sales for interviewed manufacturers are at or below a U-value of 0.30. Additionally, the highest volume of sales across all manufacturers interviewed occurred for windows with a U-value between 0.29 and 0.30, representing 45.87% of total sales for interviewed manufacturers.

In order to calculate the overall baseline efficiency in the market, Energy Trust staff made the following assumptions about the average energy performance of each efficiency tier;

Table 2: Assumed Average U-Value by Efficiency Tier

U-Value Tier	Assumed Performance
> 0.35	0.35
.33 to .35	0.34
.31 to .32	0.32
.29 to .30	0.30
.26 to .28	0.27
.25 or lower	0.25

The overall average baseline efficiency in the interviewed market is then equal to **0.311**, and is calculated as;

$$\sum_{k=1}^{6} Realtive\ Market\ Share_k * Assumed\ Performance_k$$

Where *k* represents the six U-value efficiency tiers defined in Tables 1 and 2

In addition to sales by efficiency tier, manufacturers were also asked to provide information on the incremental cost of their residential window products, by efficiency tier. Due to the

sensitive nature of cost information, relatively fewer manufacturers were willing to provide incremental cost data compared to those willing to provide data on sales by efficiency tier[1]. Additionally, these incremental cost data provided by manufacturers reflect costs to dealers, not to the final customer, and so it is not immediately clear how reported incremental costs compare to the incremental cost faced by the consumer at the time of purchase without further research. These data will serve primarily as a point of comparison for more extensive incremental cost research that will be used to inform cost-effectiveness testing and measure development for ETO's 2015 window offering(s).

The table below describes the market-share weighted average incremental cost of windows for the 67% of the Northwest windows market for which cost data was collected;

Table 2: Incremental Cost by Efficiency Tier*

U-Factor Tier	Market Share Weighted Average Incremental Cost
> 0.35**	$ 7.94
.33 to .35	$ 0.27
.31 to .32	$ 0.47
.29 to .30	$ 0.32
.26 to .28	$ 0.59
.25 or lower	$ 1.72
Weighted Average > 0.35	**$ 0.37**

* Incremental cost is measured as the difference in cost compared to the next most efficient tier of windows

** Full cost shown, not incremental cost

Lastly, window manufacturers were asked to provide information about the availability of high efficiency windows in the Northwest windows market. Interview responses indicate that the lowest window U-Value available from interviewed manufacturers, regardless of cost, is 0.20, and two of seven manufacturers reported having no window offerings with a U-value better than 0.26;

[1] Manufacturers who provided incremental cost data represented 66.5% of sales in the Northwest windows market

Table 3: Manufacturer Responses- Availability of Windows

Manufacturer	Lowest Available U-Value (Regardless of Cost)	Lowest Available U-Value (Low Incremental Cost)
1	0.26	0.28
2	0.24	0.26
3	0.20	0.29
4	0.24	0.24
5	0.26	0.25
6	0.22	0.24

Research Limitations

The research and findings presented in this paper represent the best available information that Energy Trust was able to obtain within the necessary time frame. Substantive efforts were taken by both the contractor and ETO to achieve reliable and intelligible manufacturer interview data. However, ETO also feels that it is important to acknowledge the limitations and weaknesses of the research, so that the validity of the findings presented here can be better understood.

The most significant limitation of the interview data collected by the contractor is that they are 'self-reported' by the manufacturer, and so a range of potential response biases are introduced by this data collection methodology. Ideally, actual sales data would be collected and analyzed to determine the average baseline efficiency in the regional and/or Oregon windows market. However, ETO has been unable to identify an alternative method for collecting these data in the past and so self-reported data based on manufacturer interviews were deemed to be the best available option for this research[1].

