Final Evaluation Report

New Homes Air Sealing Pilot

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Executive Summary

Background: Energy Trust's New Homes Program conducted a pilot in 2012 to test a new, standalone air sealing measure for application in code-built, single family new construction. The Program identified an inexpensive measure that consisted of affixing sill sealer to the top plate of all walls prior to drywall installation. A $125 incentive was paid directly to insulation subcontractors trained to install the measure. The Pilot tested both the effectiveness of the measure in reducing air infiltration and the feasibility of delivering it to the code-built new homes market. This evaluation assesses the Pilot's activities, provides feedback from staff and contractors, summarizes measure test results and recommends future improvements.

Methods: Blower door tests were conducted in 40 code-built homes treated with the measure and 39 comparable baseline homes without the measure. The two groups were compared to determine the measure's impact on airtightness. Energy simulation models were used to estimate the energy savings resulting from the observed reduction in air infiltration. Feedback about the Pilot process, the measure, the incentive, challenges and barriers was collected via a series of surveys and interviews with participating insulation subcontractors and Pilot staff.

Findings: During the Pilot, the measure was installed in 340 new homes, with one firm responsible for 95% of them. The blower door tests showed that the average air changes per hour (ACH) was 4.58 for treated homes and 5.38 for baseline homes, resulting in a net reduction of 0.81 ACH ($p=0.003$) in treated homes. This equated to conservative energy savings estimates of 13 therms per year in a typical 2,200 square foot gas heated home and 141 kWh per year in an electric home. Assuming a 45 year measure life, the benefit-cost ratio is 1.05 for gas and 2.30 for electric homes west of the Cascades, meaning the measure is cost-effective.

The largest issue during the Pilot was a conflict with drywall contractors who were concerned about the impact of the measure on the quality of their work. This resulted in the measure being removed by drywall crews in a number of homes. Other significant issues were perceptions that code builders did not value air sealing and that the incentive did not cover installation costs. Although using insulation contractors had its challenges, it proved to be a feasible delivery channel.

Recommendations:

- Continue to offer a stand-alone incentive for the measure. Offer the incentive to drywall subcontractors in addition to insulation subcontractors.
- Conduct an outreach and education campaign with drywall contractors to teach them to properly install drywall with sill sealer and allay their fears.
- Educate builders about the measure and incentive. Provide subcontractors with sales tools and collateral to help them pitch the idea to builders. Offer training workshops about air sealing directly to builders for continuing education credit.
- Offer a bonus incentive to get more subcontractors involved. Offer a tiered incentive based on the size of the home or the amount of sill sealer used.
- In communications with builders, include information about the New Homes program and EPS.
- Test additional air sealing measures and offer stand-alone, prescriptive incentives for those that prove to be cost-effective.

Background

Energy Trust of Oregon's New Homes Program developed and implemented an Air Sealing Pilot in 2012 to test a new, standalone air sealing measure for application in new single family construction. This report documents the Pilot's goals, activities and accomplishments and provides a summary of test results on the effectiveness and cost-effectiveness of this particular measure. It also provides feedback, lessons learned and recommendations on how to proceed based on a series of surveys and interviews with Pilot staff and participants.

According to Program staff, many builders have reported difficulty constructing homes that were tighter than the 2011 residential energy code requirements at a low- or no-cost price point. As building codes become increasingly stringent, the need for builders to properly air seal homes is becoming apparent. It is difficult and costly to retroactively air seal homes to reduce air infiltration. The Air Sealing Pilot was intended to identify and examine the effectiveness of a new, inexpensive measure that could be easily incorporated into residential new construction. The Pilot was conducted as a market test to determine the feasibility of working with subcontractors to transform the new homes market to avoid the need for costly air sealing after construction is complete.

The Pilot offered specific training and incentives of $125 per home directly to trade ally insulation subcontractors to install an air sealing measure during the construction phase. Training was conducted at the subcontractors' offices with managers and installation crews in both English and Spanish. Both the incentive and the training components of the Pilot were designed to provide the subcontractors with a low- or no-cost solution that they could market to builders. Through these subcontractors, Energy Trust also hoped to reach a new audience of code builders that were not trade allies, in order to gain exposure for the New Homes Program and its EPS™ or energy performance score. The Pilot focused on homes otherwise built to code specifications and did not include those that employed additional or above-code air sealing strategies or were already participating in the Program.

The air sealing measure selected for the Pilot consisted of affixing sill sealer to the studs at the top plate on all exterior and interior walls prior to drywall installation (Figure 1). The theory was that the sill sealer would create a barrier to air infiltration from the attic into the walls. This measure was believed to be the most cost-effective of those considered and preliminary testing indicated that it could achieve a reduction in air infiltration of up to one air change per hour (ACH). The energy savings potential for the measure was estimated through REM/Rate modeling. Assuming an average square footage of 2,220 and a measure life of 30 years per project, estimated annual savings were 195 kWh for electric heated homes or 21 therms for gas heated homes. These assumptions were tested through the course of the Pilot and evaluation.

Pilot team members were brought together from several different organizations with Energy Trust sponsoring the Pilot and providing high level oversight. Energy Trust's Program management contractor, Portland Energy Conservation, Inc. (PECI), managed the Pilot and handled the day-to-day operations, such as incentive processing. PECI also coordinated the work of staff at two other organizations hired to implement different components of the Pilot, Conservation Service Group (CSG) and Delta T (work by

Delta T was transitioned to Fluid Market Strategies (Fluid)). CSG staff recruited and trained a pool of insulation subcontractors to install the air sealing measure in new homes. Fluid and PECI staff tested the airtightness of homes to determine the effectiveness of the measure. The measure was developed in Q1 and Q2 2012 along with the Pilot materials, forms and processes. Trainings with subcontractors began in May of 2012 and the incentive offer was officially rolled out. Participating subcontractors submitted the first incentive applications in July 2012.

Figure 1. Photograph of sill sealer (pink band at top of wall) installed on the top plate prior to drywall installation (courtesy of Fluid Market Strategies; Manclark, 2013).

Goals and Objectives

The Pilot's primary goal was to identify, implement and test an air sealing measure in the new homes market. The Pilot objectives were:

- Determine if the air sealing measure can be widely adopted by the free market and at what cost.
- Determine whether the measure can achieve a one air change per hour reduction in air infiltration.
- Determine whether the Program can work effectively with subcontractors to transform the point at which new homes are air sealed.
- Reach the new construction market that is not currently working with the New Homes Program through EPS (approximately 35% of the market).
- Through the Pilot in 2012, air seal 1,665 homes (1,400 gas and 265 electric) for total savings of 33,280 working kWh and 29,400 working therms.

The goal of the evaluation was to assess the extent to which the Air Sealing Pilot met its primary objectives. Additionally, the evaluation aimed to document those parts of the Pilot that worked well and provide feedback on how it can be improved in the future. The specific research questions that the Pilot and evaluation attempted to answer were:

- How many subcontractors were reached and how many decided to participate?
- What methods of outreach were most effective?
- Which contractors have not been reached or decided not to participate?
- What was the market penetration of treated homes? By contractor?
- Did the air sealing measure proposed at the beginning of the pilot show a consistent reduction of 1 ACH when tested in QA inspections?
- Did the Pilot engage new subcontractors and non-program builders? How many? Do these subcontractors also work on existing homes?
- How effective were the outreach efforts to contractors?
- Are subcontractors satisfied with the training and leave-behind materials? What improvements could be made?
- If they decided not to participate after the training, why not?
- What do subcontractors think of the measure in terms of technical specifications and effectiveness? Do they find it easy to install? Do they have any trouble persuading builders to use the measure?
- What is the average cost incurred by subcontractors for the air sealing measure? Do they find the cost/effort reasonable given the incentive level and what builders are willing to pay?
- Are there changes to the incentive application or process that would make it easier for subcontractors (or builders) to participate?

Methods

The analysis period for the Air Sealing Pilot was from May 2012, when the air sealing incentive was first released, through December 2012. Pilot program operational data, such as number of projects and number of participating contractors, were tracked throughout the analysis period by New Homes Program staff and compiled at the end of the project.

To determine the impact of the air sealing measure on air infiltration into new homes, a statistical comparison was made between a sample of homes treated with the measure and a sample of baseline, code-built homes that did not receive the measure. Staff from Fluid Market Strategies and PECI conducted blower door tests using standard procedures on 40 treated homes and 39 baseline homes. All homes were tested for airtightness by performing a blower door test that depressurized the home to 50 Pascals. An extensive checklist was utilized to ensure that the homes were uniformly prepared for testing. For more details on the blower door methodology, see the full report from Fluid Market Strategies in Appendix E (Manclark, 2013).

The results were compiled and the reduction in air infiltration in the treated homes versus the baseline homes was calculated using two different metrics: ACH and cubic feet per minute per square foot (CFM/SqFt). Ecotope, Inc. of Seattle, Washington was commissioned to estimate energy savings based on the observed reduction in CFM/SqFt using the home energy modeling software SEEM 94 (Ecotope, Seattle, WA). Three base case homes that the Northwest Power & Conservation Council's Regional Technical Forum (RTF) uses to model energy efficient measures were used in these simulations. These cases represent typical Northwest homes of 1,344, 2,200 and 2,688 square feet and were modeled for both electric and gas heat in heating zones 1 and 2. Heating systems for the gas were assumed to have an efficiency level of 83% and the electric heat pump systems were assumed to have a coefficient of performance of 2.2 (Manclark, 2013).

As an alternative approach, savings estimates based on the reduction in observed ACH were calculated using the home energy modeling software program REM/Rate (Architectural Energy Corporation, Boulder, CO). REM/Rate savings estimates assumed that homes were otherwise built to code, using code-level heating equipment and located in heating zone 1. Energy savings were calculated for six different home sizes ranging from 1,400 to 3,007 square feet with scenarios for both electric and gas heating.

The savings estimates were then entered into Energy Trust's cost-effectiveness calculator. Three scenarios were used to calculate cost-effectiveness for each category of home, using three different assumptions about the life of the air sealing measure. The initial assumption made by the Program was a 30 year measure life. We also calculated cost-effectiveness using 45 and 70 year measure lives because there is a precedent in using each of these for shell measures in residential new construction. Energy Trust uses 45 year measure lives and the RTF uses 70 year measure lives (Stellar Processes, 2011; RTF, 2012).

A series of interviews and surveys were done throughout the Pilot to get feedback (Table 1). Interviews were conducted at the end of the Pilot period to debrief staff and compile their views about the

successes and failures of the Pilot. Staff were asked about lessons learned and suggestions for future improvements. Several rounds of feedback were collected from the insulation subcontractors, including a post-training evaluation survey, a brief early feedback interview and a post-participation survey. In addition, Pilot staff followed up with the subcontractors after the trainings and kept in communication with them throughout the Pilot.

Table 1. Summary of surveys and interviews completed during the Pilot evaluation.

