FINAL REPORT

Avista 2013 Washington Gas Portfolio Impact Evaluation

May 15, 2014

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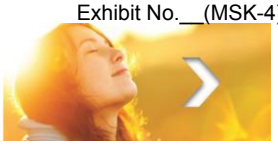

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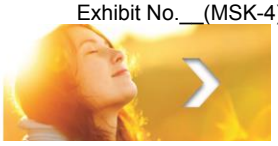

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Portfolio Executive Summary

Avista Corporation contracted with Cadmus to complete process and impact evaluations of the company's program year (PY) 2013 natural gas and electric demand-side management (DSM) programs. Avista has been administering DSM programs for several decades to reduce its customers' energy use for electricity and natural gas. Most programs are implemented in-house, but for a few, Avista utilizes external implementers. This report presents our impact findings for the PY 2013 gas portfolio in the State of Washington.

Evaluation Activities

For each of the three sectors—residential, nonresidential, and low income—we employed a variety of evaluation methods and activities, as shown in Table 1.

Table 1. PY 2013 Gas Programs Evaluation Activities

Sector	Program	Document /Database Review	Verification /Metering Site Visit	Survey	Billing Analysis	Simulation
Residential	ENERGY STAR Products	✓		✓		
	Heating and Cooling Efficiency	✓		✓		
	Weatherization/Shell	✓		✓	✓	
	Water Heater Efficiency	✓		✓		
	ENERGY STAR Homes	✓				
	Manufactured Homes Duct Sealing	✓			✓	
	Simple Steps, Smart Savings	✓				
Nonresidential	Prescriptive programs	✓	✓			
	Site-Specific	✓	✓		✓	✓
Low Income	Low Income programs	✓		✓	✓	

Savings Results

Table 2 presents sector-level reported and gross verified savings values and realization rates. Overall, the portfolio achieved a 96% realization rate, and acquired 613,788 in annual therm savings.

Table 2. PY 2013 Reported and Gross Evaluated Savings for Washington

Sector	Reported Savings (therms)	Gross Evaluated Savings (therms)	Realization Rate
Residential	296,130	285,497	96%
Nonresidential	319,804	304,081	95%
Low Income	23,676	24,210	102%
Total	**639,610**	**613,788**	**96%**

Table 3 shows gross verified savings compared to the Integrated Resource Plan (IRP) goal of 892,000 therms. The IRP goal is at the portfolio level, so in order to show a sector-level comparison, Cadmus adopted the Avista 2013 Business Plan goals by sector, and applied those proportions to the IRP target. In PY 2013, the programs achieved 69% of the IRP target in Washington, which is notable because of the uncertainty of the existence of the gas program in 2013 for Washington.

Table 3. PY 2013 IRP Goals and Gross Evaluated Savings for Washington

Sector	Savings Goal (therms)	Gross Evaluated (therms)	Achievement Rate
Residential	264,512	285,497	108%
Nonresidential	599,439	304,081	51%
Low Income	28,049	24,210	86%
Total	**892,000**	**613,788**	**69%**

Key Findings and Conclusions

Residential

For PY 2013, Avista's residential gas programs produced 285,497 therms in savings, yielding an overall realization rate of 96% of reported savings and 108% of equivalent residential IRP goals.

The evaluation produced the following residential program conclusions:

- Avista's program and tracking databases were adequate for evaluation purposes, providing sufficient contact information and measure and savings information in most cases (the one major exception was omitted Avista account numbers in the Manufactured Homes Duct Sealing Program files). The database review confirmed the information was reliable and accurate.
- High-efficiency furnaces continue to dominate the residential gas portfolio savings.
- Weatherization billing analyses revealed larger per home savings than expected.

Nonresidential

For PY 2013, Avista's nonresidential gas programs produced 304,081 therms in savings, yielding an overall realization rate of 95% of reported savings, and 51% of equivalent nonresidential IRP goals.