Secondly, the data sample is incomplete since interview responses represented only 74.5% of the Northwest windows market. As a result, and in an attempt to address the uncertainty related to incomplete manufacturer response data, a sensitivity analysis was conducted by ETO staff to determine the range of hypothetical average market efficiency values that are possible if data were available for the remaining 25.5 percent of the windows market for which we were unable to collect manufacturer data. This analysis was completed by creating three hypothetical scenarios where a range of efficiency levels were assumed for the portion of the windows market for which manufacturer sales data sales data were not provided.

[1] ETO has attempted to collected data on the NW windows market for several years running without success. Windows Data collected at the national level has also been inadequate in meeting ETO's data needs in past years.

Table 4: Sensitivity Analysis: Potential Effect of Incomplete Market Data on Average Baseline Efficiency

	Scenario Assumption	Hypothetical Baseline U-Value Efficiency
1	The remainder of sales (25.5%) are assumed to fall into the lowest efficiency tier (U-value > 0.35)	0.321
2	The remainder of sales (25.5%) are assumed to fall into the highest efficiency tier (U-value < 0.25)	0.296
3	The remainder of sales (25.5%) are assumed to be spread evenly across efficiency tiers	0.310

The results of this sensitivity analysis suggest that the missing manufacturer interview data could have an effect on the average baseline U-value efficiency finding, presented previously, as large as +/- 1.6%. The results also suggest that we can say, with a relatively high degree of confidence, that the average baseline U-value window efficiency in the Northwest windows market is no higher than .0321, and no lower than 0.296.

In addition, manufacturer data collected by the contractor did not provide adequate information to separate the new and existing homes window markets. ETO believes that the relative market share of the new homes market is enough to have a potentially significant impact on the calculated average market baseline window efficiency, so further data collection is underway.

Lastly, due to the confidential nature of data provided by manufacturers and also due to assurances of confidentiality to the manufacturers by the contractor, ETO was not provided with verbatim interview responses, and so it is hard to know exactly how interview questions were framed and presented. In this case we must rely on the contractor's ability to correctly frame interview questions so that they align with ETO's research needs.

Appendix 1: Manufacturer Interview Responses Without Attribution to Individual or Firm

Table 5: Manufacturer Responses- Sales by Efficiency Tier

	U-Value Tier					
Manufacturer	**> 0.35**	**0.33 to 0.35**	**0.31 to0 .32**	**0.29 to 0.30**	**0.26 to 0.28**	**0.25 or lower**
1	1.00%	60.00%	15.00%	20.00%	3.00%	1.00%
2	10.00%	10.00%	30.00%	35.00%	10.00%	5.00%
3	2.91%	12.07%	5.63%	61.96%	16.76%	0.67%
4	-	46.40%	9.40%	44.20%	-	-
5	-	-	40.00%	40.00%	10.00%	10.00%
6	-	5.00%	-	60.00%	30.00%	5.00%

Appendix 2: Interview Guide

Northwest Energy Efficiency Alliance
and
Energy Trust of Oregon

Windows Manufacturer Interviews
_____ ___, 2013

Introduction (Gary has an intro he uses with the manufacturers; will include stated purposes): Thanks, NEEA/ETO survey sponsorship, confidentiality, purposes of survey including:

- **Assessing current state of the market**
- **Identifying major trends in the market**
- **Collect manufacturer forecasts of expected near-term market behaviors**

First let's talk about your company's capabilities.

1. What is the lowest U factor currently achievable for your company regardless of cost for single-hung windows with a double pane fourth surface low-e coating?

2. What U factor is currently achievable for your company at a low incremental cost for single-hung windows with double pane fourth surface low-e coating?

3. What is your company's overall market share in the Pacific Northwest (OR, WA, ID, MT)?

Next let's talk about some proposed tiers for identifying levels of window performance.

4. I'd like to know the percentage of your company's sales in the past 12 months (Q3 2012 through Q2 2013) that falls into each of the U factor categories defined below, for each of the geographic areas listed.
   Please fill out FIRST for Pacific Northwest (Column a).