Survey / Interview	Respondent Group	# of Respondents
Post-training evaluation survey	Subcontractors (all training attendees)	52
Early feedback interviews	Subcontractors (primary contact)	11
Post-participation survey	Insulation subcontractors (primary contact)	10
Pilot staff interviews	Pilot team members	7

Although we originally intended to interview and obtain feedback from home builders that had homes treated with the air sealing measure, we were unable to contact any of them for this evaluation. We obtained contact information from the Pilot team for several builders who were deemed to be the most cooperative. Unfortunately, we were unable to get through to any of these builders after making several calls to each.

Findings

Project Tracking Data

The New Homes Program tracked and claimed energy savings based on provisional savings estimates throughout the Pilot. Project data from Energy Trust's FastTrack database show that incentives were paid for the air sealing measure in 340 new homes (17 electric, 323 gas) in 2012, saving 3,315 kWh and 6,783 therms per year. Figure 2 below shows the number of installations by month. The project volume and savings are substantially lower than the initial Pilot goals for a number of reasons, but those initial goals were probably overly optimistic given that it was a new, unproven measure and that the Pilot was primarily designed to test its effectiveness. In addition, the pilot started later than expected, which limited activity to the second half of the year.

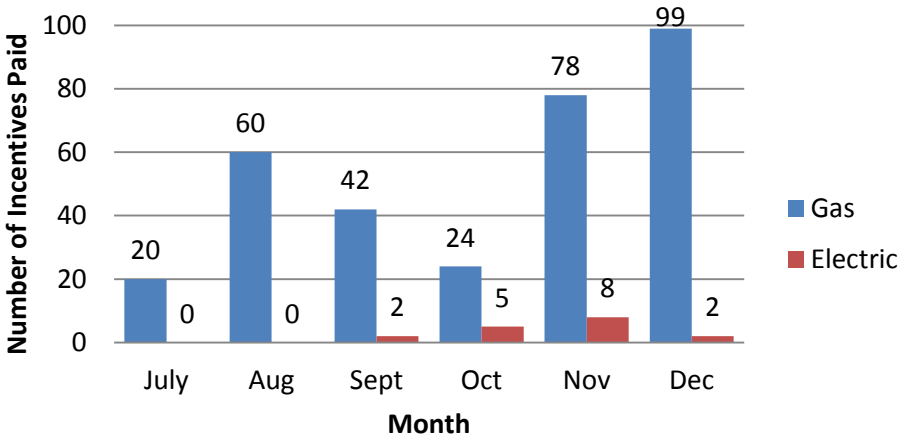

Figure 2. Number of incentives paid for air sealing projects by month and fuel type, 2012.

Pilot staff conducted quality control inspections in 30 homes where the air sealing measure had been installed. The measure inspections were done in a mix of different home configurations built by a variety of builders and installed by several of the subcontractors over the course of the Pilot. Of these 30 homes, only one failed because the drywall contractor had removed the measure. Program staff reported that in general, issues with sill sealer installation were very minor and the contractors quickly fixed any small problems that were identified. However, there were a number of other anecdotal reports from the insulation subcontractors about sill sealer being removed by drywall contractors, but staff do not believe that these projects received incentives.

Twenty-nine subcontractors were contacted during recruitment phase of the pilot. Many of these contractors were not eligible to participate in the Pilot because they did not work on new homes or code-built homes. Out of the original 29 companies contacted, 11 companies participated in one of the initial training workshops. Ten of these were already registered trade allies with the Existing Homes Program, but only one of them was previously a New Homes Program trade ally. One of the 11 companies was not an Energy Trust trade ally prior to the Pilot.

Only four of the 11 insulation subcontractors that participated in the training workshops submitted an incentive application after installing the air sealing measure in an eligible home. Of those four, one subcontractor installed 95% of the measures in the Pilot. Other subcontractors may have installed the measure in qualifying homes, but never submitted the paperwork to Energy Trust. Several contractors reported installing the measure in a large number of Energy Star, Earth Advantage or EPS homes, but these homes were not eligible for the Pilot because they use air sealing strategies that already receive program incentives. Early on in the Pilot, one of the larger subcontractors involved converted all of the builders they work with to New Homes Program trade allies to participate in EPS. Although this company installed the measure in nearly all of the homes they worked on, they were not counted in the Pilot. The following chart shows the breakdown of air sealing projects completed per contractor in 2012.

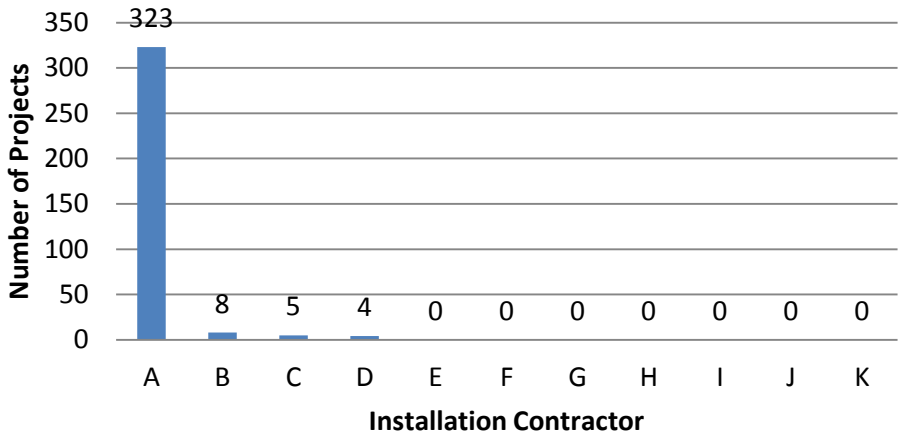

Figure 3. Number of air sealing projects completed per subcontractor, 2012.

The four participating subcontractors installed the air sealing measure in code homes being constructed by 80 different builders. None of these builders were trade allies with the New Homes Program, meaning that the Pilot significantly extended the reach of the Program in the new homes market. In addition, one very large builder was recruited into the New Homes program as a new trade ally, due in part to outreach done through the Pilot. These outcomes demonstrate that regardless of the success of the air sealing measure, working through subcontractors was an effective method to recruit non-trade ally home builders into the New Homes Program.

The 11 subcontractors that went through the training workshop reported installing insulation in a combined total of approximately 3,160 homes per year, averaging 287 homes each. This varied from 30 to 900 homes per year each. Even if a large portion of these homes were built above code, were not detached single family homes or did not fall within Energy Trust's service territory, working with just these 11 subcontractors to install sill sealer in new homes would still be a large opportunity.

Measure Testing and Analysis

Blower door testing was conducted in 40 homes treated with the air sealing measure and 39 baseline homes without the measure. The overall average size of homes that were tested was 1,945 square feet.

However, the baseline homes were 2,055 square feet on average, significantly larger than the treated homes, which averaged 1,836 square feet (p=0.025) (Manclark, 2013).

House tightness is typically expressed in ACH. While this metric is useful, it can show a bias when comparing homes of unequal sizes as larger homes usually have more square feet of conditioned space per exposed surface area than smaller homes. It is at the exposed surface areas (floors, walls, ceilings) that homes leak. The chart below shows a comparison of ACH between baseline and treated homes, highlighting the general trend that as homes become larger the ACH tends to decrease.

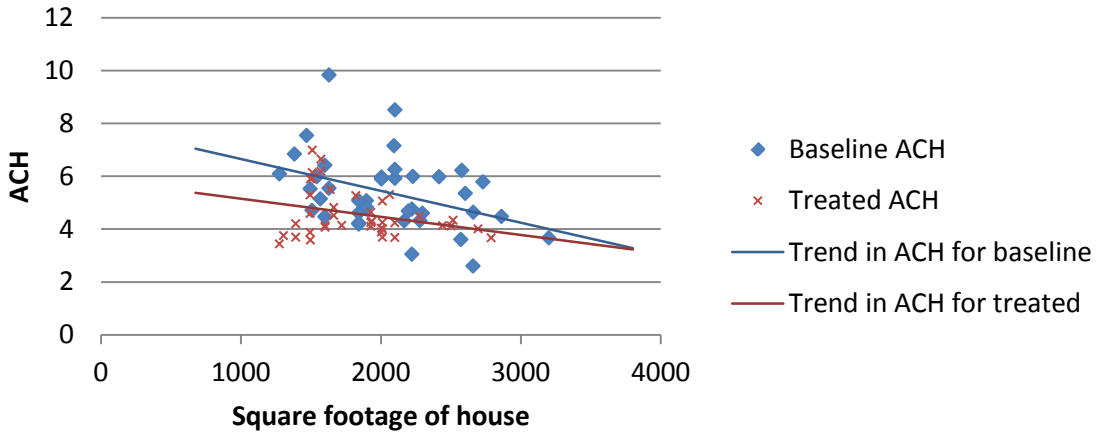

Figure 4. ACH results by square footage for treated and untreated homes tested (Manclark, 2013).

The ACH was calculated for purposes of comparison to other programs and measures. The average ACH for the untreated homes was 5.38 and 4.58 for treated homes, resulting in a difference of 0.81 ACH between the two groups. This difference was determined to be highly statistically significant using a two-sample T-test, with a p-value of 0.003. Thus, the likelihood that this difference is due to random chance is very small (Manclark, 2013).

To minimize the biasing effect that home size had on measured airtightness, Fluid used a ratio of cubic feet per minute per square foot (CFM/SqFt) to determine house tightness. This factored out home size in the comparison of the two groups and a two-sample T- test showed that there was highly significant difference in CFM/SqFt between them, with a p-value of 0.004 (Manclark, 2013).

Table 2. Comparison of measured CFM per square foot between baseline and treated homes.

Comparison	Baseline	Treated	Difference
Average CFM per Square Foot	0.76	0.65	0.11*
Standard Deviation of CFM per Square Foot	0.20	0.12	0.07
Average Square Footage	2,055	1,836	219**

*Statistically significant difference, p=0.004
** Statistically significant difference, p=0.025

The use of a sill sealer as a gasket between the top plate of interior walls and the attached sheetrock results in code level homes being 15% tighter, on average, than homes without the measure. Modeled

estimates of savings suggest this would result in annual heating savings of approximately 3.5 percent (Manclark, 2013). The following tables (Table 3 and Table 4) display the gas and electric savings estimates as calculated using the SEEM model, based on the observed reduction in CFM/SqFt and as calculated using REM/Rate, based on the observed reduction in ACH.

Table 3. Modeled annual energy savings estimates for treated homes with electric heat.

Energy Model	Air Infiltration Metric	Heating Zone*	Home Size (Sq. Ft.)	Baseline Homes: Energy Used for Heating (kWh)	Treated Homes: Energy Used for Heating (kWh)	Energy Savings (kWh)
SEEM	CFM/SqFt	1	1,344	2,196	2,126	70
SEEM	CFM/SqFt	1	2,200	4,110	3,969	141
SEEM	CFM/SqFt	1	2,688	3,414	3,288	126
SEEM	CFM/SqFt	2	1,344	3,617	3,520	98
SEEM	CFM/SqFt	2	2,200	6,464	6,271	193
SEEM	CFM/SqFt	2	2,688	5,478	5,304	174
REM/Rate	ACH	1	1,400	3,430	3,343	87
REM/Rate	ACH	1	1,562	3,896	3,792	104
REM/Rate	ACH	1	2,015	5,007	4,851	156
REM/Rate	ACH	1	2,200	5,091	4,935	156
REM/Rate	ACH	1	2,509	5,308	5,140	168
REM/Rate	ACH	1	3,007	8,413	8,168	245

*Heating zone 1 reflects climatic conditions in Western Oregon and heating zone 2 is reflective of Central/Eastern Oregon

Table 4. Modeled annual energy savings estimates for treated homes with gas heat.

