Final Report

Existing Home Prescriptive Air Sealing Pilot Evaluation

July 17, 2015

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Funded By:

Energy Trust of Oregon

Prepared By:

Research Into Action, Inc.
SBW Consulting, Inc.

research into action inc

www.researchintoaction.com

PO Box 12312
Portland, OR 97212

3934 NE Martin Luther King Jr. Blvd., Suite 300
Portland, OR 97212

Phone: 503.287.9136
Fax: 503.281.7375

Contact:
Jane S. Peters, President
Jane.Peters@researchintoaction.com

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Executive Summary

This report describes the results of the evaluation of Energy Trust of Oregon's (Energy Trust) Existing Homes Prescriptive Air Sealing (Air Sealing) pilot. The primary pilot goal was to determine whether prescriptive attic air sealing in combination with attic insulation is a viable strategy for Energy Trust to achieve cost-effective gas savings in existing gas-heated homes.

The secondary goals of this evaluation were to:

- Validate the savings of the prescriptive air sealing measures installed through the pilot.
- Determine how well the air sealing strategy works for the participating contractors.
- Identify what the incremental costs for air sealing are when installed concurrently with attic insulation.

Energy Trust will use the findings from this evaluation to decide if the Existing Homes program should incentivize this combination measure.

To complete our research, we conducted the following four data collection activities:

1. Program/implementation staff interviews (n=6)
   a. Energy Trust staff (n=2)
   b. CLEAResult implementation staff (n=4)
2. Trade ally interviews (n=5)
3. Pilot summary data review
4. Blower door analysis

Below we first present the key conclusions findings with the supporting findings for each research question. Next, we present our overall conclusion and recommendations.

Key Findings

What are the savings associated with prescriptive attic air sealing?

Measure savings vary based on heating zone. We found that attic insulation saved participants between 60 and 93 therms annually depending on heating zone, and attic air sealing saved participants between 11 and 12 therms annually. In addition, insulation installed through the pilot reduced the air leakage by an average of 0.024 air changes per hour (ACH) after the reduction of 0.079 ACH due to air sealing. The combined savings from the two measures varied from 71 to 105 therms, depending on heating zone.

What are the incremental costs associated with prescriptive attic air sealing?

Incremental costs vary based on house size and project demands. The incremental cost of prescriptive attic air sealing is tied to the time necessary to complete the job. Four of the five interviewed trade allies estimated that prescriptive attic air sealing takes from two to eight hours and costs between $400 and $1,000 per job depending on the size of house and work demands, that is, the ease and complexity of job.[1]

What are the most cost-effective areas and methods to air seal an attic?

An uninterrupted workflow and clear access in the attic are the primary elements to cost effectively air sealing an attic. All five of the interviewed trade allies noted that their preferred method of working is to start in one corner and work in a linear fashion across the attic until the job is complete. They explained that working in this linear method enabled them to move quickly through the project while doing a thorough job. Since many trade allies are paid by the job, completing as many projects per day is the most profitable approach for the contractor and cost effective for Energy Trust. However, the pilot requirements (to seal the sheetrock penetrations, chases, and top plates, in that order, as well as pausing for periodic blower door testing between sealing) resulted in allies completing fewer projects per day.

Does prescriptive attic air sealing cost less than blower door-guided air sealing?

Blower door-guided air sealing adds time and cost to attic air sealing projects, and is a disincentive to implementing the measure. All five of the interviewed trade allies reported the required blower door testing added additional time to each project. These trade allies suggested the additional time ran between 30 minutes and one hour. The second most active trade ally noted that this extra time could limit the number of projects an installation crew could complete in a day. The trade allies reported that for their crews who receive payment by the project, not being able to complete additional projects was a disincentive to participate in the pilot.

Could a cost-effective air sealing measure be designed for gas heated homes?

The savings are likely too small to offer a cost-effective air sealing measure. Trade allies reported that the pilot incentive ($400) did not cover the full costs of implementing the measure while adhering to all the pilot requirements. These costs may have limited pilot participation, lengthened the pilot period, and led to lukewarm acceptance of the measure by trade allies. When trade allies provided their thoughts on the viability of the measure on a larger scale, it was difficult to know whether they could make that assessment based on their experience in the pilot. Overall, they reported that the $400 incentive was necessary and that being able to implement the

[1] The most active ally representative was unable to provide feedback on incremental costs.

measure with minimal work stoppage was critical. While the later point can be addressed, the former will require additional research as the limited savings available for the measures is too small to warrant a $400 incentive.

Could a measure and incentive structure be designed that ensures accurate reporting of project details?

A flat rate incentive minimizes the reportable data and caps the incentive amount. While the pilot flat rate incentive design ensured accurate reporting of project details, adequate quality assurance was difficult and costly to implement, as air sealing is difficult to verify post installation.

Could quality assurance be easily performed on this type of measure?

Staff will need to carefully consider how to incorporate oversight protocols that will achieve a high level of confidence in savings and be easily implemented by trade allies. All pilot staff expressed concern about how to easily verify air sealing as a combined measure with attic insulation. Because air sealing is not visible it is hard to verify once the attic insulation is completed. In addition, staff noted concerns about the potential time and expense required to ensure trade allies complete the air sealing appropriately. One method mentioned by several (4) staff was for trade allies to provide geo-stamped and time-stamped photo evidence of air sealing as verification of appropriate installation. One of these staff members also mentioned the possibility of combining photo evidence with a required checklist as a way to provide additional evidence of correct installation.

Three trade allies suggested that requiring pictures and a checklist to ensure quality would be possible in a full-fledged offering.[2] However, two of the three noted it would change their current procedures and one of these two expressed some concern with purchasing cameras or smartphones for staff. The remaining trade ally noted that he already used a checklist and pictures as part of quality assurance in a low-income program. This ally reported it would be easy to adopt this procedure for the Energy Trust Existing Homes program.

Could a prescriptive attic air sealing measure expand the number of homes that receive air sealing?

Trade allies believe there remains a large market of eligible customers for a combined attic air sealing and insulation measure. However, trade allies need further convincing that the measure can be profitable to promote the measure. Four of the five interviewed allies estimated conducting between 100 and 1,500 attic insulation jobs per year with about half of the jobs (50 to 750 per trade ally) being eligible for the Energy Trust combined measure. Three of these allies estimated about half and the remaining trade ally estimated about a third of these jobs would qualify for prescriptive attic air sealing.

[2] The two most active ally trade allies did not provide feedback on future quality assurance.

According to pilot staff and trade allies, some eligible customers may not have been offered the opportunity. Specifically, three trade allies assessed eligibility after recruitment and two assessed it before. Three allies also reported that they did not do much staff training, due to concerns the measure would not be available in the future.

Would a prescriptive attic air sealing measure achieve market acceptance?

It is uncertain if a prescriptive attic air sealing measure will achieve market acceptance. The majority (5) of the interviewed program staff expressed uncertainty regarding market acceptance of a perspective attic air sealing measure. However, their reasoning was not uniform. Specifically, two allies spoke of lack of interest from customers and contractors in the measure; one noted the general reduction in participation in energy efficiency from owners of gas heated homes (he linked this to the lowering of natural gas prices); and the fourth staff member reported that air sealing produces less certain savings when compared to other energy efficiency upgrades.

Conclusion and Recommendations

Conclusion

There were challenges in implementing the pilot and while the trade ally reception to the measure was lukewarm, the general response to the possibility of Energy Trust offering the combined measure was positive. However, the limited savings available from the measure will require establishing efficient, effective monitoring requirements and offering a minimal incentive, which may be insufficient to support trade ally engagement.

Recommendation #1

Determine the ideal incentive requirements. Our research indicates that, although trade allies are interested in promoting the combined measure, incentives remain critical. The only incentive trade allies have experienced is the $400 pilot incentive. A quick query with these trade allies should be conducted to explore what incentive amount might be acceptable if the measure could be implemented within the trade allies preferred installation workforce, which was not achieved in the pilot.

Recommendation #2

Re-engage trade allies to expand participation. Trade allies did not like the additional time and effort required to conduct the pilot. If moving forward with the measure, Energy Trust will need to engage with trade allies, informing them of the reduced requirements, and any other changes such as incentive amount.

MEMO

Date: September 2, 2015
To: Board of Directors
From: Marshall Johnson, Sr. Program Manager, Residential Sector
Dan Rubado, Evaluation Project Manager
Subject: Staff Response to Evaluation of the Existing Homes Prescriptive Air Sealing Pilot

In the face of low avoided costs for natural gas for the foreseeable future and gas weatherization measures that have had decreasing savings and increasing costs, Energy Trust's Existing Homes program designed a pilot to improve the cost-effectiveness of air sealing in gas heated homes. The strategy was to lower installation costs and focus only on areas for air sealing with the highest energy savings potential. Contractors were paid an incentive to air seal the attic plane during attic insulation projects, thereby reducing the base cost by aggregating the two services. The attic plane has a higher savings potential for air sealing than other areas of a home, it is theoretically the most cost-effective area to do air sealing. In addition, contractors were instructed to focus on the areas within the attic that had the highest potential energy savings.