Do the percentages you just assigned each tier differ when looking at sales in Oregon only? *[If so, please re-apportion for Oregon only – probe hard on this to ensure ETO's Oregon sales share info is distinguishes from PNW sales shares, where applicable. If no claimed difference, indicate in "Oregon" column b.]*

If able to provide Oregon sales shares by tier:

Are you able to break out sales in Oregon by Western Oregon and Eastern Oregon? *[If so, have them re-apportion for <u>each</u> of Western and Eastern Oregon]*

Note: Each column, as applicable, should add to 100%, e.g., "For all of your sales in Western Oregon only, what percentage are U factor greater than 0.35?"

	Percentage of Company Sales in Each Geographic Area				
		(a) **Pacific Northwest** **(OR, WA, ID, MT)**	**(b)** **Oregon**	***If available***	
				(c) **Western Oregon**	**(d)** **Eastern Oregon**
	Tier	**Percentage**	**Percentage**	**Percentage**	**Percentage**
1	**Greater than U0.35**				
2	**U0.33 to U0.35**				
3	**U0.31 to U0.32**				
4	**U0.29to U0.30**				
5	**U0.26to U0.28**				
6	**U0.25 or lower**				
	TOTAL(each column must sum to 100% for the six U factor tiers)	**100%**	**100%**	**100%**	**100%**

5. I'd like to get some basic cost information by the tiers we just covered. First, please think of the U0.35 windows you offer. What is the average cost/sf of the windows you sell at this U factor? *[Enter in grid below]*
   Thinking of U factors 0.33 to 0.34, what is the incremental cost/sf of such windows over 0.35 windows? – please answer the same question for each of the tiers in the grid below.

   Please enter each incremental cost in the appropriate box.

	Tier	Cost/sf	
1	**U0.35**		***Average* cost/sf**
2	**U0.33 to U0.34**		***Incremental* cost/sf compared to U0.35**
3	**U0.31 to U0.32**		***Incremental* cost/sf compared to U0.33 to U0.34**
4	**U0.29to U0.30**		***Incremental* cost/sf compared to U0.31 to U0.32**
5	**U0.26to U0.28**		***Incremental* cost/sf compared to U0.29 to U0.30**
6	**U0.25 or lower**		***Incremental* cost/sf compared to U0.26 to U0.28**

We'd like to get some additional information specifically about each tier.

Greater than U0.35

6. What operator types do you offer within this tier?

7. Does your company offer products at this tier for an entire house of windows?

   1. Yes
   2. No

8. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

U0.33 to U0.35

9. What operator types do you offer within this tier?

10. Does your company offer products at this tier for an entire house of windows?

    1. Yes
    2. No

11. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

U0.31 to U0.32

12. What operator types do you offer within this tier?

13. Does your company offer products at this tier for an entire house of windows?

    1. Yes
    2. No

14. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

U0.29 to U0.30

15. What operator types do you offer within this tier?

16. Does your company offer products at this tier for an entire house of windows?

    1. Yes

2. No

17. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

U0.26 to U0.28

18. What operator types do you offer within this tier?

19. Does your company offer products at this tier for an entire house of windows?

    1. Yes
    2. No

20. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

U0.25 or lower

21. What operator types do you offer within this tier?

22. Does your company offer products at this tier for an entire house of windows?

    1. Yes
    2. No

23. What emerging technologies might you utilize in the future to provide a more robust and cost effective product offering at this tier? We are interested in technologies aside from fourth surface double pane or triple pane.

24. *[If no differentiation on product offering/availability responses]* For which of the tiers we just discussed does your company offer robust product offerings?***(Robust = offers an entire house full of windows)*** **CIRCLE ALL THAT APPLY**

1. Greater than U0.35

2. U0.33 to U0.35
3. U0.31 to U0.32
4. U0.29 to U0.30
5. U0.26 to U0.28
6. U0.25 or lower

Thank you for your time. We may want to follow up with you if we have additional questions or to get more information on what we have discussed. Will that be okay? If you have any questions, you can feel free to Adam Shick at Energy Trust (503-445-2953; adam.shick@energytrust.org).