Energy Model	Air Infiltration Metric	Heating Zone*	Home Size (Sq. Ft.)	Baseline Homes: Energy Used for Heating (Therms)	Treated Homes: Energy Used for Heating (Therms)	Energy Savings (Therms)
SEEM	CFM/SqFt	1	1,344	199	193	6
SEEM	CFM/SqFt	1	2,200	373	360	13
SEEM	CFM/SqFt	1	2,688	310	298	11
SEEM	CFM/SqFt	2	1,344	328	319	9
SEEM	CFM/SqFt	2	2,200	587	569	17
SEEM	CFM/SqFt	2	2,688	497	481	16
REM/Rate	ACH	1	1,400	194	185	9
REM/Rate	ACH	1	1,562	323	312	11
REM/Rate	ACH	1	2,015	400	383	17
REM/Rate	ACH	1	2,200	410	393	17
REM/Rate	ACH	1	2,509	433	414	19
REM/Rate	ACH	1	3,007	713	687	26

*Heating zone 1 reflects climatic conditions in Western Oregon and heating zone 2 is reflective of Central/Eastern Oregon

The annual energy savings estimates using the SEEM model are slightly more conservative than those from the REM/Rate model. The most typical home size scenario is 2,200 square feet, which was associated with 13 therms per year in gas homes and 141 kWh per year in electric homes in Western Oregon using the SEEM estimates (Manclark, 2013). Savings were slightly higher for Central/Eastern Oregon, as expected. The REM/Rate model showed that measure savings should steadily increase with home size. Estimated savings for the typical 2,200 square foot home in Western Oregon using REM/Rate were 17 therms per year in gas homes and 156 kWh per year in electric homes. Table 5 below summarizes these savings estimates for the typical new home in Western Oregon, which are slightly lower than initially projected.

Table 5. Summary of annual energy savings for a typical 2,200 square foot home in Western Oregon.

Energy Model	Heating Type	Initial Energy Savings Projection	Final Energy Savings Estimate	Energy Unit
SEEM	Electric	--	141	kWh
SEEM	Gas	--	13	Therms
REM/Rate	Electric	195	156	KWh
REM/Rate	Gas	21	17	Therms

Measure Life Assessment

Sill sealer is a polyethylene foam product designed to last the life of a house. In its application as a gasket between dry wood and sheetrock, it is not exposed to water or UV light, and therefore the material is not likely to degrade. The RTF deems shell measures in residential new construction with a life of 70 years (RTF, 2012). Energy Trust generally deems shell measures with a life of 45 years (Stellar Processes, 2011). In addition, several subcontractors commented in the post-participation interviews that they believed sill sealer was much less prone to degrading and failing over time than caulk or other alternatives and would likely last the life of the structure. For these reasons, it is probably safe to assume that this air sealing measure will have a longer life than the 30 years initially assumed for the purposes of this Pilot.

Measure Cost-Effectiveness

Table 6 and Table 7 below show the cost-effectiveness test results of the air sealing measure for a typical 2,200 square foot home in Western Oregon with three different measure life assumptions using both the SEEM model and the REM/Rate model savings estimates. Benefit-cost ratios for gas and electric heated homes are presented in separate tables. The total cost of the measure is equal to the incentive amount paid to the subcontractor, which was assumed to cover the entire cost of installation. The total benefits include the net present value of the energy savings based on the assumed measure life.

Table 6. Benefit-cost ratios for the air sealing measures installed in a typical 2,200 square foot home in Western Oregon with electric heat.

Energy Model	Air Infiltration Metric	Measure Life	Total Cost	Total Benefit	Benefit/Cost Ratio*
SEEM	CFM/SqFt	30	$125	$246	**1.97**
SEEM	CFM/SqFt	45	$125	$288	**2.30**
SEEM	CFM/SqFt	70	$125	$316	**2.53**
REM/Rate	ACH	30	$125	$271	**2.17**
REM/Rate	ACH	45	$125	$317	**2.54**
REM/Rate	ACH	70	$125	$349	**2.79**

*Benefit-cost ratios above 1 are considered cost-effective.

Table 7. Benefit-cost ratios for air sealing measures installed in a typical 2,200 square foot home in Western Oregon with gas heat.

Energy Model	Air Infiltration Metric	Measure Life	Total Cost	Total Benefit	Benefit/Cost Ratio*
SEEM	CFM/SqFt	30	$125	$114	**0.91**
SEEM	CFM/SqFt	45	$125	$131	**1.05**
SEEM	CFM/SqFt	70	$125	$143	**1.14**
REM/Rate	ACH	30	$125	$149	**1.19**
REM/Rate	ACH	45	$125	$172	**1.38**
REM/Rate	ACH	70	$125	$187	**1.50**

*Benefit-cost ratios above 1 are considered cost-effective.

Staff Interviews

Overview

Seven staff involved in the Pilot from Energy Trust, PECI, CSG and Fluid were interviewed to get their perspectives on how the Pilot went and what could be done differently moving forward. Most respondents thought that the Pilot was an overall success. As one person put it, "*It's definitely been a successful learning experience*." Staff noted they learned a lot about the measure and the potential energy savings as well as about outreach to subcontractors and builders, communication between different stakeholders and Program processes. Staff noted that the Pilot succeeded in training a large portion of the insulation subcontractors working on new homes and in gaining market awareness for the air sealing measure among builders and subcontractors.

Goals

Staff agreed that the Pilot had achieved its primary goal of testing whether the air sealing measure was effective. They reported that testing went well and the sample of homes was large enough to quantitatively assess the measure's impact on airtightness. However, staff also reported that the Pilot was only partially successful in introducing the new measure into the market. Several staff commented that they were disappointed that more subcontractors didn't participate and it was not more widely adopted. "*We didn't get the number of subcontractors that we wanted*," was a common sentiment. As a

result, the Pilot fell short of its numeric goals for the number of projects and energy savings, but this wasn't critical to the overall success of the Pilot. A couple of staff mentioned that the Pilot had good success in its ancillary goal to gain exposure for the Program by reaching code builders that they do not normally work with. A large number of builders were touched by the Pilot and at least one builder was recruited to be a New Homes Program trade ally.

Communication

Internal. In general, communication among Pilot staff was effective; roles were clearly established and there was good coordination. "*I haven't had any issues with communication*," was a common theme. The only comment made about internal communication was that the blower door testing work could have been better coordinated from the beginning. However, issues that arose with scheduling and tracking tests were resolved midway through the Pilot.

Subcontractor. Staff reported that communication with the subcontractors was relatively good. Staff made multiple follow up calls to each firm to resolve issues, ensure they knew how the Pilot worked and clarify what they needed to do to participate. This follow up was regarded by many staff as an important step to keep the subcontractors engaged. The only reported major miscommunication was a case where two subcontractors had a similar name which resulted in lengthy delays for incentive checks to one of those subcontractors. Unfortunately, this caused that company to pull out of the Pilot. One staff member felt that staff could do a better job of communicating the value of the air sealing measure to the subcontractors and that it could be marketed to builders as a free service.

Builders. Builders were very difficult for staff to contact during the Pilot. The only direct contact that staff had with builders was scheduling and conducting blower door tests. In particular, builders of untreated homes were often unresponsive to requests to do testing for the baseline. Even paying these builders to allow access was problematic, because many of them either did not complete or incorrectly completed the necessary W9 tax form. According to blower door staff, in treated homes the builders generally knew that the air sealing measure had been installed, but they didn't necessarily know why.

Outreach & Recruitment

There was broad agreement among staff that the initial outreach and recruitment of subcontractors for the Pilot was successful. Program staff contacted nearly all of the insulation subcontractors in the Portland Metro area and then concentrated on recruiting the firms that focused on new homes. Staff succeeded in recruiting a high proportion of insulation subcontractors to participate in the Pilot and go through the training, including the biggest firms in the metro area. During the initial outreach and trainings, staff reported that the subcontractors seemed interested in the air sealing measure and excited about the opportunity to provide a new service to builders. Unfortunately, it was hard to get many of the subcontractors to follow through despite their initial enthusiasm and subsequent follow up calls from staff to answer questions and encourage them to participate.

Training

Staff didn't have many comments on the subcontractor trainings, although several people mentioned that it was important to work with the people who would actually be filling out the forms. Staff also

suggested that the training workshops might more effective if broken into a technical and administrative component. Although this was done to some extent, staff suggested two separate trainings with two different groups. One would be specific to installation crews and job supervisors, teaching them about the measure and how to install it properly. It was often difficult for staff to meet with the installation crews because they were usually working in the field, so another suggestion was to arrange technical trainings at home sites with a demonstration of how to properly install the measure. The other training group would be for office assistants and managers. The purpose of this training would be to explain the initiative and the measure, which homes are eligible, and how to complete the incentive application and contact Program staff.

Pilot Process

Staff reported that the process for subcontractors to participate in the Pilot, including the eligibility requirements, incentive application, and approval and payment process, worked smoothly. Staff frequently mentioned that the incentive application form had been improved. At the beginning of the Pilot, the form required far too much information. Several staff observed that this was a major barrier to participation for the subcontractors, but the form was simplified early in the Pilot it much easier to complete. According to staff, the one subcontractor that had appreciable project volume also had office support and a process in place to complete the applications as well as promote and install the measure. Staff believed that these factors contributed to this subcontractor's success.

Subcontractor Participation

Although the Pilot was somewhat slow to get started, staff agreed that once it got going, subcontractor participation moved quickly. Several people commented that it is typical for pilot initiatives to get a slow start and that this Pilot was about average. Another perspective was that new measures take time to develop and gain market acceptance but this one was able to ramp up relatively fast. As one person commented, "*I actually was surprised by how quickly this new measure got incorporated*." Staff counted it as a success that two of the biggest insulators in the state, serving the largest builders in the state, were recruited for the Pilot. One of these subcontractors did not participate in the Pilot because they converted all of their builders to EPS trade allies. The other large subcontractor was responsible for the vast majority of air sealing projects within the Pilot.

At the beginning of the Pilot, there was a lot of interest and activity among the pool of subcontractors. However, staff reported that not all of them submitted the application paperwork after completing projects, some became discouraged and stopped participating, and others never installed the measure. Staff reported that the process of determining eligibility, buying a new product, training installation crews, and submitting applications were barriers that some subcontractors were unable to overcome. There was also resistance to the measure from builders, drywall contractors and the insulators themselves, simply because it was a new measure and required them to change their practices. "*That's just typical with anything that's new*," one person noted, "*there's a little bit of a learning curve*." Staff believed that resistance would diminish over time as the measure becomes more commonly used.