This evaluation report documents the results of the pilot. In short, the estimated gas savings of prescriptive air sealing activities conducted during attic insulation projects were lower than expected and the costs reported by the contractors were higher than expected. Given the low savings and high cost, the measure does not appear to be cost-effective, even using very optimistic assumptions. To be a cost-effective measure, the air sealing work would need to be completed for less than $70, given the estimated 11-12 therms of gas savings, not the roughly $400+ cost estimated by contractors. In addition, moving to a prescriptive approach would add some additional quality assurance requirements. Although, this would likely cost much less than conducing blower door testing, it would still be an additional cost borne by the program to ensure that work is performed according to specifications and that there are reliable energy savings.

Given these results, the Existing Homes program does not plan to move forward with an incentive for prescriptive attic air sealing.

1. Introduction

In October 2014, Energy Trust of Oregon (Energy Trust) contracted with Research Into Action, Inc., in partnership with SBW Consulting, Inc. (SBW), to conduct an evaluation of the Existing Homes Prescriptive Air Sealing (Air Sealing) pilot. The primary pilot goal was to determine whether prescriptive attic air sealing in combination with attic insulation is a viable strategy to achieve cost-effective gas savings in existing gas-heated homes.

To help determine the viability of the pilot, staff coordinated with trade allies to meet at each participating home and performed a blower door test to measure the reduction in air leakage in at each of the following stages: prior to any work being done, after each segment of air sealing (chases, sheetrock penetrations, and top plates), and after the insulation was installed. Based on these results, as part of the blower door analysis, sufficient information was available to determine the energy savings associated with each stage of the project (see Section 4 for further details of the blower door analysis).

Although the pilot participation goal was to complete 100 homes, ultimately only 45 homes participated in the pilot. However, we excluded two of these homes during the blower door analysis due to uncertainties regarding the test results (see Section 4 for further details) leaving a total of 43 homes for this study.

In addition to the blower door analysis, this study included the following three data collection activities: 1) in-depth program staff interviews, 2) in-depth trade ally interviews, and 3) review of pilot summary data.

Our data collection activities addressed the following nine research questions:

- What are the savings associated with prescriptive attic air sealing?
- What are the incremental costs associated with prescriptive attic air sealing?
- What are the most cost-effective areas and methods to air seal an attic?
- Does prescriptive attic air sealing cost less than air sealing guided by blower door testing?
- Would a prescriptive attic air sealing measure achieve market acceptance?
- Could a cost-effective air sealing measure be designed for gas heated homes?
- Could a measure and incentive structure be designed that ensures accurate reporting of project details?
- Could quality assurance be easily performed on this type of measure?
- Could a prescriptive attic air sealing measure expand the number of homes that receive air sealing?

This report includes four sections following this introduction. Section 2 summarizes the staff interview findings, and Section 3 summarizes the trade ally interview findings. In Section 4 we review the pilot data and blower door analyses and in Section 5 we discuss the estimated energy savings for the pilot. The five appendices provide the backup analyses and data collection guides.

2. Staff Interviews

As part of the evaluation of Energy Trust's Air Sealing pilot, we conducted interviews with the six key program staff. These interviews ranged from 30 minutes to an hour in length and covered the following researchable questions:

- What were the perceived issues with installation, verification, and quality assurance procedures?
- How were trade allies recruited and what attrition occurred, if any?
- How is communication conducted across all parties involved in the pilot and how successful was the communication?
- What successes and challenges occurred in the pilot and how do they relate to future deployment?
- Would a prescriptive attic air sealing measure achieve market acceptance?
- Could a cost-effective air sealing measure be designed for gas heated homes?
- Could a measure and incentive structure be designed that ensures accurate reporting of project details?
- Could quality assurance be easily performed on this type of measure?
- Could a prescriptive attic air sealing measure expand the number of homes that receive air sealing?

2.1. Background

We conducted one group interview with two Energy Trust staff and four interviews with four CLEAResult staff for a total of five interviews with six staff members. Table 2-1 summarizes the roles each staff person played in the pilot.

Table 2-1: Overview of Air Sealing Pilot Staff

FIRM	TITLE	KEY ROLES			
		Admin.	Design	Technical	Implement
Energy Trust	Program Manager	✓			
	Senior Project Manager		✓	✓	
CLEAResult	Regional Field Manager	✓			
	Program Associate	✓	✓		✓
	Senior Technical Director		✓	✓	
	Technical Field Specialist			✓	✓

Of the six staff, no one person was responsible for all elements of the pilot and no more than three staff contributed to one role. However, staff did allude to additional members (not interviewed) contributing to roles such as the initial program design and implementation.

2.1.1. Rationale for Pilot

All six interviewed staff reported a similar understanding of why it was important to conduct the pilot. Over all, these staff focused on cost-effectiveness and savings of the potential measure. Specifically, they were interested in determining…

- …the costs in terms of time and materials needed to complete attic air sealing;
- …the savings associated with air sealing different areas of an attic (chases, sheetrock penetrations, top plates, and any other opportunities);
- …whether prescriptive air sealing cost less than blower door-guided air sealing; and
- …whether contractors would adopt a combined attic insulation and air sealing measure.

These reasons for conducting the pilot reflected two (bolded below) of the four pilot goals set out in the Air Sealing implementation plan:

- Design a measure and incentive structure that ensures accurate reporting of project information.
- **Design a cost-effective air sealing measure.**
- Design a measure upon which quality assurance can easily be performed.
- **Expand the number of homes that receive air sealing treatment.**

These reasons were also aligned with all four of the evaluation goals (listed below):

- Determine if the combination measure is a viable strategy to achieve cost-effective gas savings in existing gas heated homes.
- Validate savings associated with the prescriptive air sealing measure.
- Determine how well the air sealing strategy works for the participating contractors.
- Identify what the incremental costs are when installed concurrently with attic insulation.

2.1.2. Trade Ally Recruitment and Orientation

Staff reported they recruited the six most active attic insulation trade allies from the 2013 heating season to participate in the pilot. The pilot design staff confirmed that it was the past participation of these trade allies that informed the original participation goal for the pilot.

Most (5) staff confirmed that trade allies received a pilot orientation from the implementation (CLEAResult) staff. These orientation sessions typically occurred at the trade ally's office (to minimize hassle for trade allies), included operations and field staff, and covered topics such as:

- The participation agreement between Energy Trust and the trade ally.
- An explanation of how the trade ally would receive their incentive.
- The sequential procedures required for attic air sealing.
- The role and responsibilities of the trade allies and implementation team (CLEAResult and Portland State University (PSU) students).[3]

Staff agreed that the ultimate intent of the orientation was to convince the trade ally to participate in the pilot and promote the combined measure.

2.2. Implementation

Overall, all staff agreed that the pilot ran smoothly with clear communications between Energy Trust and CLEAResult staff members, as well as between CLEAResult and the trade allies. However, staff noted that the lower than anticipated trade ally participation significantly contributed to fewer than expected completed projects. In addition, staff agreed that the use of PSU students did not turn out to be as functional as hoped. See Section 2.2.3 for further detail of the use of students in the pilot.

In addition, the majority (5) of the interviewed program staff expressed uncertainty regarding market acceptance of a perspective attic air sealing measure. However, their reasoning was not uniform. Specifically, two allies spoke of lack of interest from customers and contractors in the measure; one noted an overall reduction in participation in energy efficiency from owners of gas-heated homes (he linked this to the recent lowering of natural gas prices); and the fourth reported that air sealing produces less certain savings when compared to other energy efficiency upgrades. Only one staff member indicated that if there was need for attic air sealing trade allies would sell the job and customers would get it done.

2.2.1. Communications

None of the staff reported any communication challenges among the core program staff (Energy Trust and CLEAResult) and all agreed that their regular communication via phone, email, and in-person was successful. In addition, all staff reported that the vast majority of the communication occurred on an as-needed basis, opposed to more formal meetings, such as when coordinating a project site visit or reviewing project results to identify ways to increase participation.

[3] Energy Trust engaged masters level PSU students to assist with the on-site blower door testing. The original plan was for the students to implement the blower door tests with minimal supervision after receiving blower door training. However, this did not occur due to the smaller than anticipated number of projects and the longer timeframe needed to complete projects. See Section 2.2.3 for more discussion of this topic.