D. Energy Trust Windows Measure Approval Document

UPDATED Measure Approval Document for Windows in Single Family, Manufacture Homes, and Small Multifamily

Applicable Programs:

Home Energy Savings, Home Performance with ENERGY STAR, and Existing Manufactured Homes programs and the Multifamily Existing Buildings program for properties with four or fewer living units in both Oregon and Washington

Measure Description

Energy Trust offers incentives for two tiers of windows measures installed in the applicable programs. For both tiers, energy savings from reduced space heat use are measured against a market baseline of what homeowners would likely have purchased in the absence of the Energy Trust program. At the present time, Tier 1 is for new windows with a U-factor between 0.26 and 0.30; Tier 2 is for the even more efficient windows with a U-factor 0.25 or less. Since last updated in 2009, our assumption for the market baseline U-factor has aligned with the RTF at 0.35.

Multifamily Existing Buildings has separate windows retrofit measures for large properties with five or more living units, which calculate savings and costs from the existing condition. The difference between larger multifamily buildings and the single family and small multifamily measures is a result of market research that indicates that large multifamily projects are less likely to have occurred without Energy Trust incentives, whereas single family homeowners are more likely to replace their windows without our incentive, but may be influenced to purchase more efficient windows than they would otherwise have done.

Multifamily properties with four or fewer properties were moved from the single family to the multifamily program in 2012 because the delivery channel had more similarities with other multifamily properties. However, the characteristics of the buildings have more in common with detached single family homes. More detailed data on windows in small multifamily buildings are not available and would be costly to develop. Further, the number of projects in small multifamily buildings is far less than single family, so that any small differences in building construction would be further diminished in their impact by their relative infrequency. This iteration of the windows blessing memo asserts that the savings used for single family windows measures may be used for multifamily properties with four or fewer living units.

Need for Review

Since 2009, Energy Trust has received indications that the market baseline has become more efficient than the 0.35 U-factor baseline we currently assume. ENERGY STAR released a draft windows

specification change announcement in the summer of 2013 for a 2016 proposed change, which showed that 81% of the national windows market meets their current criteria of a 0.30 U-factor or better. Also, anecdotal evidence suggests that most new homes in the region are using 0.30 U-factor windows or better. Due to a lack of local market data to support these indications Energy Trust decided to commission a market survey to inform any change to baseline U-factor assumptions.

The market survey consisted of interviews with regional window manufacturers, which were conducted by an independent contractor who has existing relationships with manufacturers in the area and who is considered an expert on this technology in the region. Participating window manufacturers represented 74.5% of sales in the region.

Interviews took place in October and November of 2013. Manufacturers were asked about their regional and Oregon market share, the percent of sales in each efficiency category, and the average incremental cost for each efficiency category for the time period Q3-2012 to Q3-2013. The data allow us to calculate sales weighted average baseline window efficiency and sales weighted average incremental cost of efficiency for the entire NW windows market.

Energy Savings

Calculation of market baseline

The results of the survey for the market share of windows at various efficiency levels are shown in Table 1.

Table 1: Percent of Sales by Efficiency Tier

U-Factor Tier	Relative Market Share
> 0.35	2.78%
.33 to .35	26.25%
.31 to .32	15.05%
.29 to .30	45.87%
.26 to .28	7.91%
.25 or lower	2.15%
Total	**100.00%**

These data include new homes and replacement windows as well as the portion of sales from participants in our program. To construct a natural market baseline to define the existing home, replacement market without our program influence, two adjustments were made. 1) The new homes market was estimated to be approximately half of the overall market, based on NEEA's Long Term Monitoring and Tracking report and to be composed almost entirely of windows with a U-factor of 0.30 or less. Therefore, we removed fifty percent of the market share of new homes at 0.3 or less from the data. 2) Approximately 6% of the overall market, after removing free-riders, participated in the Energy Trust Existing Homes program. This proportion was also removed from the data.