Staff reported that the one high volume subcontractor in the Pilot was particularly motivated because they viewed the Pilot as a business opportunity to develop a new service to offer to builders. This firm

was genuinely interested in the project and determining how effective the measure was, even if they didn't make any money. The primary contact for this subcontractor was described as an "*energy nerd*." Other subcontractors adopted the measure to do air sealing in EPS, Energy Star, or other above-code homes that did not qualify for the Pilot, as an inexpensive alternative to reliably reduce air infiltration to meet various standards. Staff believed that because the measure was simpler and less expensive than other air sealing measures that it would become standard practice over time, at least in Program homes.

Staff suggested a few changes to increase participation and reduce conflicts in the future:

- Educate builders about air sealing to increase their interest in and acceptance of sill sealer and reinforce that it should not be removed.
- Communicate with builders about the incentive and encourage them to request this service, which will drive subcontractors to do the work.
- Communicate with drywall contractors about what they need to do differently in treated homes to accommodate the sill sealer.
- Hold a pre-construction meeting or add verbiage to drywall contractors' scopes of work to provide the insulation subcontractor with an opportunity to explain the measure and reduce the uncertainty and conflict about it.
- Target drywall contractors to install the measure which would streamline the installation, prevent them from removing it and increase participation.
- Try using other types of subcontractors to increase participation and decrease costs, such as framers, plumbers, electricians, air sealing contractors and home performance contractors.

Quality Control

There were not a lot of comments about the quality control (QC) component of the Pilot program. However, one staff member warned, "*I wouldn't make the mistake of saying [the Pilot] will continue to work without the QC*." Another person noted that the subcontractors may have done a better job because they knew that someone was coming in behind them to check their work. Staff noted that during the 30 QC visits, the vast majority of projects were satisfactory and subcontractors were quick to return and fix minor issues that were discovered.

Measure Removal

Staff reported that in some cases, the drywall contractors removed the measure because it was in their way or they thought it might cause problems with their work. In one case a staff member entered a house to conduct QC while the drywall crew was tearing the sill sealer down. This home was disqualified from receiving an incentive and the subcontractor quickly resolved the problem. Some builders were also skeptical of the measure and echoed the drywall contractors' concerns that it might cause problems with the drywall. Measure removal was identified as a risk early on and stickers were created to inform other subcontractors to leave the sill sealer in place. Although measure removal was a serious issue during the Pilot, the blower door test team observed that the vast majority of projects were intact.

Measure Costs and Incentive

Staff reported that they received many complaints from subcontractors that the incentive amount was insufficient and the cost of installation was too high to make it worthwhile. Some subcontractors said that they were just breaking even under the existing arrangement. Staff suggested a number of possibilities to overcome the cost hurdle, given that the measure savings were fairly small. One person

mentioned that the measure could be used to help beat the blower door test requirement for builders using the code path requiring six air changes and that it would be cheaper than many other methods in this application.

Some staff speculated that as volume increased and crews became more efficient at installing the measure that costs would decrease significantly. It was a common conception among staff that the Pilot's one high volume subcontractor was making money on the deal. Others felt that if the subcontractors could better promote the concept as a free service to builders to improve the quality of homes, which would create more demand. If builders requested the measure, then the subcontractors would install it even at the break-even point. A few people expressed skepticism that the initiative would grow unless the incentive was increased or it was variable, based on the size of the home or the amount of product used. One person suggested that $200 would probably be a much better motivation than the current $125 incentive.

Future of the Initiative

Staff generally agreed that the sill sealer was a good measure that was simple, inexpensive and had a measurable impact on air infiltration. However, several people also noted that very few subcontractors were still engaged with the initiative and that the barriers they faced would have to be addressed before the measure could be widely adopted. "*We would need to do some type of reengagement*." Even so, many staff expressed optimism that more subcontractors would participate in the future. There were also several suggestions for alternative measures and approaches for decreasing air infiltration, including caulking the exterior face of the top plate where it joins the sheathing, better sealing plumbing and electrical penetrations, blown-in blanket insulation, and lower energy ventilation strategies. Staff felt that most alternatives would be more expensive than sill sealer.

Subcontractor Surveys

Overview

A series of surveys was conducted with the 11 insulation subcontractors that were recruited for the Pilot and participated in one of the initial training workshops. A post-training feedback survey was given to all individuals after attending a training session. Forms were provided in both Spanish and English. The feedback forms were completed by 52 training attendees, including managers, office staff and installation crews. See Appendix A for the post-training survey instrument.

Next, an early feedback survey was conducted with the primary contacts at all 11 subcontractors enrolled in the Pilot, two to three months after they received the training. This was survey was intended to catch any major issues early on so that the Pilot could change course, if need be. See Appendix B for the early feedback interview guide. At the end of the Pilot we interviewed 10 of the 11 subcontractors again (late January and early February 2013) to get feedback about their experiences with the Pilot and the air sealing measure. The five subcontractors that did not submit any incentive applications were only asked questions about their reasons for not participating, not specific aspects of the Pilot. See Appendix C for the post-Pilot subcontractor survey.

The findings from these three surveys are organized into the following sections: general comments, reports of measure removal, barriers to participation, measure feedback, measure costs and incentive, working with drywall contractors, training, and motivation for participating.

General Comments

The Pilot concept was usually well liked – one subcontractor commented, "*I think you guys are doing a great job over there.*" During the early feedback survey, the subcontractors were positive about the Pilot and the air sealing measure, "*Everything has been pretty good.*" However, only four of them reported submitting applications for an incentive at that time. Those that had submitted incentive applications reported that the process was smooth and that changes to the forms early on had made things easier. One exception was a subcontractor who experienced lengthy delays in receiving incentive checks, which caused that company to cease participating in the Pilot. By the end of the Pilot, only five of the subcontractors had participated. Of those, some were satisfied with the Pilot and others were not. Areas where there was concern or disagreement among the respondents included the incentive amount, the application process, ease of installation, beliefs about effectiveness, participating in the future, and builders' views on air sealing. These results are summarized in Figure 5 below.

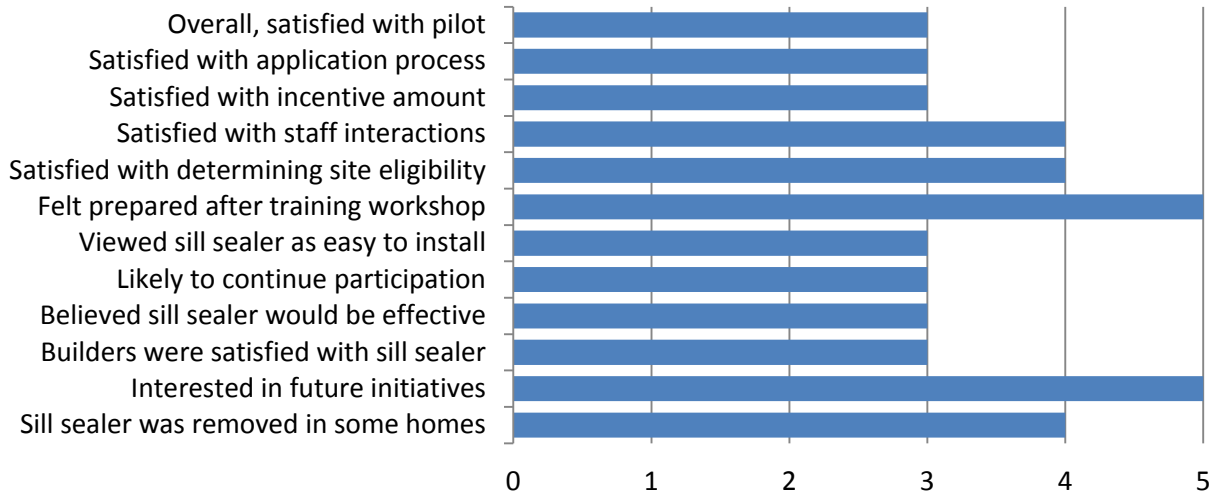

Figure 5. Post-Pilot survey responses of participating subcontractors (N=5).

Training

The results from the post-training evaluation surveys were generally very positive and are summarized in Figure 6 below.

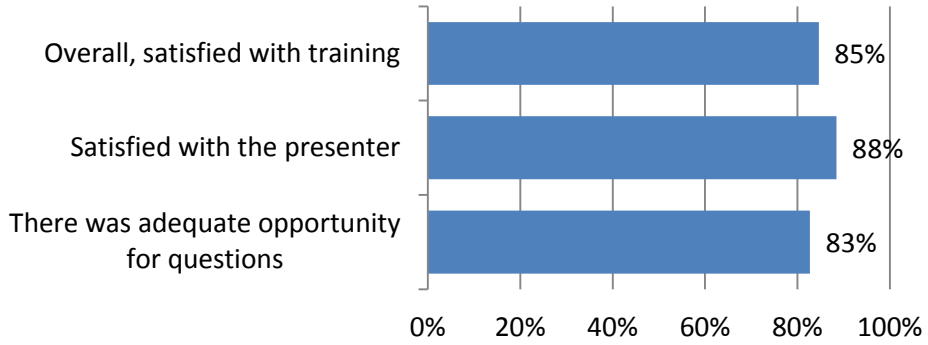

Figure 6. Subcontractor post-training survey responses.

Open-ended comments from participants about the training sessions were either neutral or positive, indicating that subcontractors understood the material and were interested in the Pilot and the new measure. There were no substantive suggestions for improvement. Fifty-one of the 52 respondents reported having good comprehension of how to install the sill sealer after the training. Although a majority of attendees were already familiar with using sill sealer, those who were not appeared to gain a good understanding of the measure as a result of the training.

Subcontractors were asked about the training workshops again during the post-Pilot survey. The majority of comments about the training workshops were positive, consistent with the post-training surveys. A few subcontractors suggested additional types of training that could improve the initiative:

- Do a separate training session with the installation crew on a job site to allow for a more hands-on experience.
- Do education and outreach to train drywall contractors and builders how to properly install drywall with the sill sealer.
- Educate builders about the importance of air sealing so they will instruct their drywall contractors not to remove the sill sealer and to handle it properly.
- Offer training seminars to builders about air sealing that would qualify for continuing education (CE) credit with the Oregon Construction Contractors Board (CCB) to provide them with an opportunity to meet part of their CE requirement while getting them to think about air sealing.

Motivation for Participating

For those subcontractors that received at least one incentive for installing the air sealing measure, we asked about their motivation for participating in the Pilot. Nearly all of the respondents mentioned that staying involved in what Energy Trust is doing and maintaining that relationship was important to their business and a primary motivator for participating in the Pilot. As one subcontractor put it, "*I love working with the Energy Trust. I try working with the Energy Trust every chance I get. It's a great selling opportunity for me*."

Some subcontractors were also interested in the research aspect of the Pilot. These subcontractors were motivated to test the effectiveness of the air sealing measure and work out the kinks in installation both out of curiosity and to determine whether they could offer it to builders as an extra service. As one subcontractor explained, "*We felt* [the Pilot] *was a very good thing. It was interesting*." Another company wanted to find a less costly method to air seal Program homes as well as code homes going

through the blower door code compliance path: "*We knew that there was a lot of air that comes up through the top plate and figured there had to be a cheaper way*."