2.2.2. Trade Ally Participation

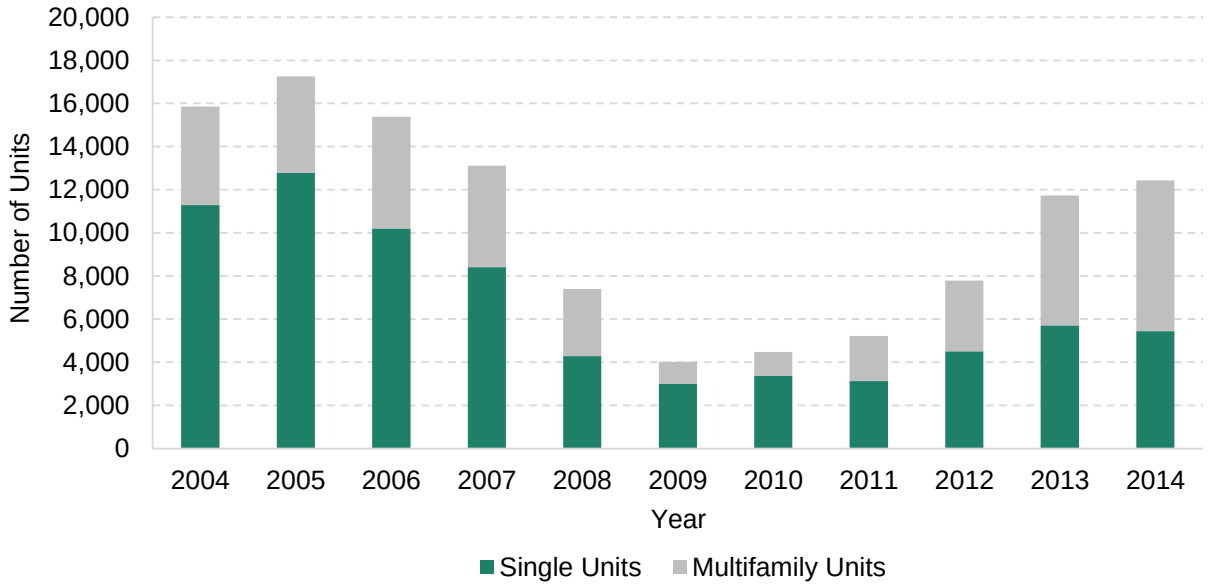
All staff confirmed that trade allies were solely responsible for recruiting customers for pilot projects. However, most (4) staff members suggested that the largest volume trade ally resisted the pilot requirements (for example, the structure of air sealing and blower door testing) and ultimately chose to abandon the pilot despite signing a participation agreement. In addition, one staff person mentioned that an aggressive sales person promoting the pilot for one trade ally firm changed jobs during the pilot and the replacement sales staff did not promote the pilot as effectively. Ultimately, all staff agreed that the lack of participation from these two large volume trade allies contributed to the lower than anticipated number of completed projects.

Compounding the lack of participation from the two aforementioned trade allies, two staff explicitly stated, and two others implied, that changes in the market for insulation services may have decreased the number of residential customers that trade allies sought to engage. Specifically, these staff reported trade allies were changing focus from small retrofit projects to higher margin projects such as new construction, major renovations, and commercial/multifamily projects. As one staff member noted, the "market forces conspired to create lower customer demand [for existing home attic insulation]."

The Census Bureau data for the Portland Metro Region supports this theory, suggesting a change in focus toward commercial/multifamily projects. More multifamily construction permits were filed in 2014 than at any time in the last decade and overall, residential new construction permits steadily increased from 2009 to 2014 (Figure 2-1).

However, trade allies disputed this theory and reported ongoing engagement with residential retrofits during this period of time (see Section 3.1 for further detail).

Figure 2-1: Number of Residential Building Permits in Portland Metro Region*



* U.S. Census Bureau. Building Permits Survey, Permits by Metropolitan Area – Annual, *http://www.census.gov/construction/bps/msaannual.html* (Accessed on April 15, 2015).

2.2.3. Use of Students

The implementation staff all agreed that the PSU students used for conducting blower door tests were generally not able to conduct projects without CLEAResult staff supervision, which had been the original plan. These staff provided the following reasons for why students were unable to take on the intended responsibilities:

- Students did not have sufficient prior building science experience to act independently.
- With far fewer projects than originally envisioned, students were unable to attain the necessary field experience to take on a leading role on-site.
- The pilot timeline took almost twice as long as anticipated, conflicting with students' schedules as they had only committed through December 2014 and the pilot ran into March 2015

Due to these three issues, the CLEAResult Field Specialist reported attending almost all of the 45 completed pilot projects.

2.3. Future of an Air Sealing and Attic Insulation Combination Measure

Staff reported they were encouraged by the possibility that the combination air sealing and attic insulation measure may be a cost-effective way to garner gas savings. However, all staff mentioned a few potential barriers that would need to be addressed in order for a combined attic insulation and air sealing measure to be successful outside of the pilot. We discuss each of these barriers below.

2.3.1. Quality Assurance

All staff expressed concern about how to easily verify air sealing as a combined measure with attic insulation. Because air sealing is no longer visible, and therefore hard to verify, once the attic insulation is completed, staff noted concerns about the potential time and expense required to ensure trade allies completed the air sealing appropriately. One method mentioned by several (4) staff was for trade allies to provide geo-stamped and time-stamped photo evidence of air sealing as verification of appropriate installation. One of these staffers also mentioned combining photo evidence with a required checklist as a way to provide additional evidence of correct installation.

2.3.2. Market Measure to Customers

To remedy the problem of trade allies not strongly recruiting attic insulation jobs (see Section 2.2.2), two staff contacts suggested Energy Trust could market directly to customers in addition to relying on trade allies to promote the measure. In addition to marketing the energy savings associated with air sealing, one of these staff noted Energy Trust could entice customers by emphasizing the reduced moisture infiltration and improved durability that air sealing provides a

building. However, this same staff member recognized that direct marketing could increase future program costs, thus potentially making the measure less cost-effective, unless closely integrated into existing marketing efforts.

2.3.3. Driving Trade Ally Interest in Combined Measure

Of the six trade allies staff initially recruited to participate in the pilot, two completed almost three-quarters of the 45 pilot projects. Most (5) staff suggested that these two trade allies had figured out a way to integrate the pilot requirements into their business model. However, these same staff hypothesized that it may be harder to convince lower volume trade allies to participate because of the perception that measure requirements are burdensome.

3. Trade Ally Interviews

As part of the evaluation of Energy Trust's Air Sealing pilot, we conducted interviews with five of the six participating trade ally firms. We conducted the interviews in April and May of 2015. The interviews averaged 30 minutes each and covered the following researchable questions:

- What were the perceived issues with installation, verification, and quality assurance procedures?
- How were trade allies recruited and what attrition occurred, if any?
- How did trade allies communicate with staff and how successful was the communication?
- What successes and challenges occurred in the pilot and how do they relate to future deployment?
- Would a prescriptive attic air sealing measure achieve market acceptance?
- Could a cost-effective air sealing measure be designed for gas-heated homes?
- Could quality assurance be easily performed on this type of measure?
- Could offering a prescriptive attic air sealing measure expand the number of homes that receive air sealing?

3.1. Trade Ally Background

We requested, and received, contact information for all six participating trade ally firms from the pilot implementer. Next, we made multiple efforts to contact each of the trade ally firms, completing interviews with representatives from five of the six firms. We completed one group interview with three representatives (all from one firm who all held similar roles in the company) and the remaining four interviews with individual respondents.[4] The respondents included:

- Five sales staff/managers, from two trade ally firms, whose principal responsibility is selling projects and coordinating crews to complete projects;
- One company owner; and,
- One office manager who schedules and coordinates the sales and work crews.

All five interviewed trade allies reported that prescriptive attic air sealing is highly dependent on the size of the home and job details such as accessibility of the attic and degree of sealing required. In sum, the allies reported air sealing jobs could take between two and eight hours and cost between $300 and $1,000 to complete.

[4] For the purposes of this report, we considered the group interview as one respondent.

As presented in Table 3-1, four of the five interviewed firms primarily work in the residential sector. Of these, two focus on existing home retrofits and two on new construction. The remaining firm reported that they work evenly across both the residential and commercial sectors.

Table 3-1: Sectors Served by Trade Ally

TRADE ALLY	COMMERCIAL	RESIDENTIAL	
		New Construction	Existing Homes
#1	-	+	-
#2	+/-	+/-	+/-
#3	-	-	+
#4	-	+	-
#5	-	-	+

* '+' primary focus, '-' secondary focus, '+/-' neither primary or secondary focus

Trade allies completed more than two-thirds (31 of 45) of the pilot projects between September and December 2014. As shown in Table 3-2, the pilot began slowly with only three allies completing one project during the first month (May) and no more than one project per month per trade ally until the fifth month (September) of the pilot.

Table 3-2: Distribution of Trade Ally Projects by Month*

TRADE ALLY	2014								2015			COMPLETED PROJECTS	
	May	June	July	August	September	October	November	December	January	February	March	Count	Percent
#1	1	1			3	2	5	3	1	1	1	18	40%
#2		1	1	1	3	2	1	4	1	1		15	33%
#3	1					1	2	2				6	13%
#4				1	1		1	1	1			5	11%
#5	1											1	2%
#6												0	0%
Total	3	2	1	2	7	5	9	10	3	2	1	45	100%

* Bolded and italicized lettering indicates interviewed contractors.

All six trade allies were located in the Portland Metro area and nearly all (96%) of the completed projects took place in Portland and its neighboring jurisdictions (Table 3-3).

Table 3-3: Completed Projects by Region (n=45)

REGION	COUNT	PERCENT
Portland	25	56%
Portland Metro	18	40%
Salem	2	4%

3.2. Implementation

Trade allies reported on the following key pilot implementation areas:

- Pilot orientation
- Customer recruitment
- Interactions with Energy Trust
- Pilot challenges
- The future of the pilot

We discuss the interviewees' feedback on these five areas below.

3.2.1. Trade Ally Orientation

All (5) interviewees recounted receiving an in-person pilot orientation from Energy Trust representatives. Typically, each orientation session lasted about an hour and involved between one and three trade ally staff and two Energy Trust representatives. Trade allies recalled that the orientation covered the pilot administrative procedures and troubleshooting ways to align the pilot procedures with the trade ally's current attic insulation procedures.

Additionally, at each trade ally's first project site, an Energy Trust representative went over expectations of the pilot and quality control procedures with the installation crews.