The adjusted weighted average market baseline of replacement windows for Existing Homes was calculated, with a resulting U-factor of 0.334.

Proposed changes to tiers

Before working through adjustments to measure savings and cost assumptions due to this adjusted market baseline, it was important to look to market influences to help define what new measure tiers could be implemented going forward that would continue to drive the market towards higher efficiency levels. Energy Trust proposes to change the windows tiers at the beginning of 2015 in anticipation of expected changes to ENERGY STAR windows specifications in 2016 for the Northern climate zone. For Energy Trust, the first tier will include windows with a U-factor of 0.28 to 0.30. The second tier will include windows with a U-factor equal to or less than 0.27 or with an equivalent energy performance, as defined by ENERGY STAR.

The basic requirement will be a U-factor of 0.27 or better, though equivalent performance may be achieved with a higher SHGC, as shown in table 2. By shifting one year ahead of Energy Star, we have time to better help prepare the market for 2016 changes.

Table 2: ENERGY STAR Qualification Criteria for Windows, version 6.0

Climate Zone	U-factor	SHGC
Northern*	≤0.27	Any
	=0.28	≥0.32
	=0.29	≥0.37
	=0.30	≥0.42

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

Calculation of savings

Gas savings estimates are based on billing analysis from installations completed in the program from 2005 to 2008. Electric savings are taken from earlier years, as in later years not enough homes with electric space heat installed windows to produce a statistically valid sample. The impact analysis from 2005 and 2006 done by EcoNorthwest found 564 kWh per year savings. The impact analysis from 2007 and 2008 done by Opinion Dynamics Corporation found 39 annual therms, which was corroborated by billing analysis done by Energy Trust evaluation staff for gas heated homes that installed windows in 2009. The average area of windows replaced was 151 square feet, so that the savings per square foot are 3.76 kWh per year and 0.26 annual therms for windows with a U-factor equal to or less than 0.30.

To translate those energy savings into values that would apply for our new tier structure, a linear fit was assumed in relation to the change in U-factor and 2013 program average U-factors were binned in the new tier structure. The resulting savings are 2.86 kWh per year per square foot or 0.198 annual therms per square foot for windows with a U-factor between 0.30 and 0.28. For windows with a U-factor of 0.27 or lower or equivalent energy performance, savings are 6.92 kWh per year per square foot or 0.478 annual therms per square foot.

Measure Cost

The market research used to set the new efficiency market baseline also indicated wholesale incremental cost for each efficiency bin.

Table 3: Incremental Cost by Efficiency Bin

U-Factor Bin	Incremental Wholesale Cost per square foot to the Next Efficiency Bin
.33 to .35	baseline
.31 to .32	$ 0.47
.29 to .30	$ 0.32
.26 to .28	$ 0.59
.25 or lower	$ 1.72

However, the cost for measure analysis is properly defined as the cost of efficiency, which is not reflected in the wholesale cost for two reasons. First, the costs should be retail, and second, many features of windows such as style and frame material affect the cost and are not related to efficiency. To determine the cost of efficiency, both the Regional Technical Forum and the Energy Trust have previously used the 25th percentile cost of windows, in order to separate out the cost of other features. The 25th percentile cost is the cost at which one quarter of the windows are cheaper than the given amount, and three quarters are more expensive.

Using the 25th percentile of program cost data for windows installed in 2013, the incremental cost of efficiency from a maximum U-factor of 0.30 to an average U-factor of 0.24 is $3.25. The market research data indicated a wholesale incremental cost of $2.31. Therefore, the 25th percentile retail cost appears to be approximately 41% higher than average wholesale cost.