Reports of Measure Removal

In the post-pilot interviews, insulation subcontractors reported that drywall contractors had removed the air sealing measure in a total of 17 homes, although this includes many non-Pilot homes. Conflict with drywall contractors was a key issue for nearly all of the subcontractors. All of the respondents agreed that communication with the builder and drywall contractor, including educating them about the sill sealer, were essential to resolving this conflict. Simple modifications to drywall installation can ensure that sill sealer is not damaged and that it does not cause problems. However, the drywall contractor must be aware of these practices and get instructions from the builder to adopt them.

Barriers to Participation

"*I haven't had that many jobs that qualify*." This was the most frequent reason that subcontractors cited for not submitting more incentive applications throughout the Pilot. Subcontractors that did not participate or had limited participation reported working mostly on above-code construction or multifamily buildings. This barrier persisted and as one subcontractor noted in the post-Pilot survey: "*We've been doing a lot of the sill sealer, it's just all been on above-code homes*." Another said, "*The builders we have are doing Earth Advantage or EPS*," neither of which qualified for the Pilot.

Lack of interest among code builders was also a major barrier. Some builders were skeptical of the measure, either because they got complaints from drywall contractors or they thought it might negatively affect the drywall job. As one subcontractor put it, "*We're giving it away and they won't let us do it*." Another stated, "M*y estimators kind of got tired of getting turned down and gave up on it*." More than one subcontractor observed that better communication with builders would allow them to install the measure in more homes. They suggested providing a brochure, product sample and other information about the measure to educate them about air sealing and allay their fears about sill sealer. "*I think reaching out to the builders could make this more successful*," one respondent summarized.

A few subcontractors reported that they simply did not do much work in new construction or single family homes, or lacked the time and resources to handle the administrative burden of participating in the Pilot. These subcontractors are probably a poor fit for this initiative and are unlikely to increase their participation under the current design. There were also a few subcontractors that continued to express confusion about the eligibility requirements and did not understand why some homes they worked on did not qualify for the incentive. One subcontractor recommended an interactive mapping tool to alleviate confusion about which homes qualified by displaying Energy Trust's service territory and allowing users to determine which utilities a were connected to a particular house.

Other frequently mentioned barriers were the cost of installing the measure and conflicts with drywall contractors that did not like working with the sill sealer. These are discussed in more detail below.

Measure Feedback

"*Folks that have done it have just loved it*." Some of the respondents really liked the air sealing measure and felt that it was cheap, simple and effective. One subcontractor said, "*I'm a firm believer in sill*

sealer," and "*it's going to last the life of the building*." These 'believers' also mentioned that their builders liked the product and that *"there's nothing that would be cheaper than sill sealer*." However, other subcontractors thought it was too expensive to install and caused too many problems with the drywall contractors. Subcontractors that liked the measure and those that did not both suggested possible alternatives including caulking, spray foam, spray adhesives and sealers. Other ideas included sealing the bottom plate and sealing around windows and doors. A few subcontractors strongly supported using caulk in place of sill sealer to avoid issues with the drywall installation, while others expressed doubt about caulk as an alternative, criticizing its cost, performance, and longevity.

Measure Costs and Incentive

"*I don't like to say it, but it's not really worth it*." Since the incentive was first rolled out, some of the subcontractors felt that it was not enough to cover the cost of installing the measure, a theme that was reiterated in both surveys. Several respondents indicated that the amount of sill sealer needed was higher than originally estimated and that the incentive was insufficient to make the Pilot financially appealing. The subcontractors believed that large homes would be particularly costly to treat with the air sealing measure.

This sentiment was even stronger in the post-Pilot survey where the majority of subcontractors interviewed felt that the cost of the air sealing measure, including the materials and installation work, made it a financial loser, given the incentive amount. One respondent said, "*The incentive wasn't enough for us from a business perspective*," and this sentiment was echoed by many others. Only one subcontractor said that the incentive covered their costs, but they were buying sill sealer in very large quantities. As shown in Table 8, subcontractors reported using an average of 9 rolls of sill sealer per home, at a cost of about $50 and it took approximately 2 man-hours to install. As one subcontractor put it, "*It involved more product and a little bit more time than I think you guys considered*."

Table 8. Reported costs of installing sill sealer.

	N	Mean	Std. Dev.	Min	Max
Average # of rolls of material used per home	4	9.13	1.65	7.00	11.00
Average cost of materials per home	4	$50.00	$25.50	$15.00	$75.00
Average man-hours per home	5	2.00	1.08	1.00	3.75

At the end of the Pilot, a number of subcontractors reiterated that the incentive amount should be based on the size of the home or the amount of material actually used, to compensate for the additional time and material required in larger homes. Offering a tiered incentive based on home size might be justifiable given the fact that the energy savings would be greater in larger homes.

Respondents that did not receive incentives through the Pilot felt that they would have to charge builders to install the sill sealer in order to justify the added cost of the service. However, they did not believe that code builders would be willing to pay extra for the measure: "*I think it's a very good product, but I can't convince them to pay for it*." Some subcontractors thought that the measure might be more valuable to builders who follow the code path requiring a blower door test. This option in the

Oregon building code requires that builders attain a certain level of airtightness without prescribing specific measures, making effective air sealing a valuable service that they might be willing to pay for.

Working with Drywall Contractors

"*The sheet rockers are not liking it*," was a common sentiment expressed during the early feedback survey, mentioned by all four of the subcontractors that had submitted incentive applications. These respondents reported that there were concerns and complaints from drywall contractors and builders about the potential of the sill sealer to cause problems with the drywall. Two of the subcontractors mentioned that drywall contractors had removed the sill sealer in some of the treated homes. Several respondents reported that, "*trying to explain what we're doing to builders has been difficult*." If the builder didn't understand the purpose of the measure, then it was inconsequential to them if the drywall contractor removed it.

In the post-Pilot survey, opposition to the air sealing measure from drywall contractors had become the biggest challenge reported by the insulation subcontractors. The measure required drywall contractors to modify their practices and posed a potential threat to the quality of their work. Nearly every respondent reported problems working with drywall contractors during the post-Pilot survey. Some cited these conflicts as the primary reason for not participating more in the Pilot because some drywall contractors refused to put up drywall on top of the sill sealer. One subcontractor recounted, "The sheet rocker said they were having problems, saying their nails were going to pop. So, we actually quit using [the sill sealer] right away because they refused to use it." Other responses echoed this remark. Some drywall contractors wouldn't warranty their work if the sill sealer was present and others wanted more money. Another respondent observed, "It's all about warranty with them."

Respondents described instances where drywall contractors removed the measure, sometimes repeatedly. One subcontractor explained, "It's *very typical for them to slide the sheetrock up the wall and that just bunches it up, which in turn forces them to rip it off*." The technique that drywall contractors need to use with the measure was described as follows, "*They actually have to hold the sheetrock up and push it on top of the sealer*." While some respondents discredited claims that the measure would affect the drywall, others allowed that it could cause problems and required a different installation method. One subcontractor admitted, "*It was causing more dents in the sheetrock, because they were having to really hammer the nails pretty hard. And then it was pulling the nails through the sheetrock, which in turn caused more taping issues*."

When asked how to resolve these issues, nearly every respondent mentioned communication with the drywall contractors about the air sealing measure and explaining what they need to do differently. One subcontractor summarized, "*I think working with the drywallers is what needs to happen. To me, that's what would be my next task*." Some subcontractors thought that a brochure should be distributed, explaining the purpose and benefits of the sill sealer and giving instructions on the proper way to install drywall on top of it, such that it does not cause any problems. Another suggested meeting onsite with the drywall contractors to talk about the sill sealer and bring them donuts and coffee.

Conclusions and Recommendations

The Air Sealing Pilot proved the effectiveness of a new measure, applying sill sealer to the top plate, and the feasibility of a new Program delivery mechanism for the New Homes Program, working with subcontractors. While the overall conclusion of this evaluation is positive, there are some major obstacles to the proper installation and adoption of this new air sealing measure that must be overcome in the near future. The measure appears to be cost-effective or borderline cost-effective for most typical new home scenarios, even though the observed reduction in air infiltration and estimated savings are slightly lower than originally projected. The measure life should be increased to 45 or 70 years to reflect the true longevity of this measure and to be consistent with similar shell measures, which will help improve its cost-effectiveness. However, if the measure is to continue to be effective and have a long working life, then training and quality control procedures must continue.

The air sealing measure was installed in a relatively large number of new homes, achieved significant energy savings and helped the Program reach many of the high volume code builders in the state. However, the measure was adopted in earnest by only one of the 11 insulation subcontractors initially trained. The others were either unable or unwilling to install it in very many homes. The largest participation issue was the ongoing conflict with drywall contractors who were concerned about the impact of the measure on the quality of their work. Other significant issues were the perceptions that code builders did not value or want added air sealing and that the incentive did not cover the costs of installation. Although using insulation subcontractors had significant challenges, it proved to be a realistic delivery channel and it may be successful if the market barriers can be addressed.

Conclusion: The air sealing measure is simple, inexpensive and successfully reduces air infiltration making it a cost-effective measure.

- ***Recommendation:*** Continue to offer a stand-alone incentive for the measure as well as include it in the air sealing options for the EPS track and add it to the best practices guide.

Conclusion: The biggest single problem facing the Pilot was the backlash from drywall contractors. This conflict resulted in the air sealing measure being removed from a number of homes, several subcontractors dropping out of the Pilot and some builders rejecting the measure.

- ***Recommendation:*** Conduct an outreach and education campaign with drywall contractors to teach them how to install drywall properly on top of sill sealer and convince them that the measure will not cause problems with their work. Continue to place “Do Not Remove” stickers on sill sealer and possibly leave behind information about the measure and how to install drywall on top of it. Offer the air sealing incentive to drywall subcontractors in addition to insulation subcontractors.

Conclusion: While some builders were satisfied with the air sealing measure and happy to take advantage of a free service, others were skeptical of the measure. Those builders that were using other air sealing techniques, either to meet the blower door code path or to build to an above code standard, were more interested in the measure and less concerned with possible drywall problems. If builders understand the value of air sealing and are aware that there is an incentive for a free service, they will

be more likely to request the measure and instruct their drywall subcontractors not to tear it down, leading to more successful adoption.

- ***Recommendation:*** Educate builders about air sealing, the measure and the incentive, and allay their fears that it might cause problems with the drywall. To accomplish this, the subcontractors need sales tools to help them pitch the idea to builders. Provide participating subcontractors with materials to distribute to builders, including an informational brochure, describing the benefits of the measure and the proper method of installing drywall with it, along with a product sample of the sill sealer. Another option would be to offer training workshops about air sealing directly to builders for continuing education credit.