3.2.2. Customer Recruitment

Trade allies reported employing two different customer recruitment methods; however, these methods did not appear to make a substantial difference on the number of completed projects. Three trade allies, the most active (#1)[5] and the two least active (#4 and #5) recalled using the pilot as a sales tool, suggesting customers may be eligible for the pilot incentive to entice participation. The other two trade allies (#2 and #3) determined eligibility before telling customers about the pilot.

[5] Trade ally number assignment corresponds with Table 3-2.

One of the trade allies, with modest participation (#4)[6] who mentioned the pilot to all customers, suggested his firm aggressively looked for opportunities to make projects fit into the pilot. For example, this trade ally mentioned the pilot to customers that were not obvious candidates, such as those that were interested in larger remodeling projects.

In contrast, another ally with modest participation (#3)[7] who evaluated eligibility before telling customers about the pilot, stated he determined eligibility by assessing how easy it would be for his crews to do the work. For example, he would look at housing characteristics such as can lights, at least four feet of attic clearance, and gable ends that made the air sealing process easy to install by his crews.

3.2.3. Interactions with Energy Trust Representatives

In general, all five interviewed trade allies reported positive interactions with pilot staff. No trade allies reported problems reaching Energy Trust representatives such as when scheduling a job or to answer a question. Additionally, all trade allies reported positive interactions with staff on project sites. One trade ally (#4) was particularly positive, stating, "CLEAResult [the pilot implementer] did everything for us, and they were a pleasure to work with. They were understanding when paperwork was not perfect [and helped us resolve any issues]."

The only on-site issue raised by one trade ally (#3) was the performance of one student running the blower door on one of the first projects. According to this respondent, the student had difficulty installing the blower door and the trade ally helped him set-up. However, all subsequent projects went more smoothly.

3.2.4. Pilot Challenges

Trade allies reported several challenges to completing more pilot projects. These challenges related to the scope and requirements of the pilot, the limitations allies put on their participation, and billing difficulties experienced by trade allies.

- **Initial restricted scope of pilot.** Initially the pilot required trade allies to install air sealing in houses only receiving attic insulation. The most active trade ally (#1) and the least active ally (#5) noted this requirement made it difficult to sell jobs because customers often wanted other work completed. In addition, the least active ally mentioned that the commission-based sales staff were disinterested in pilot projects as they are rewarded for selling larger projects.

6 As shown in Table 3-2, trade ally #4 completed five projects.

7 As shown in Table 3-2, trade ally #3 completed six projects.

- **Extra time required to accommodate pilot requirements.** All five interviewed trade allies reported that waiting for the blower door testing between sealing specific areas and air sealing as directed by the pilot added additional time to each project.[8]
  - Two trade allies (#2 and #4) estimated an additional hour;
  - One (#5) estimated an additional 30 minutes; and,
  - Two trade allies (#1 and #3) were unable to provide an estimate.

  The second most active trade ally (#2), who was one of the allies who reported the extra hour, noted that this extra time limited the number of projects the installation crew could complete in a day. For crews who receive payment by the project, not being able to complete additional projects was a disincentive to participate in the pilot.

  Additionally, two allies, the most active and a moderately active ally (#1 and #3) noted their installation crews did not work the way the pilot assumed. In these cases, different crews conduct specialized tasks with one crew completing air sealing, one completing attic insulation, and another the crawlspace insulation. Coordinating with multiple crews made it more difficult to incorporate the blower door testers because instead of working with two schedules they had to coordinate with three or more.

- **Limited number of trained trade ally staff.** The three trade allies that did the fewest projects (#3, #4, and #5)[9] noted their firms limited their ability to participate by only training a subset of employees to do pilot projects. Trade allies reported that due to the uncertainty of the pilot turning into a regular offering, training all employees was not viewed as a good business investment during the pilot.

- **Billing and receiving payment.** In addition to challenges with completing more projects, the two allies that completed the most projects (#1 and #2), noted modest difficulties aligning their internal workflow procedures with the needs of the pilot. Typically, allies submit only one bill to their customer, but in the case of the pilot, they submitted two bills, one to the customer and one to Energy Trust. In the case of the two franchisee firms, which use a nationwide corporate accounting system, this sometimes caused confusion between the local office and the corporate headquarters. In a few instances, the corporate office incorrectly sent bills to a customer that should have been sent to Energy Trust. This created extra work for the local office staff including resolving the confusion with customers.

8 All five interviewed trade allies report that starting in one corner of attic and working in a linear fashion across the attic is their preferred method, but the pilot required doing sheetrock penetrations, chases, and top plates (in that order).

9 As shown in Table 3-2, trade ally #3 completed six projects, ally #4 completed five projects, and ally #5 completed one project.

3.2.5. Future of Pilot

We asked trade allies if they thought the pilot identified a viable strategy for air sealing gas-heated homes, what portion of their jobs might qualify for participation, and for feedback on possible methods for ensuring quality.

All five interviewed trade allies stated the pilot identified a viable strategy for air sealing gas-heated homes. However, four (#1, #2, #3, and #5) of the five trade allies noted that the $400 incentive would need to persist to promote trade ally participation Despite this, it was unclear if the trade allies fully considered a post-pilot scenario where the pilot requirement no longer existed or if the responses implicitly figured in the additional time, and therefore cost, required in the pilot. The remaining trade ally, with modest participation (#4)[10] did not indicate if the incentive was necessary for the pilot to evolve into a full-fledged offering.

All but the most active ally estimated conducting between 100 and 1,300 attic insulation jobs per year. Three allies (#2, #4, and #5) estimated about half and one trade ally (#3) estimated about a third of all those jobs would qualify for prescriptive attic air sealing. The most active ally (#1), who primarily worked in the office, reported not having enough field experience to provide an estimate.

The three (#3, #4, and #5) trade allies who completed the fewest projects suggested that requiring pictures and a checklist to improve quality assurance would be possible in a full-fledged program. However, two of the three (#3 and #4) noted it would change their current procedures and one of these two expressed some concern with purchasing cameras or smartphones for his staff. The remaining (#5) trade ally reported already using a checklist and pictures to support quality assurance as part of his participation in a low-income program. This ally reported it would be easy to adopt this procedure for his Energy Trust jobs. The two most active trade allies (#1 and #2) did not provide feedback on future quality assurance.

10 As shown in Table 3-2, trade ally #4 completed five projects.

4. Pilot Data Review & Blower Door Testing Analysis

As part of the Air Sealing pilot evaluation, the team reviewed the pilot summary data, specifically the participant housing characteristics that Energy Trust supplied in late March 2015, and analyzed the results of the blower door tests.[11]

4.1. Methods

This section begins with a discussion of the methods used for the analyses and then provides the findings.

4.1.1. Blower Door Testing Data

Pilot staff performed a blower door test to measure the reduction in air leakage prior to any work being done on participating homes, after each segment of air sealing (three segments), and after adding the insulation at the end of the job. The blower door test pressurized the house to 50 pascals, and reported the number of cubic feet per minute (CFM) of air blown into the house required to maintain that pressure.[12] The CFM50 was recorded at each of the tests. Energy Trust provided data for 45 pilot homes. However, we excluded two of the homes due to uncertainties regarding the blower door test results (some of the results below exclude both sites, and some just exclude one of the sites).

- One site was excluded because the tester noted that they were unable to reach a pressure of 50 pascals, yet there was no "Can't reach 50 factor" applied.
- Another site was excluded because testers shifted from one blower door test rig to another during testing, with the result that the CFM50 reportedly increased rather than decreased after an air sealing segment. In our judgment, while this reflects normal testing error, the key result here is the change in CFM50 due to air sealing, and that this result is best obtained when using same equipment throughout the process.

4.1.2. SEEM Modeling

Because energy savings from weatherization measures, such as those in the pilot, cannot practically be measured directly, we used Simplified Energy Enthalpy Model (SEEM) building

11 Research Into Action and SBW reviewed pilot data and SBW conducted the blower door testing analysis.

12 The measure of air leakage at 50 pascals, is referred to as CFM50 throughout this document.

energy simulation software to estimate the energy usage of participating homes at various levels of insulation and air leakage.[13]

For purposes of the blower door analysis, the most important housing characteristics are as follows:

- Year of construction (vintage)
- Floor area (square feet)
- Attic area (square feet)
- Foundation type (crawl space or basement)
- Number of levels
- Furnace type
- Initial level of attic insulation (inches)
- Initial level of air leakage (natural air changes per hour, or ACH)

We used some of these characteristics as direct inputs to SEEM, and included others because they may be of interest to program operators. We present these detailed home characteristics below.

4.2. Review of Analysis Parameters

4.2.1. Participant Housing Characteristics

The pilot required participating homes to be heated with natural gas.[14] In addition to the primary heating fuel, pilot staff captured eight distinct participant housing characteristics such as type, age, size, and heating systems for each pilot project (see Section 4.1.2). Based on these characteristics the average participant house was…

- …Average year of construction was 1953
- … about 1,800 square feet,
- … one-story, and
- …had an 11-year-old heating system.

13 The Northwest Power and Conservation Council (NWPCC) and its Regional Technical Forum (RTF) support the SEEM residential simulation package: *http://rtf.nwcouncil.org/measures/support/SEEM/Default.asp*.