No program data exist for the baseline window, as they are less efficient than any windows that receive an Energy Trust incentive. To calculate the baseline cost, the mark-up was applied to the wholesale incremental cost between the baseline and the first efficiency tier, and the result subtracted from the average cost of an efficient window at that level to arrive at a baseline cost of $25.45. The incremental retail costs are then calculated from the baseline to the 25th percentile cost, as shown in Table 5.

Table 4: Incremental Retail Cost

Maximum U-factor	Minimum U-factor	Average U-factor	25th percentile cost ($/SF)	Calculated Incremental Retail Cost ($/SF)
Baseline		0.334	25.40	$0.00
0.30	0.28	0.296	26.56	$1.16
0.27	0.15	0.242	29.81	$4.41

The absence of market data on the baseline retail cost introduces some uncertainty into the calculation of measure cost. Unfortunately, this lack of data is unavoidable for the windows measure. Program data will not include products with the baseline efficiency and considerable effort to collect market cost data through a survey gathered only the wholesale cost. Planning staff consider the given baseline cost estimate to be the best achievable with the available data.

Measure life

Measure life remains 45 years, consistent with previous Energy Trust windows measures.

Incentives

The current incentive for windows with a U-factor of 0.25 is $3.50 per sq ft. It compares to an incentive of $2.25 per sq ft for windows with a U-factor of 0.30. For 2015, the maximum cost effective incentive is $4.31 per sq ft. for products with a U-factor of 0.27 and less, and $1.78 for products with a U-factor between 0.28 and 0.30.

Cost Effectiveness

The proposed measures are cost-effective. Table 1, below provides maximum incentives that pass the Utility Cost Test and are no more than incremental cost. Cost-effectiveness is further documented at:

\\eto-share\etoo_share\Planning\EE Programs\Home Energy Savings\HOUSE TYPES AND measures\single family\windows\High performance windows\bencost\ETO CEC windows 2015_16.xlsx

Table 1. Cost-Effectiveness Summary for Efficient Single Family Windows

Project	Measure Lifetime (Maximum 70 yrs)	Annual Electricity Savings, kWh	Annual Gas Savings, therm	Incre-mental Cost	Max ETO Incentives	Combined Utility System BCR	Combined Societal BCR
U-value 0.30 to 0.28	45	2.86		$1.11	$1.78	3.0	4.6
U-value 0.30 to 0.28	45		0.196	$1.11	$1.78	1.0	1.5
U-value equal to or less than 0.27	45	6.92		$4.36	$4.31	3.0	2.9
U-value equal to or less than 0.27	45		0.475	$4.36	$4.31	1.0	1.0

E. Delphi Study Recruitment Letter

November 21, 2014

EnergyTrust of Oregon
energytrust.org

[Participant]:

As you may already know, Energy Trust of Oregon offers incentives for the installation of high-efficiency windows in Oregon homes. As an expert in energy efficiency, we would like to get your impressions of the current market for residential windows and your thoughts on where the windows market may be heading over the next several years. We are requesting your participation in a short online study, followed by a one hour webinar focus group in early December.

Energy Trust has contracted with Apex Analytics to conduct this research. Apex Analytics is offering $350 for your participation in both the brief online survey and webinar focus group, as a thank you for your time and effort. If you choose to participate in this effort, your responses will not be associated to your organization, and all results will be presented in aggregate. This effort is purely for Energy Trust program planning purposes.

As background, we have included a document with a brief description of the goals of the study and the type of information we are looking for. In addition, we have attached the 2014 Residential Windows Market Research Report from our prior residential windows research in the Northwest.

If you would like to participate in the study, please go to and enter in the login ID X476494X. We are requesting that you have the survey completed by the end of November. If you are having trouble with the survey, please call Noah Lieb of Apex Analytics at 303- 590-9888 ext.103. If you have any questions about this study, please contact me at the number below.

We thank you in advance for your insights into the evolving high-efficiency windows market.

Sincerely,

Sarah Castor
Evaluation Sr. Project Manager
Energy Trust of Oregon
503-445-7619