Conclusion: The incentive appeared to be insufficient to encourage subcontractors to install the air sealing measure unless motivated by some other factor. In addition, the amount of time and material required, and therefore the cost, was higher for bigger homes. Thus, subcontractors were reluctant to install the measure in large homes, because they could not recoup their costs. There is some evidence to suggest that the installation costs may come down as subcontractors increase their project volume. Therefore, helping subcontractors surmount the initial startup costs may increase participation.

- ***Recommendation:*** Offer a bonus incentive to subcontractors for the first group of projects that they complete to get them engaged in the initiative and give them an opportunity to ramp up their use of the measure. Also, offer a tiered incentive based on the size of the home or the amount of sill sealer used. The additional savings seen in larger homes should allow for a small increase in the incentive while maintaining the cost-effectiveness of the measure. Since the measure is implemented by subcontractors and the incentive is paid directly to them, this strategy should not influence or incentivize the construction of larger homes.

Conclusion: Working through subcontractors was a successful strategy for recruiting new builders into the Program and could be even more successful with additional outreach.

- ***Recommendation:*** Include info about the New Homes Program, EPS, and the benefits of becoming a trade ally in informational materials for builders regarding the air sealing measure. Provide additional outreach to code builders, including training workshops or webinars about air sealing for continuing education credit.

Conclusion: Many of the participating subcontractors did not do enough work with code built single family new construction to make it worth their while. Other subcontractors did not have the capacity to incorporate a new service into their business or to complete the required paperwork.

- ***Recommendation:*** Do not target these subcontractors; they are probably a poor fit for this initiative. Identify subcontractors that work on a large volume of code built, single family new construction, are interested in an additional service to provide to builders and have the time and resources to implement the measure and handle the paperwork. Potentially target other types of subcontractors that might participate more actively.

Conclusion: Training workshops could have been structured differently to better prepare subcontractors and motivate them to actively participate.

- ***Recommendation:*** Split subcontractor training workshops into two parts: 1) an overview and administrative training with managers and office staff that includes going through the incentive application and 2) an on-site, hands-on technical training with work crews that includes installing the measure.

Conclusion: Staff and subcontractors identified a number of additional air sealing strategies that may be worth investigating, including: blown in blanket insulation; sealing the bottom plate; sealing the junction of the sheathing and the top plate; additional sealing around windows, doors and plumbing and electrical penetrations; caulking, spray foam or spray adhesive in place of sill sealer; Owens Corning EnergyComplete; and low energy, alternative ventilation strategies.

- ***Recommendation:*** Test the effectiveness of additional air sealing measures and offer stand-alone, prescriptive incentives for those that prove to be cost-effective.

Citations

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Appendix A: Training Session Evaluation Survey

English Version

Thank you for attending out training workshop. We make every effort to provide you with innovative and useful training experiences. Please take a moment to let us know how we are doing.

Circle your answer

1. **Overall, how satisfied were you with this training?**

   1= Very Unsatisfied 2= Unsatisfied 3= Neutral 4= Satisfied 5= Very Satisfied

2. **How satisfied were you with the presenter(s)?**

   1= Very Unsatisfied 2= Unsatisfied 3= Neutral 4= Satisfied 5= Very Satisfied

3. **Do you agree that there was adequate opportunity for questions and discussion?**

   1= Strongly Disagree 2= Disagree 3= Neutral 4= Agree 5= Strongly Agree

4. **Please rate your knowledge / ability to install sill sealer:**

   Prior to training:
   1= Very Poor 2= Poor 3= Fair 4= Good 5= Very Good

   After completing the training:
   1= Very Poor 2= Poor 3= Fair 4= Good 5= Very Good

5. **What did you find most interesting/informative?**

6. **What did you find the most difficult to understand?**

7. **What else should have been included in the training?**

Thank you for your input!

Please return this form to the presenter.

Spanish Version

Gracias por asistir a nuestro taller de capacitación. Hacemos todos los esfuerzos posibles para proporcionarle experiencias innovadores y capacitaciones útiles. Por favor tome un momento para hacernos saber cómo lo estamos hacienda.

Marque con un círculo su respuesta

9. **En general, ¿Cuán satisfecho quedó usted con esta capacitación?**

   1= Muy insatisfecho 2= Insatisfecho 3= Neutral 4= Satisfecho 5= Muy satisfecho

10. **¿Cuán satisfecho quedó usted con la presentadora(s)?**

    1= Muy insatisfecho 2= Insatisfecho 3= Neutral 4= Satisfecho 5= Muy satisfecho

11. **¿Usted está de acuerdo que hubo oportunidad adecuada para preguntas y discusión?**

    1= Totalmente en desacuerdo 2= En desacuerdo 3= Neutral 4= De acuerdo 5= Muy de acuerdo

12. **Por favor evalúe su conocimiento/capacidad para instalar el sellador de umbrales:**

    Antes de la capacitación:
    1= Muy mala 2= Mala 3= Regular 4= Buena 5= Muy buena

    Después de completer la capacitación:
    1= Muy mala 2= Mala 3= Regular 4= Buena 5= Muy buena

13. **¿Qué hallo más interesante/informativo?**

14. **¿Qué no entendió?**

15. **¿Qué información extra se debió incluir en la capacitación?**

¡Gracias por su colaboración!

Por favor devuelva este formulario a la presentadora.

Appendix B: Subcontractor Early Feedback Interview Guide

Instructions

Interview to be conducted with ALL subcontractors enrolled in the pilot whether or not they have submitted projects for an incentive yet.

Introduction

Hi, this is _____ from Energy Trust of Oregon. As you know, we're running a pilot program to pay cash incentives to contractors for installing sill sealer on the top plate during construction of new, code-built homes. We would like to improve the pilot and your feedback is very important to us. I'd like to ask you a couple questions about your participation in the pilot. It should take just a few minutes. Is this a good time?

> If "NO", then schedule a time to call back.

Screening questions

S1) Have you submitted any incentive applications to Energy Trust yet?

> If "YES", then got to Section1, if "NO", then go to Section 2.

Section 1: Questions for subcontractors that have already submitted a project

Q1) What is the biggest issue that you've had with Energy Trust's air sealing pilot so far?

> (Probe about: training, time, cost, not enough information, incentive application, interaction with Energy Trust, installation, measure choice, builders)

Q2) What would you change about the pilot?

Section 2: Questions for subcontractors that have not submitted a project yet

Q1) Why haven't you submitted any air sealing projects for an incentive yet?

> (Probe about: training, time, cost, not enough information, incentive application, interaction with Energy Trust, measure choice, builders)

Q2) What would you change about the pilot?

Appendix C: Subcontractor Post-Pilot Participation Survey

Respondent Information:

Company Name: _____
# of Projects: _____
Contact Name: _____
Contact Phone #: _____
Contact Email Address: _____

Survey Introduction:

Hello, this is _____ with Energy Trust of Oregon. I would like to ask you some questions about your company's participation in Energy Trust's pilot program to improve air sealing in new single family homes. The interview should take about a half hour. Is this a good time?

- □ Yes
- □ No

➔ If Yes, then PROCEED
➔ If No, then SCHEDULE SURVEY. When would be a good time for me to call you back?

(If Yes): Energy Trust has made incentives available since May of 2012 for contractors to install sill sealer on the top plate of new homes prior to drywall installation. We would like to get your feedback on how well the pilot program and the sill sealer worked so that we can make improvements.

I would like to record this interview in order to accurately document your responses. Is that okay with you?

Screening Questions:

1. Our records show that your company has submitted [# OF PROJECTS] application(s) for sill sealer projects in new homes since the beginning of the pilot. Does that sound correct?
   - □ Yes
   - □ No, please specify correct number:_____
   - □ (Don't Know)

➔ If # OF PROJECTS = 0, then ask Q2 and Q3 then skip to END OF SURVEY. Else skip to Q4.

2. (If # OF PROJECTS = 0): Why hasn't your company submitted any air sealing projects for an incentive yet?
   (Probe about: finding jobs that qualify, training, time available, installation cost, not enough information, incentive application, incentive amount, interaction with Energy Trust, measure choice, builders, not contractor's target market, business is slow)

3. (If # OF PROJECTS = 0): What could Energy Trust do to get your company to participate in the future?
   (Probe about: installation cost, incentive amount, support, identifying eligible sites, project leads, better marketing/distribution of information, provide information to builders)

➔ If # OF PROJECTS = 0, then skip to END OF SURVEY.

The pilot program, process and measure:

4. After the training workshop, how prepared were you to begin installing sill sealer in new homes? On a scale from 1 to 5, 1 is 'Not Prepared at All' and 5 is 'Very Prepared'.
   - □ 1 = Not Prepared at All
   - □ 2
   - □ 3
   - □ 4
   - □ 5 = Very Prepared
   - □ (Don't Know)

5. What else should Energy Trust include in the training, if anything?

6. What was is it that motivated your company to participate in the air sealing pilot program? (Probe about: Energy Trust cash incentive, Ability to offer an additional service to builders, To gain a competitive edge over other contractors, The opportunity for a free training workshop, Information received from Energy Trust, Communication with an Energy Trust representative, Information provided at the on-site training workshop)

7. For each of the following components of the pilot program, tell me how satisfied you were. On a scale of 1 to 5, 1 is 'Very Dissatisfied' and 5 is 'Very Satisfied'.

	Response:					
Pilot component:	**1**	**2**	**3**	**4**	**5**	**DK**
Incentive application process.						
Incentive amount offered for air sealing projects.						
Interactions with Energy Trust staff.						
The quality control inspections.						
Determining if sites were eligible for the incentive.						

➔ If any Q7 response = 1 or 2, then ask Q8. Else skip to Q9.

8. (If any Q7 response = 1 or 2): Why weren't you satisfied with the [ENTER PILOT COMPONENT]?

9. How difficult was it to install the sill sealer on the top plate in new homes? On a scale from 1 to 5, 1 is 'Very Difficult' and 5 is 'Very Easy'.
   - □ 1=Very Difficult
   - □ 2
   - □ 3
   - □ 4
   - □ 5=Very Easy
   - □ (Don't Know)

➔ If Q9=1 or 2, then ask Q10. Else skip to Q11.

10. (If Q9 = 1 or 2): What made installation difficult?

11. How effective do you think the sill sealer will be in reducing air infiltration into homes? On a scale from 1 to 5, 1 is 'Not Effective at All' and 5 is 'Very Effective'.
    - □ 1= Not Effective at All
    - □ 2
    - □ 3
    - □ 4
    - □ 5=Very Effective
    - □ (Don't Know)

12. What air sealing products or methods, if any, do you think would be preferable to installing sill sealer on the top plate? Why?

13. How much sill sealer did your company use in the average home?

14. How much did the sill sealer cost to install in the average home?

15. How many man-hours did it take to install the sill sealer in the average home?

16. If the pilot becomes a permanent part of Energy Trust's program, how likely is it for your company to continue offering sill sealer installation to home builders? On a scale from 1 to 5, 1 is 'Not Likely at All' and 5 is 'Very Likely'.
    - □ 1 = Not Likely at All
    - □ 2
    - □ 3
    - □ 4
    - □ 5 = Very Likely
    - □ (Don't Know)

General satisfaction with pilot program:

17. Overall, how satisfied are you with Energy Trust's air sealing pilot program? On a scale from 1 to 5, 1 is 'Very Dissatisfied' and 5 is 'Very Satisfied'.
    - □ 1 = Very Dissatisfied
    - □ 2
    - □ 3
    - □ 4
    - □ 5 = Very Satisfied
    - □ (Don't Know)

18. What aspect of the pilot program were you the most happy with?

19. What aspect of the pilot program were you the least happy with?

20. Based on your experience with this pilot, would your company be interested in participating in future Energy Trust initiatives to install other energy upgrades in new homes?