14 We did not include energy savings associated with air conditioning as these savings are electrical and the purpose of the pilot was to determine gas savings.

4.2.2. Vintage and Number of Levels

As shown in Table 4-1, all participating homes were built prior to 1980, with a significant number built before 1940.

Table 4-1: Vintage of Participating Home

VINTAGE	NUMBER
Prior to 1919	4
1920-1939	5
1940-1959	15
1960-1980	20
Total	44

The number of levels in the home is part of the specification of the SEEM prototype homes. Nearly 75% (34 of 44) of participating homes were single-story; with just over 10% (5) of the remaining homes being two-story and just under 10% (4) were split-level homes (Table 4-2).

Table 4-2: Housing Levels

NUMBER OF LEVELS	NUMBER
NA	1
1	34
1.5	4
2	5
Total	44

4.2.3. Floor and Attic Area

Floor and attic area are both key characteristics of the SEEM prototype homes. We used the floor square footage distribution, shown in Table 4-3, to inform our determination of how to approach SEEM simulations (see Section 5.2 for further detail). We also note that the attic area can be less than floor area in multi-level homes, or homes with partially vaulted ceilings. However, as most participating homes were single-story this would not have been a significant factor for most participating homes.

The majority (29 of 44) of participating homes were between 1,200 and 2,400 square feet, with a mean of 1,791 square feet.

Table 4-3: Floor Square Footage

FLOOR SQUARE FOOTAGE	NUMBER
769	1
800-1,199	9
1,200-1,399	10
1,400-1,799	9
1,800-2,399	10
2,400-2,799	3
2,800-3,599	1
Greater than 3,600	1
Total	44

4.2.4. Foundation Type

The fourth SEEM parameter is foundation type. As shown in Table 4-4, there was a slight majority of participating homes with basements (24 of 44) over those with crawlspaces (19 of 44), and only one home with a slab.

Table 4-4: Foundation Type

FOUNDATION TYPE	NUMBER
Crawlspace	16
Crawlspace, Half Basement	2
Crawlspace, Half Basement, Slab on Grade	1
Full Basement	22
Half Basement	2
Slab on Grade	1
Total	44

4.2.5. Furnace Type

The type of furnace can be used to infer its efficiency, which is an important parameter in converting the energy savings found with SEEM from electric savings to gas savings. As shown in Table 4-5, just under half (19 of 43)[15] the furnaces in participating homes were high-efficiency condensing. We assumed efficiencies of 65% for the atmospheric, 80% for induced draft, and

[15] We excluded one of the homes due to uncertainties regarding the blower door test results.

92% for condensing furnaces,[16] coming to an average furnace efficiency of 85% for participating homes.

Table 4-5: Furnace Type

FURNACE TYPE	NUMBER*
Atmospheric	3
Condensing	19
Induced Draft	18
NA	3
Total	43

* We excluded one of the homes due to uncertainties regarding the blower door test results.

4.2.6. Initial Level of Attic Insulation and Air Leakage

Two other key parameters for SEEM are the initial level of attic insulation and air leakage. As shown in Table 4-6, half (22 of 43)[17] of the participating homes began with 3 inches or less of insulation.

Table 4-6: Initial Level of Attic Insulation

INITIAL INCHES OF INSULATION	NUMBER*
0-1	7
1-2	7
2-3	8
3-4	17
4-5	4
Total	43

* We excluded one of the homes due to uncertainties regarding the blower door test results.

We present the air sealing results in this report as ACH. However, SEEM actually uses CFM50 rather than ACH. The conversion of CFM50 to ACH requires an "N-Factor," which depends on region, number of floors in the building, and other factors. A value of 20 is often used for an approximation, and that is what we used for the conversion shown in Table 4-7.[18]

16 Canada Mortgage and Housing Corporation, "A Guide to Residential Wood Heating," Table 2, *https://www.nanaimo.ca/assets/Departments/Community~Planning/Environmental~Planning/Burn~It~Smart/Guide2ResidentialWoodHeating.pdf*

17 We excluded one of the homes due to uncertainties regarding the blower door test results.

18 *http://gothermalstar.com/resources/ConvertingBetweenCFMAndNaturalFlow-GreenSheet.pdf*

The ACH bin values are midpoints in bins of 0.05 ACH, starting at 0.35 and going to 1.0 ACH. The final bin includes values up to 1.34 ACH. A value of 0.35 ACH is considered a well-sealed home. Although one home started out at this level and another one home started at 0.37, the median initial leakage of participating homes was 0.60 ACH and the mean initial air leakage was 0.67 ACH. The coefficient of variation (cv) in the initial air leakage was 0.37.

Table 4-7: Air Changes per Hour

ACH BIN	NUMBER*
0.35 - 0.45	8
0.45 - 0.55	8
0.55 - 0.65	9
0.65 - 0.75	6
0.75 - 0.85	5
0.85 - 0.95	2
Greater than 0.95	5
Total	43

* We excluded one of the homes due to uncertainties regarding the blower door test results.

4.2.7. Comparison of Pilot Home Characteristics with SEEM Prototype Characteristics

SEEM simulations for Regional Technical Forum (RTF) measures are based on three prototype home designs. A prototype includes parameters such as floor area, foundation type, window area, number of levels, location of heating ducts, and wall construction type.[19] Many of these parameters were not available for the participating pilot homes. However, we were able to compare key parameters to the RTF prototypes.[20]

Table 4-8: Distribution of Prototype Homes Used in RTF Measures

PROTOTYPE	WEIGHTING
1344c	53%
1344s	2%
2200c	12%
2200s	4%
2688b	28%

[19] The prototypes are more fully defined in the RTF workbook: *http://rtf.nwcouncil.org/measures/support/SEEM/rtfSEEMtemplate_v1_4.xlsm*

[20] The RTF uses this mix of prototypes for its weatherization measures for homes with electric furnaces, workbook: *http://rtf.nwcouncil.org/measures/res/ResSFWx_v3_3.xlsm*.

* The ‘c’ in the table refers to crawlspace, the ‘b’ to basement, and the ‘s’ to slab.

When comparing the pilot homes with the RTF prototypes several differences emerged:

- RTF prototypes include fewer homes with basements and more homes with slabs.
- The weighted average RTF floor area is 1,856 square feet, while the mean in the pilot was 1,791 square feet.
- The 1,344 square foot prototype home is single-level, the other prototypes have two floors.
- Pilot homes are more heavily single-level. Single-level homes will have a higher proportion of attic space to floor space than multi-level homes.
- Ceiling height in the prototypes are 8-10 feet. Ceiling heights data collected in the pilot, ranged from 7.5 feet to 14 feet, with the great majority being 8 feet. Our judgment is that the RTF prototypes are adequate to present the pilot homes in this parameter.

Despite these differences, our conclusion is that the standard RTF prototype weightings are adequate to represent the pilot homes, as long as savings results are presented per square foot of attic or floor space so that the results can be adjusted to fit the pilot sample.

Using the RTF prototypes as a baseline, we examined attic insulation and air sealing for performance changes following participation in the pilot.

4.2.8. Attic insulation

As shown in Table 4-9, the relatively high standard deviation in the initial level of insulation (1.5 compared with a mean of 3.0) indicates a fairly wide spread in the distribution of insulation. The low standard deviation in the final level of insulation (2.6 compared with a mean of 15.9) indicates that most homes ended fairly close to the mean insulation level. The R-value corresponding to the final insulation level is closely approximated by standard RTF measures with R-49 attic insulation installed.

Table 4-9: Pre and Post Attic Insulation

	INITIAL ATTIC INSULATION (INCHES)	FINAL ATTIC INSULATION (INCHES)
Mean	3.0	15.9
Standard deviation	1.5	2.6
Coefficient of variation	0.49	0.16

4.2.9. Air sealing

Table 4-10 illustrates the change in air leakage. We found that pilot installed insulation reduced the air leakage by an average of 0.024 ACH after the reduction of 0.079 ACH due to air sealing.

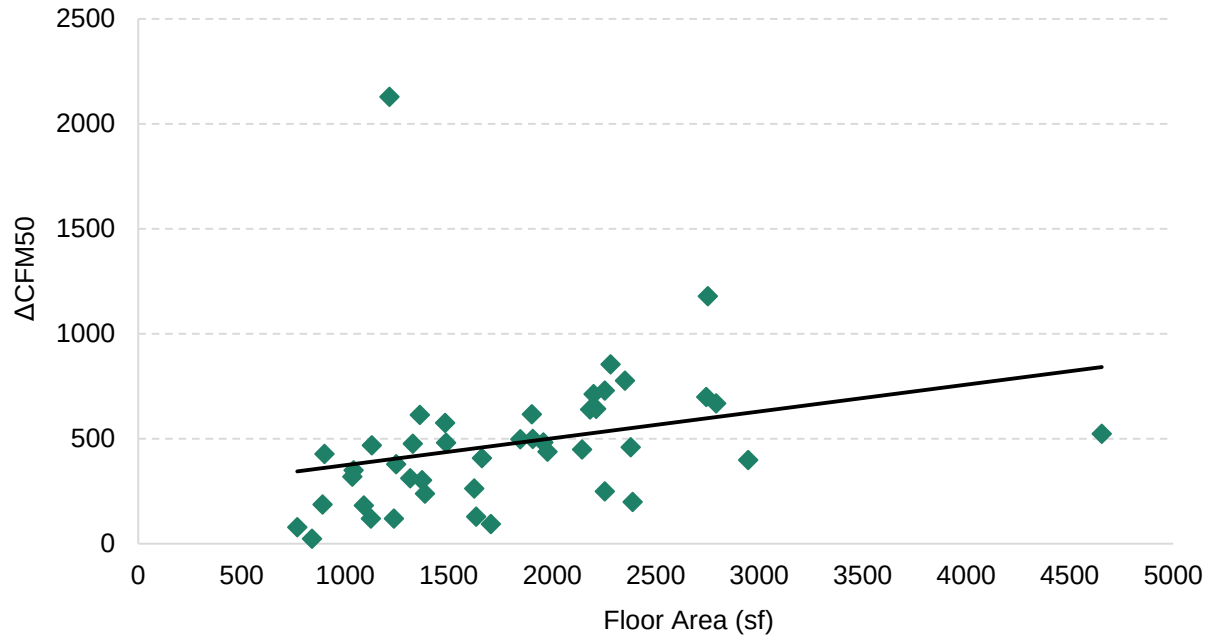
The total reduction is very close to the standard RTF infiltration-reduction measure, which assumes a reduction of 0.10 ACH. The variation in reduction (ΔACH) is large, with a cv of 0.93 (standard deviation almost as large as the mean).

Table 4-10: Change in Air Leakage

	PRE ACH	POST AIR SEALING ACH	AIR SEALING ΔACH	POST INSULATION ACH	TOTAL ΔACH
Mean	0.668	0.588	0.079	0.564	0.104
Standard deviation	0.25	0.21	0.10	0.21	0.10
Coefficient of variation	0.37	0.36	1.22	0.37	0.93

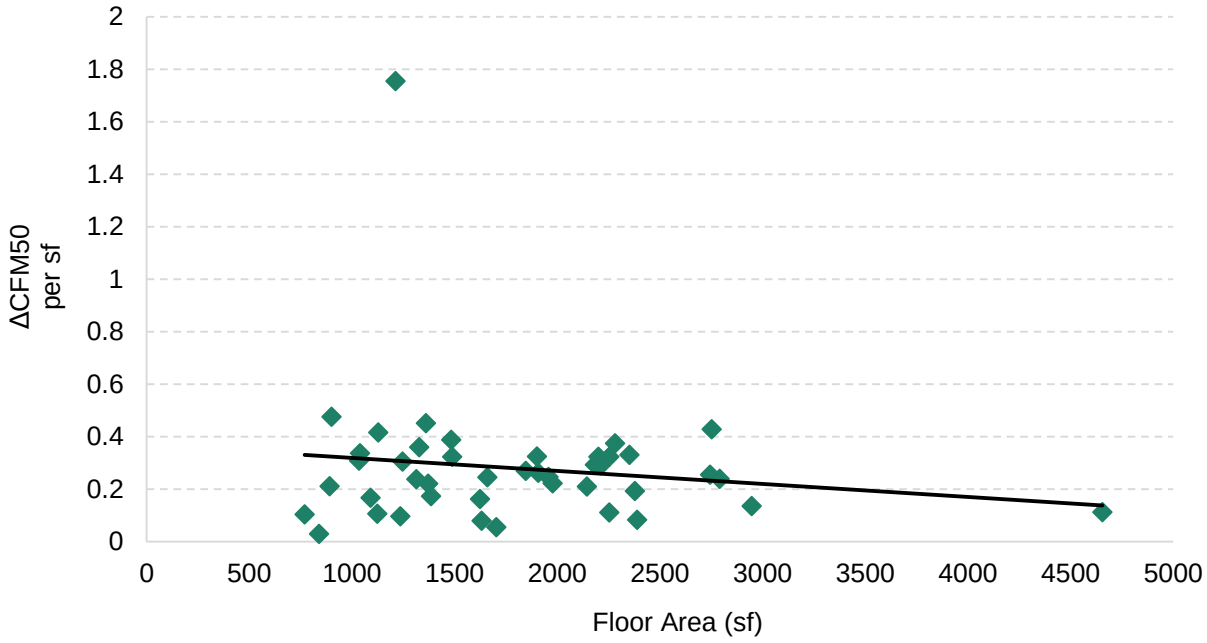
As shown in Figure 4-1, total reduction in leakage, measured by ΔCFM50, increased with floor area, as expected, with some outliers, with an average reduction of 475 CFM50.

Figure 4-1: Total Change CFM50



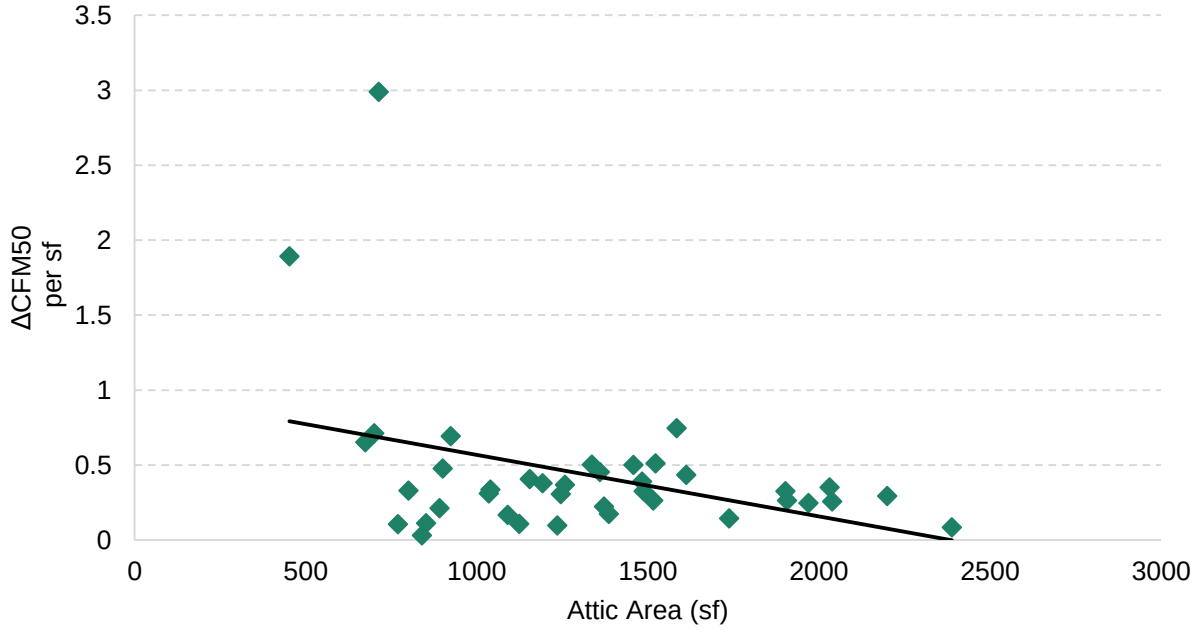
In addition, the change in leakage normalized by floor area (ΔCFM50 per square foot) was relatively constant (Figure 4-2).

Figure 4-2: Change CFM50 (Total) per Square Foot



Finally, the change in leakage normalized by attic area was also relatively constant, with a couple outliers (Figure 4-3).

Figure 4-3: Change CFM50 (Total) per Attic Square Foot



5. Estimate of Energy Savings

To estimate the energy savings associated with the pilot we first determined that the changes in attic insulation and the reduction in infiltration were well represented in the RTF single-family weatherization measures.[21] Next, we selected measure savings from the electric forced-air-furnace group of measures and converted to gas savings using the assumption of 100% efficiency for the electric furnace, and 85% efficiency for the gas furnace (see Section 4.2.5). We assumed losses through furnace ducts to be the same in both cases and accounted for them in the SEEM simulations. Finally, we derived savings per home, based on average attic area among pilot homes, and average CFM50 reduction among pilot homes. We present our savings findings below.

5.1. Air Sealing

We looked at the following two attic insulation measures:

- Starting at R-0 and installing R-49
- Starting at R-11 and installing R-49

Based on the initial insulation level (Table 4-9), we used the weighting in Table 5-1 to reflect the insulation savings achieved by the pilot. Assuming R-3 per inch of attic insulation[22], 32% of the homes started at R-6 or less (see Table 4-6). Based on the initial insulation levels measured in inches and assuming R-3 per inch of attic insulation, we used the weighting in Table 5-1 to reflect the insulation savings achieved by the pilot.

Table 5-1: Attic Insulation Measure Weighting

ATTIC INSULATION MEASURE	WEIGHTING
R0 -> R49	33%
R11 -> R49	67%

Savings for the attic insulation measures are heavily influenced by the starting level of insulation. RTF savings for the R0 ->R49 measure in Heating Zone 1 are 2.45 kWh/year/square foot, while savings for the R11->R49 measure in Heating Zone 1 are 0.67 kWh/year/square foot.

21 As of June 4, 2015: *http://rtf.nwcouncil.org/measures/res/ResSFWx_v3_3.xlsm*

22 As of July 15, 2015: http://energy.gov/energysaver/articles/types-insulation

5.2. Simulation Discussion

To identify savings achieved in the pilot, we would ideally run simulations for each home, capturing all building characteristics, including wall and floor insulation, and window type and area. We would first model the baseline heating energy use, then model the home following air sealing, and finally model the home following installation of attic insulation. However, we did not have all the necessary information, and this approach is time consuming and therefore costly, without providing comparably better results.[23] Therefore, we used prototype homes, and made assumptions about the state of non-measure home characteristics (see Section 4.2.7).