- □ Yes
- □ No
- □ (Don't Know)

Builders' reactions to the pilot:

21. In general, how satisfied do you think builders were with the sill sealer? On a scale from 1 to 5, 1 is 'Very Dissatisfied' and 5 is 'Very Satisfied'.
    - □ 1 = Very Dissatisfied
    - □ 2
    - □ 3
    - □ 4
    - □ 5 = Very Satisfied
    - □ (Don't Know)

22. How much do you think builders are willing to pay for sill sealer installation in the average home?

23. What did builders like about the sill sealer?

24. What complaints, if any, did you hear from builders about the sill sealer?

25. To your knowledge, were there any cases where the builders or drywall contractors removed the sill sealer after your company installed it?
    - □ Yes
    - □ No
    - □ (Don't Know)

➔ If Q25 = Yes, then ask Q26 and Q27. Else skip to Q28.

26. (If Q25 = Yes): How many homes do you know of where this happened?

27. (If Q25 = Yes): What can be done to avoid this in the future?

28. How did your company promote air sealing services to builders?

29. What could Energy Trust do to help your company sell air sealing services to home builders?

Company characteristics:

I have just a few more questions and then we'll be done. These questions are about your company so that we can understand the types of companies are participating in the pilot.

30. Was your company an Energy Trust trade ally PRIOR to this pilot program?
    - □ Yes
    - □ No
    - □ (Don't Know)

31. Does your company participate in Energy Trust's Existing Homes program as well as the New Homes program?
    - □ Yes
    - □ No
    - □ (Don't Know)

32. Prior to the pilot program, did your company provide air sealing services or make air sealing packages available to builders?
    - □ Yes
    - □ No
    - □ (Don't Know)

33. What types of homes make up your company's core business? Choose all that apply from the following list:
    - □ New construction
    - □ Existing homes
    - □ Single family homes
    - □ Small multifamily buildings (If necessary, clarify: duplex/triplex/quad/town homes)
    - □ Large multifamily buildings (If necessary, clarify: >4 unit apartment buildings, condos, etc.)
    - □ Commercial buildings

34. About how many people does your company CURRENTLY employ?

35. About how many NEW single family homes has your company worked on in 2012?

36. About how many EXISTING single family homes has your company worked on in 2012?

Wrap-Up:

37. Do you have any additional feedback or comments about the pilot or Energy Trust?

That's it. Thank you for taking the time to answer all of my questions. Your feedback is important to us and will help us make improvements to the pilot program.

Appendix D: Staff Interview Guide

Respondent Information:

Staff Name: _____
Phone #: _____
Email Address: _____

Introduction:

Hi, this is _____ at Energy Trust; I'm calling to talk about the New Homes Air Sealing Pilot. Is this still a good time? I'd like to discuss how the pilot went/is going from your perspective. What worked, what didn't work… that sort of thing. It should take about a half hour.

Pilot Goals

1. What are the goals of the Pilot, as you understand them?
2. Do you feel that the Pilot is achieving its goals?
    a. Why or why not?

Pilot Process

3. What changes have been made to the Pilot since its launch? (Probe: incentive application, incentive amount, geographic area, impact of changes)
4. How well has the incentive application and approval process worked?
    a. What have the challenges been? (Probe: too much data required, getting contractors to send in forms, bulk incentive applications)
    b. What would you change going forward, if anything?

Outreach/Recruitment

5. How did outreach to and recruitment of insulation subcontractors go? (Probe: met training/ enrollment goals, difficulty generating interest, few existing relationships, getting subcontractors to take time, incentive not enticing enough)
    a. What outreach and recruitment methods worked? (Probe: cold calls, site visits)
    b. What didn't work?
    c. Do you have any other ideas for outreach strategies going forward?
6. Has the Pilot resulted in any new builder trade allies?
    a. Why or why not?
    b. Could prescriptive air sealing be a useful strategy for recruiting new builders into the program?

Uptake

7. Subcontractor participation was slow to get going. What were the reasons for this? (Probe: low project volume, only a few large companies, reluctance to try something new, disinterest from builders, too busy already)

8. The Pilot has been dominated by Westside Drywall. Why do you think this is? (Probe: Large company, number of jobs, economy of scale)
9. If air sealing continues as a prescriptive measure, do you think other subcontractors will install a significant amount of sill sealer in the new homes market?
    a. Why or why not?

Communication

10. What communication issues have arisen with the subcontractors, if any? (Probe: understanding of Pilot, understanding of eligible sites, incentive application issues, proper sill sealer installation)
11. What communication issues have there been internally or between PECI and Energy Trust, if any?
12. What communications are builders receiving about the Pilot and sill sealer, if any?

Training Workshops

13. Could anything be improved or changed with the training workshops?
14. Were the onsite quality control visits a valuable part of the training process for subcontractors?

Quality Control

15. There were a couple documented cases where the drywall installer pulled down the sill sealer. What could be done to prevent or quickly address situations like this in the future?

Incentive/Costs

16. Do you think the incentive is sufficient to make installing sill sealer attractive to subcontractors? (Probe: cost of time and material, value to builders)
17. What can be done to improve the value proposition for subcontractors?

Other Avenues

18. What other groups besides insulation subcontractors could Energy Trust work with to increase air sealing in the new homes market? (Probe: drywall contractors, home builders)
    a. How could we do effective outreach to that group?
19. Do you think the initiative should continue using the same measure?
    a. Are there other potential air sealing measures that you think might be more effective or have a lower cost?

Wrap-Up

20. What is your overall feeling about the Pilot?
    a. Has it been a successful learning experience? (Probe: learned about measure, learned about working with subcontractors, learned about pilot process)
21. Do you have any other comments about the Pilot?

Thank you for your time.

Appendix E: Fluid Market Strategies Top Plate Air Sealing Report

Top Plate Air Sealing Pilot

Draft Report

Prepared by Fluid Market Strategies for
Energy Trust of Oregon
03.14.2013

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DRAFT REPORT - TOP PLATE AIR SEALING PILOT

BACKGROUND

Energy Trust of Oregon operates multiple programs that reduce energy use in newly constructed homes. To explore the possibility of expanding these offerings, Energy Trust conducts pilots to help determine the market acceptance and cost effectiveness of possible new measures. This report provides results on a pilot program that initiated the use of sill sealing to provide a gasket between the top plate of walls and the sheetrock in new home construction. This measure was tested to determine if it would create a tighter air seal in the homes treated. The sill sealer was applied to the top plate of exterior and interior walls of only the top floor of the structure. The picture below indicates the location of the sill sealer gasket.

Figure 1 – Sill Sealer Gasket Location

INCENTIVES

Insulation contractors were paid an incentive of $125 to install the measure. Builders that allowed the program to test non-treated homes were paid an equal amount.

PRODUCT DESCRIPTION

Sill sealer is a polyethylene foam product designed to last the life of a house. In its application as a gasket between dry wood and sheetrock, it is not exposed to water or UV light, and therefore the material is not likely to degrade. The Regional Technical Forum (RTF) deems shell measures with a life of 70 years. This study finds no reason to disagree with the RTF assessment.

The pilot project was jointly carried out by Energy Trust, PECI and Fluid Market Strategies (Fluid). PECI was the project lead in contractor training, contractor outreach and program management. Fluid aided with contractor outreach, conducted the field measurements and analyzed the data. There was a high degree of cooperation between all parties in this pilot, which aided in its successful completion.

This report focuses on the in the infield inspection/diagnostics and the results of those efforts.

RESEARCH DESIGN

The project involved the air tightness testing of two groups of newly constructed homes. The untreated sample tested 39 homes without treatment and the treated sample tested 40 homes with top plate gasket installed. The homes were limited to single family detached homes constructed in 2012 and built in the greater Portland, Oregon area. No homes greater than 3,500 square feet were tested. The builders were recruited for testing by telephone and site visits. The homes were tested at "final" with all trim, carpeting and painting completed. Homes participating in energy efficient home programs such as Energy Star New Homes or ERPS were excluded from the study.

TESTS CONDUCTED

All homes were tested for airtightness using a Minneapolis blower door in conjunction with a DG-700 manometer. An extensive checklist (located in Appendix A) was utilized to ensure that the homes were uniformly prepared for the testing. This included such items as crawl space ventilation position, window latch position and exterior garage door position.

In addition to the air tightness test, exhaust fans were measured using the Energy Conservatory's Exhaust Fan Flow meter. In addition, the same device was used to measure the pressure at electrical wall outlets when the house was depressurized to – 25 Pascals. Outlet measurements were done purely to identify a possible quality control test and not as a possible house tightness measurement.

In addition to the diagnostic pressure measurements, all homes with treatment were visually inspected from the attic for presence of the sill sealer, the picture below indicates the presence of the sill sealer.

Figure 2 – Sill Sealer Installation confirms from attic

HOUSING CHARACTERISTICS

The average conditioned square footage of the homes in the study was 1944 square feet. The average square footage of the homes without treatment was 2055. The average square footage for with treatment homes was 1837. The chart below shows the breakdown in-house size for both groups.

Of the 79 homes in the project, only was one was a single-level houses, four were three stories and rest were two story homes. All homes had ducted heating systems.

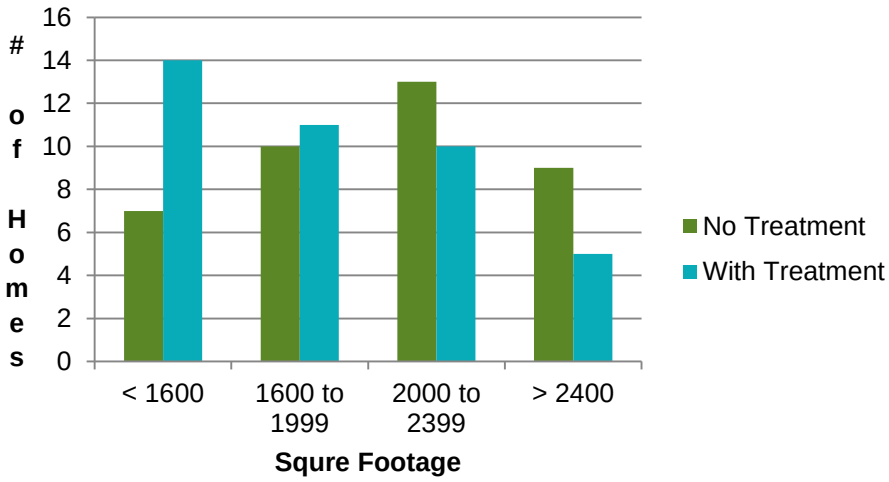

Figure 3 – Conditioned Square Footage

FINDINGS

House tightness is most typically expressed in air changes per hour at 50 Pascals (ACH@ 50Pa.) While this ratio is useful, it can show a bias when comparing homes of unequal sizes. Larger homes usually have more square feet of conditioned space per square footage of exposed surface area than do smaller homes. It is at the exposed surface areas (floors, walls, ceilings) that homes leak. The chart below shows the general trend that as homes become larger the ACH @50Pa tend to decrease.