The state of non-measure home characteristics is important, because measure savings tend to be greater for the first weatherization measures installed. For example, if we are modeling the savings due to attic insulation, the modeled savings will be greater if we assume the walls, floor, and windows are poorly insulated, and the home is leaky. If attic insulation is modeled as the last measure installed – the remainder of the home is tight and well-insulated, modeled savings are lower. The current RTF solution to this problem is to model a given measure, for example attic insulation, with a number of simulation runs covering a mix of home characteristics. These "characteristic scenarios" are based on data found in the regional Residential Building Stock Assessment (RBSA). Homes in the RBSA with low levels of attic insulation were examined to determine the state of other home characteristics. The home characteristics are grouped so that the attic insulation measure can be modeled in a limited number of scenarios. Savings are averaged across the scenarios.

One additional issue is that we don't want to give any individual measure too large a "share" of weatherization savings. For example, if we modeled all measures as first-measure-in, and a home received all weatherization measures, total savings would be much greater than actual savings. Modeling all measures as last-measure-in provides an estimate closer to true savings, but is not accurate for all measures.

The characteristic scenarios approach is the current RTF solution to this issue. The methodology involves a final adjustment to the characteristic scenarios savings. These savings are multiplied by the ratio of last-measure-in savings for the measure in question to the sum of all last-measure-in savings. Again, the goal of this procedure is to most accurately and fairly apportion savings across all weatherization measures.

In determining pilot savings, we did not know the state of non-attic home characteristics. Our judgment was that the current RTF approach is as good as we can come to accurately modeling pilot savings, while also allowing for these homes to be treated with other measures, such as wall insulation or window replacement, and have those savings also be accurately represented with SEEM simulations. Therefore, we derived our results using the characteristic scenario methodology, as represented in the standard RTF workbook.

[23] Custom simulations per home might take one or more days per site to complete.

5.3. Results

Table 5-2 shows the relevant measure results from the RTF measure workbook.

Table 5-2: Savings by Category and Unit

CATEGORY NAME	UNITS	SAVINGS (KWH/YR) PER UNIT
Single Family Weatherization - Insulate Attic - R0 to R49-Heating Zone 1 (Electric FAF)	attic square foot	2.45
Single Family Weatherization - Insulate Attic - R11 to R49-Heating Zone 1 (Electric FAF)	attic square foot	0.67
Infiltration Reduction - CFM50 reduction-Heating Zone 1 (Electric FAF)	CFM50 reduction	0.55
Single Family Weatherization - Insulate Attic - R0 to R49-Heating Zone 2 (Electric FAF)	attic square foot	3.43
Single Family Weatherization - Insulate Attic - R11 to R49 -Heating Zone 2 (Electric FAF)	attic square foot	0.71
Infiltration Reduction - CFM50 reduction -Heating Zone 2 (Electric FAF)	CFM50 reduction	0.64
Single Family Weatherization - Insulate Attic - R0 to R49-Heating Zone 3 (Electric FAF)	attic square foot	4.34
Single Family Weatherization - Insulate Attic - R11 to R49-Heating Zone 3 (Electric FAF)	attic square foot	0.74
Infiltration Reduction - CFM50 reduction-Heating Zone 3 (Electric FAF)	CFM50 reduction	0.63

Using the weightings and average values described above, we determined pilot savings by measure and heating zone (Table 5-3). We derived the insulation savings as the product of average pilot attic square footage, and the kWh savings per attic square foot noted above. Air sealing savings are the product of average Pilot whole house CFM50 reduction, and the savings per CFM50 reduction noted above.

Table 5-3: Savings by Measure and Heating Zone

MEASURE	SAVINGS (THERMS/YR) PER HOME
Attic Insulation, Heating Zone 1	60
Attic Insulation, Heating Zone 2	77
Attic Insulation, Heating Zone 3	93
Attic Air Sealing, Heating Zone 1	11
Attic Air Sealing, Heating Zone 2	12
Attic Air Sealing, Heating Zone 3	12

5.4. Alternative Methods

In addition to using the standard RTF measures, we performed a limited number of custom SEEM runs to provide further perspective on the savings values. Doing custom SEEM runs allowed us to modify certain parameters to more closely match the pilot characteristics. As shown in Table 5-4, we changed the distribution of prototypes to more closely match the pilot.

Table 5-4: SEEM Modeled Savings Estimates for Prototype Homes

PROTOTYPE	RTF WEIGHTING	PILOT WEIGHTING
1344c	53%	45%
1344s	2%	2%
2200c	12%	43%
2200s	4%	0%
2688b	28%	9%

In addition, homes' starting and ending CFM50 levels were based on pilot program values. The pilot average CFM50 per square foot was multiplied by the prototype square footage to derive the CFM50 input parameters. Starting and ending attic insulation levels were treated as described above. We present the results for Heating Zone 1 in Table 5-5.

Table 5-5: Heating Zone 1: Savings (Therms/Yr) by Measure

MEASURE	SAVINGS (THERMS/YR) PER HOME
Attic Insulation, Heating Zone 1	47
Attic Air Sealing, Heating Zone 1	12

These savings are based on "last-measure-in" simulation runs rather than characteristic scenarios simulations, due to the complexity of the latter process noted above. Our judgment is that these results serve as a sanity-check on the standard measure savings. However, the process of running SEEM simulations is complex enough that we prefer using the standard measure savings.

Appendices

Appendix A. Program Staff Interview Guide

Energy Trust Air Sealing Pilot: Staff In-depth Interviews

Researchable Questions

We used the researchable questions listed in Table A- to inform the development of the following interview guide.

Table A-1: Researchable Questions and Associated Question Placement

RESEARCHABLE QUESTIONS	ASSOCIATED QUESTION PLACEMENT
What were the perceived issues with installation, verification, and quality assurance procedures?	Q2 – Q6
How were trade allies recruited and what attrition occurred, if any?	Q9 – Q18
How do trade allies perceive the feasibility and attractiveness of the pilot approach?	Not relevant to staff guide
How is communication conducted across all parties involved in the pilot and how successful was the communication?	Q19 – Q25
What successes and challenges occurred in the pilot and how do they relate to future deployment?	Q26 – Q33, Q38
What are the incremental costs associated with prescriptive attic air sealing when combined with attic insulation?	Not relevant to staff guide
What are the most cost effective areas and methods to air seal an attic?	Not relevant to staff guide
Does prescriptive attic air sealing cost less than air sealing guided by blower door testing?	Not relevant to staff guide
Would a prescriptive attic air sealing measure achieve market acceptance?	Q32
Could a cost-effective air sealing measure be designed for gas heated homes?	Q34
Could a measure and incentive structure be designed that ensures accurate reporting of project details?	Q35
Could quality assurance be easily performed on this type of measure?	Q36
Could a prescriptive attic air sealing measure expand the number of homes that receive air sealing?	Q33

Instrument

Introduction

Hello, may I speak to [*Name from call list*]?

Hello, my name is _____ from Research Into Action. I am calling regarding the Energy Trust Prescriptive Attic Air Sealing pilot. I am working with Dan Rubado at Energy Trust on an evaluation of this pilot and would like to schedule a time to speak with you about your involvement in the pilot. Is there a convenient time for us to talk in the next week or so, the call will last approximately one hour?

[*Start of Interview*]

Thank you for taking the time to talk with us today. As I mentioned earlier, we are evaluating the Energy Trust Prescriptive Attic Air Sealing pilot and are interested in your feedback as a key program staff member.

We will be taking notes as we talk and audio recording this interview to ensure the accuracy of the notes. However, both the notes and the recording are for research purposes only and will not be provided to anyone outside the Research Into Action team.

S1. Is it ok that I record our conversation? Do you have any questions before we get started?

Background

Q1. Please tell me your job title and describe your overall role in the Air Sealing pilot.

Q2. What do you see as the primary goal for conducting the Prescriptive Attic Air Sealing pilot?

Q3. Were you involved in the design of the Prescriptive Attic Air Sealing pilot?

Q4. [IF Q3 = RESPONDENT INVOLVED IN DESIGN] What was the pilot program's genesis?

Q5. [IF Q3 = RESPONDENT INVOLVED IN DESIGN] Who participated in the design of the pilot and what were their roles?

Q6. [IF Q3 = RESPONDENT INVOLVED IN DESIGN] How were the measure specifications determined?

Q7. [IF Q3 = RESPONDENT INVOLVED IN DESIGN] How were the incentives determined?

Q8. Just to clarify, the trade allies received the incentive for air sealing but the customer received the incentive for the insulation? Is that correct? If not, who received the incentives for air sealing? For insulation?

Trade Ally Recruitment and Training

Q9. How did you recruit trade allies to participate in this pilot?

Q10. In recruiting trade allies for the pilot, were there any eligibility requirements (certifications, participation application, past program engagement i.e., already established trade allies with Energy Trust, etc.)?

Q11. We understand trade allies received training in air sealing and in turn recruited customers into the pilot. Is that correct?

Q12. Who trained trade allies in installing the prescriptive air sealing measure?