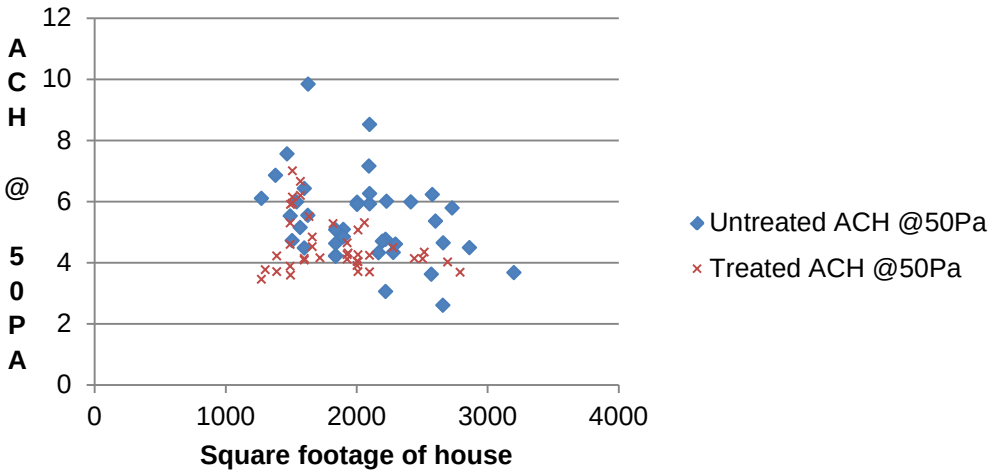

Figure 4 – ACH @ 50PA VS Square Footage

ACH @50Pa

For purpose of comparison with other programs, the ACH @ 50Pa was calculated. The ACH@50Pa for the untreated homes was 5.38. The same ratio for treated homes was calculated at 4.58, resulting in a difference of 0.8

ACH@50Pa between the two groups. The ACH 50 for Energy Star Homes built in Northwest Oregon for the years 2007 through 2012 is a shown for comparative purposes.

Western Oregon	2007	2008	2009	2010	2011	2012
Ach@50Pa	5.48	5.24	5.09	4.48	4.11	3.76

Table 1 – Energy Star ACH 50 for 2007-2012

CFM@50Pa/ SQ Ft

To minimize the bias that house size has on reported house tightness, this report uses a ratio of cubic feet per minute, at 50 Pascals, per square foot (CFM @50Pa/sq. ft.). This minimized the standard deviations in both groups and a T-test resulted in a low p-value of 0.004, indicating that the difference between the two groups is statistically significant.

	Without Treatment	With Treatment	Difference
Average CFM@50Pa/Ft.2	0.76	0.65	0.11
Standard Deviation of Average CFM50/Ft^2	0.20	0.12	0.07
Average Ft^2	2055	1836	

Table 2 – CFM@50p/Sq Ft

An example using this data indicates that an untreated 2,000 sq. foot house would have a CFM@50Pa reading of 1520 while an identical house with the measure would have a CFM@50Pa reading of 1300, for a difference of 220. This represents a leakage reduction of 15 percent.

	Sq. Ft.	CFM50Pa/Sq.	CFM @50Pa
Without measure	2000	0.76	1520
With measure	2000	0.65	1300
			220

Table 3 – Extent of Leakage Reduction

Outlet Pressure Measurements

These tests were conducted with the house depressurized to -25Pa and using the Exhaust Fan Flow Meter to cover electrical wall outlets. These measurements were taken only on the top floor of the homes. Additionally location of the outlet on interior and exteriors walls was recorded. As the chart below indicates, there was a difference in the average pressure reading for homes with and without treatment.

Outlet Location	With Treatment	Without Treatment
Exterior Walls	0.47 Pa	0.57 Pa
Interior Walls	0.31 Pa	0.37 Pa

Table 4 – Outlet pressure for home with and without treatment

The original intent of these readings was to determine if simple, easy–to-follow rules could be developed using these readings that could accurately determine if a measure was installed or not. While on average, the homes with treatment do have lower outlet pressure readings than homes without the treatment, no easy-to-follow rules could be developed that could serve as a quality control tool.

ENERGY SAVINGS

Ecotope Inc. of Seattle Washington was commissioned to generate energy savings using the energy modeling software SEEM 94. The three base case homes that the RTF uses to model energy efficient measures were used in these simulations. These homes represent typical Northwest homes of 1344 square feet, 2200 square feet and 2688 square feet. The homes were assumed to be built to Oregon code levels and were modeled in both Portland and Redmond, Oregon. The heating system for the gas heated homes was assumed to have an AFUE of 83% and the heat pump system was assumed to have an annual operating COP of 2.2.

Additionally, it was assumed that these homes had a 50 CFM exhaust fan running four hours per day.

The modeled house nearest to the homes found in the sample is the 2200 square foot house. It is a two-story house typical of the style that dominated the homes tested in this project. Therms savings for this house are estimated to be 13 therms annually in Portland, and 17 therms annually in Redmond.

Modeled House	State	City	Without Treatment	With Treatment		Without Treatment	With Treatment	
			Therms used for heating	Therms used for heating	Therm Savings	kWh Heat pump COP 2.2	kWh Heat pump COP 2.2	Kwh Savings
1344 sq. ft.	OR	Portland	199	193	6	2196	2126	70
2200 sq. ft.	OR	Portland	373	360	13	4110	3969	141
2688 sq.	OR	Portland	310	298	11	3414	3288	126
1344 sq. ft.	OR	Redmond	328	319	9	3617	3520	98
2200 sq. ft.	OR	Redmond	587	569	17	6464	6271	193
2688 sq. ft.	OR	Redmond	497	481	16	5478	5304	174

Table 5 – Energy savings in RTF base case homes

OVERALL CONCLUSIONS AND FINAL COMMENTS

The use of a sill sealer as a gasket between the top plate of interior walls and the attached sheetrock results in Oregon code levels homes being on average 15% tighter than homes without the measure. Modeled estimates of savings suggest this would result in annual heating savings of 3.5 percent in the typical new home.

The degree to which this is a reproducible measure in terms of contractor training and quality control must be subject to scrutiny before this measure is approved as a deemed measure.

Finally, all homes in this study would not meet Washington's State ventilation code or ASHRAE 62.2. Some are not in compliance with Oregon's code. The issue of ventilation in new homes will only become more complex in the near future as homes continue to become tighter and code in Oregon shifts to meet national standards such as ASHRAE 62.2. There is evidence from the Energy Star homes program in Oregon (that must meet ASHRAE 62.2) that the ventilation system contractors most often choose (supply only delivered through the HVAC system) to meet the ventilation standard has large energy use implications. Energy efficiency programs in the new home market will have to develop a strategy to comprehensively manage the incorporation of ventilation mandates or many of the gains in energy efficiency will be lost.

ACKNOWLEDGEMENTS:

This pilot program was funded by Energy Trust of Oregon. In addition to the funding, the engaged and consultative management style of Matt Braman aided its successful completion. The open communication between PECI and Fluid helped to make the pilot successful and enjoyable to conduct. Special thanks are due to Scott Leonard, Eric Bell, and Patrick DeGiovanni for their professionalism and cordiality. Finally, the relentless efforts of Sean Williamson in the recruitment of builders and his careful testing are due recognition.

APPENDIX A – BLOWER DOOR TEST PROCEDURES FOR HOMES INVOLVED IN THE AIR SEALING PILOT

Background: The goal of this document is standardize testing for individuals conducting air tightness tests for the air sealing pilot. As always, using recently calibrated equipment is a must. As standard maintenance, it's always a good idea to check hoses for leaks, and trim off the "bell" that tends to form on the end of the hoses from being forced over the various blower door and manometer fittings.

House Set up

1. Exterior Garage door shut
2. Check to see if the majority of crawl space vents are open
3. All exhaust fans off
4. Air handler off
5. All gas appliances set to off or pilot
6. If house has a hole in the return side ventilation system, make sure damper is shut. Most dampers are power open so cutting the power supply to the furnace will close dampers
7. Tape off dryer vent from inside if dryer not in place
8. Latch all windows
9. Open all interior doors
10. Install blower door; make sure there are no edge gaps. Make sure outside tap is not in discharge airstream of the fan
11. Depressurize house to 25Pa and conduct the "idiot sweep" looking and feeling for air movement that would suggest an open window or crawl access

Conducting the test

12. Set manometer to pressure and flow@50Pa
13. Ramp up blower door to around 25. Record calculated flow at 50Pa
14. Switch manometer to read pressure flow. Adjust Pressure to minus 50Pa WRT outside. Record CFM@50Pa. The two numbers should be within 50. If not, repeat test.

Other Measurements

15. Calculate or capture total floor square footage for ACH calculation.
16. Measure the liner footage of interior and exterior walls on top floor of house
17. Depressurize house to -25Pa WRT outside, using TEC exhaust flow meter in the CLOSED position record the pressure when placed over an electric outlet. Be sure to wait at least 5 seconds for the reading to stabilize. Record if outlet is on an interior or exterior wall.
18. Using the TEC exhaust flow meter, record CFM of all bathroom exhaust fans.
19. If house has the top plate with seal sill, attempt to locate from the attic and photograph
20. Pick up and a pack
21. Return all equipment to as found
22. Lock house
23. Retrieve coffee mug

APPENDIX B – EXHAUST FAN FLOW

Exhaust fan flows were measured primarily to collect data on exhaust fan performance. Oregon code and ASHRAE 62.2 require minimum flow rates of 50 CFM intermittent for bathrooms with showering or bathing facilities. This study did not note the presence of shower/bath facilities, however this report can state that the master bedroom bath always had a shower facility and the secondary upstairs bath in the majority of homes also contained shower/bath facilities. Downstairs bathrooms typically functions as a toilet facility and of course laundry rooms never have these shower/bath facilities.

As evidenced by the chart below, there is a strong correlation between location and exhaust fan flow. This is due to the standard building practice of installing higher quality fans in bathrooms with showers/baths and perhaps also reflects that it easier to vent exhaust fans located on the top floor of a house than from the first floor. This harder-to-vent condition may cause venting paths to become complex on their path to outside the house, thus raising the static pressure the fan has to operate against, and lowering the CFM throughput.

	Average Flow	# Over 50	# Under 50	% under 50 CFM
Master Bedroom 1	68	59	9	13%
Master Bedroom 2	48	6	10	63%
Upstairs Bathroom	67	60	5	8%
Downstairs Bathroom	50	29	27	48%
Laundry	51	41	24	37%
Total		195	75	38%

Table A.1 – Correlation between location and exhaust fan flow