Q13. How was training delivered to trade allies? [*If needed: On site, in-classroom, combination?]*

Q14. Who received the training? [*If needed: Trade ally crew chiefs, field staff, both?*]

Q15. What topics were included in the training? [*If needed: Did it include the following? How to do air sealing, how to sell air sealing, appropriate documentation of project, advantages of air sealing with insulation, etc.?]*

Q16. [IF Q11UNDERSTANDING IS **NOT** CORRECT] Please explain how trade allies participated in the pilot?

Q17. [IF Q11 UNDERSTANDING IS **NOT** CORRECT] Please explain how customers participated in the pilot?

Q18. [IF Q11UNDERSTANDING IS CORRECT] Did any projects come to the program other than through trade allies? If so, how?

Communication

Q19. What format (e.g., in-person, phone, email) and how frequently did you communicate with other program staff (Energy Trust and CLEAResult) throughout the pilot?

Q20. Would you describe the communication as successful or challenging? Please elaborate on the success/challenges faced.

Q21. What communication, if any, did you have with trade allies throughout the pilot?

Q22. [IF COMMUNICATED WITH TRADES ALLIES IN Q21] How did you communicate with trade allies [*If needed: Email, meetings, phone, on-site etc.?*]

Q23. [IF COMMUNICATED WITH TRADES ALLIES IN Q21] Would you describe communication with the trade allies as successful or challenging? Please elaborate on the success/challenges faced.

Q24. What communication, if any, did you have with customers? *[Prompt: This could include technical assistance, application/incentive processing etc.]*.

Q25. [IF COMMUNICATED WITH CUSTOMERS IN Q24] How did you communicate with customers?

Implementation

Q26. The original target was 100-150 projects by October 2014. However, the actual number is about 50 projects. How were the participation projections determined?

Q27. What do you think was the primary reason fewer projects were completed? (*probe to clarify role of recruitment, role of trade allies, role of the blower door testing, role of QA in getting projects recruited and then done*)

Q28. Do you think anything could have been done differently to achieve higher a larger number of projects?

Q29. Who conducted the blower door tests that were required as part of the pilot?

Q30. [IFQ29 = BLOWER DOOR TESTS DONE BY SOMEONE OTHER THAN TRADE ALLY] How were blower door tests coordinated with trade allies?

Q31. [IF Q29 = BLOWER DOOR TESTS DONE BY SOMEONE OTHER THAN TRADE ALLY] What feedback did you receive, if any, about the coordination needed between trade allies and the blower door tester?

Conclusion

Q32. Do you think the low participation seen in the pilot is indicative of the potential market acceptance for an attic air sealing measure? Why or why not?

Q33. Based on your experience, would it be possible to expand the number of gas heated homes that install air sealing during attic insulation? Why/Why not?

Q34. Based on your experience, do you think the pilot identified a viable air sealing measure for gas heated homes? *[If not]* What changes do you think are needed to create a cost-effective measure?

Q35. Based on your experience, do you think the current incentive structure is difficult for contractors to manipulate? *[If so]* What changes do you think are needed to make is more difficult?

Q36. Based on your experience, do you think quality assurance was easily performed during this pilot? *[If not]* What changes do you think are needed to make it more easily integrated into the pilot?

Q37. As part of this evaluation, we will interview the trade allies that were involved. What would you like us to learn from the trade allies? What are some key questions you think we should ask them?

Q38. Going forward, what do you see as the greatest success of the pilot and would like to continue? What, if anything, would you like to change? Why?

That is all the questions I have for you. Thank you for your time.

Appendix B. Trade Ally Interview Guide

Energy Trust Air Sealing Pilot: Trade Allies In-depth Interviews

Researchable Questions

We used the researchable questions listed in Table B- to inform the development of the following interview guide.

Table B-1: Researchable Questions and Associated Question Placement

RESEARCHABLE QUESTIONS	ASSOCIATED QUESTION PLACEMENT
What were the perceived issues with installation, verification, and quality assurance procedures?	Q16, Q20
How were trade allies recruited and what attrition occurred, if any?	Q4,Q7
How do trade allies perceive the feasibility and attractiveness of the pilot approach?	Q5,Q6
How is communication conducted across all parties involved in the pilot and how successful was the communication?	Q11-Q15
What successes and challenges occurred in the pilot and how do they relate to future deployment?	Q28,Q29
What are the incremental costs associated with prescriptive attic air sealing when combined with attic insulation?	Q19
What are the most cost effective areas and methods to air seal an attic?	Q17,Q18
Does prescriptive attic air sealing cost less than air sealing guided by blower door testing?	Q21
Would a prescriptive attic air sealing measure achieve market acceptance?	Q24-Q27
Could a cost-effective air sealing measure be designed for gas heated homes?	Q23
Could a measure and incentive structure be designed that ensures accurate reporting of project details?	Not relevant to trade ally guide
Could quality assurance be easily performed on this type of measure?	Q22
Could a prescriptive attic air sealing measure expand the number of homes that receive air sealing?	Q24,Q26,Q27

Instrument

Introduction

Hello, may I speak to [*Name from call list*]?

Hello, my name is _____ from Research Into Action. I am calling regarding the Energy Trust Prescriptive Attic Air Sealing pilot. I am working with the Energy Trust on an evaluation of this pilot and would like to schedule a time to speak with you about your involvement in the pilot. Is there a convenient time for us to talk in the next week or so, the call will last approximately 30 minutes?

[*Start of Interview*]

Thank you for taking the time to talk with us today. As I mentioned earlier, we are evaluating the Energy Trust Prescriptive Attic Air Sealing pilot and are interested in your feedback as an Energy Trust trade ally.

I'm taking notes as we talk and audio recording this interview to ensure the accuracy of the notes. However, both the notes and the recording are for research purposes only and will not be provided to anyone outside the Research Into Action team.

S1. Is it ok that I record our conversation?

Do you have any questions before we get started?

Background

Q1. Please tell me your job title

Q2. Do you provide services to mostly residential customers, mostly commercial customers, or are your services about evenly split between residential and commercial customers?

Q3. What services do you typically provide to attic insulation customers?

Trade Ally Recruitment and Training

Q4. How did you first hear about the Energy Trust Prescriptive Attic Air Sealing pilot *[Probe for how they were recruited]*?

Q5. What did you perceive as the benefits of participating in pilot?

Q6. How feasible did you think integrating the pilot requirements for attic air sealing into your existing attic insulation workflow would be when you first started participating?

Once you started participating, was integrating the pilot requirements for the attic air sealing into your existing workflow as *[Insert response from Q6]* as you thought it would be? If not, what was different an?

Q7. *[For "disengaged TAs only]* Why did you stop doing attic air sealing projects for the pilot?

Q8. What, if any, type of training did you receive from Energy Trust's Existing Homes program staff for this pilot?

Q9. Who provided the training?

Q10. How was the training delivered? [*If needed: On site, in-classroom, combination?]*

Communication

Q11. What format (e.g., in-person, phone, email) and how frequently did you communicate with Existing Homes program staff throughout the pilot?

Q12. Would you describe the communication as successful or challenging? Please elaborate on the success/challenges faced.

Implementation

Q13. How did you identify customers to recruit into the pilot? *[Prompt: Did the Energy Trust/CLEAResult team provide any marketing support e.g., informational cards with the pilot website]*

Q14. When and how did you communicate with customers throughout the project?

Q15. What, if anything, did you tell customers about the pilot?

Q16. What, if any, were the issues you faced when completing a pilot project? *[Probe: installation, verification, and quality assurance*]

Q17. What do you believe are the least costly *(If needed: labor and materials)* areas in the attic to seal?

Q18. How about the least costly method to air seal an attic? [*Prompt: Do one type of sealing at a time, work across the attic, etc?*]

Q19. What was the added cost per house, in labor and materials, of air sealing the attic before installing the insulation? *(Note: test sufficiency of $400 incentive for air sealing)*

Q20. Generally, how long did it take to complete the air sealing for each pilot project? *[Note: Energy Trust assumed four to six hours per house]*

How much of that time do you think was needed to complete the blower door tests verses complete the air sealing itself?

Q21. Based on your experience, have you found prescriptive attic air sealing to cost less, more, or about the same as blower door-guided air sealing? *(Probe: for example air sealing distinct areas of the attic)*

Q22. Based on your experience, do you think quality control was easily performed during this pilot? *[If not]* What changes do you think are needed to make it more easily integrated into the pilot? *(Probe: What do you think of a requirement of a before and after cell phone photo as part of the quality control?)*

Conclusion

Q23. Do you think the pilot identified a viable air sealing strategy for gas heated homes? *[If not]* What changes do you think are needed?

Q24. Based on your experience, would it be possible for Energy Trust to expand the number of gas heated homes that install air sealing during attic insulation? Why/Why not?

Q25. How many attic insulation projects do you typically do in a year? Why/Why not?

Q26. How many of these projects do you think you could add attic air sealing to assuming the Energy Trust offered an incentive? Why that many?

Q27. Would you offer combined air sealing and attic insulation to your customers if the Energy Trust DID NOT continue to provide incentives? Why/Why not?

Q28. What was the greatest success of the pilot? Why?

Q29. What was the most significant problem with the pilot? What, if anything, would you recommend changing? Why?

Q30. Is there anything we have not yet talked about regarding the pilot that you would like to tell me about?

That is all the questions I have for you. Thank you for your time.