Cadmus evaluated 30 of 160 measures installed through the programs in PY 2013 in Washington, representing 44% of tracked savings. Through evaluation, we determined that Avista generally implemented the programs well. Cadmus identified the following key issues that reduced evaluated energy savings below the reported values:

- Some calculations provided by participants/contractors contained information that varied from what Cadmus engineers found on site.
- One prescriptive project had not actually been installed as reported.
- Retrofit natural gas consumption varied from predicted values for some site-specific projects.

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Low Income

In PY 2013, Avista's low-income gas programs produced 24,210 therms in savings, yielding a 102% overall realization rate of reported savings and 86% of the equivalent low income IRP goals.

Compared to the PY 2010 billing analysis, Avista's PY 2013 low-income program demonstrated an average increase in gas savings per participant, in addition to an increase in the overall program realization rate (from 31% to 102%). Several factors may have contributed to the increase in participant savings, including:

- An increased frequency of installing high-saving measures (e.g., shell) in the evaluation period,
- Changes in agency delivery protocols or energy-saving installations made with non-utility funding, and
- Exogenous effect (e.g., economic, rate changes) that may have occurred simultaneously with program activity.

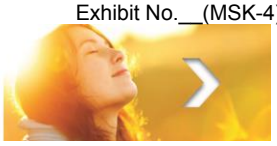
One factor contributing to higher realization rates is lower average reported savings occurring in the PY 2013 evaluation period compared to previous years.

Recommendations and Further Analysis

Residential

Based on our evaluation results, Cadmus offers the following recommendations:

- If the clothes washer measure is reinstated, Avista should consider moving all rebates to the electric program, as the majority of savings will likely result from a reduction in consumed electricity from the dryer. Qualifying for the program should be based on the presence of an electric dryer in the home. Given the large percentage of savings achieved through reduced dryer energy, and because of the high likelihood that most participants have an electric dryer, this measure predominantly produces electric energy savings.
- Avista should consider increasing the amount of data tracked as part of the Manufactured Homes Duct Sealing Program, including such fields as the Avista customer account number.
- Avista may consider performing a targeted billing analysis for weatherization participants who use *both* electricity and gas to heat their homes. Our current study analyzes homes based on the program they are tracked in. Customers who use multiple fuels to heat their home may be saving more energy than currently estimated.
- High-efficiency gas furnaces continue to provide the largest portion of savings for the residential portfolio. The last billing analysis we performed was in 2011 on PY 2010 participants, so those results could be re-estimated in the next evaluation.
- Once the gas heated homes participation in the Manufactured Homes Duct Sealing Program has reached sufficient size, consider conducting a billing analysis to estimate savings.



Nonresidential

Cadmus offers the following recommendations based on the evaluation results:

- Streamline the file structure to enable internal and external reviewers to more easily identify the latest documentation.
- Avista should continue to perform follow-up measure confirmation and/or site visits on a random sample of projects (at least 10%).
- Consider flagging sites for additional scrutiny where the paid invoice does not list installation labor.

Low Income

The impact evaluation revealed several areas where program performance and savings calculation accuracy could be improved. Consequently, we have the following recommendations:

- Consider including a control/comparison group in future billing analyses.
- Consider options to increase the analysis sample size due to small program populations (such as combining Washington and Idaho program participants).
- Obtain a full list of weatherization measures from agencies.
- Consider targeting high-use customers.
- Track and compile additional data from agency audits.
- Consider performing a quantitative, non-energy benefit analyses.

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1. 2013 Residential Gas Impact Report

1.1. Introduction

During PY 2013, Avista's residential gas DSM programs in Washington reported savings of 296,130 therms for 3,958 measures installed through the following programs:

- ENERGY STAR Products
- ENERGY STAR Homes
- Heating and Cooling Efficiency
- Water Heater Efficiency
- Weatherization/Shell
- Manufactured Homes Duct Sealing
- Simple Steps, Smart Savings

This report explains the methods we used to qualify and verify these savings.

1.1.1. Evaluation Methodology

We designed our impact evaluation to verify reported program participation and energy savings using:

- Data collected in the tracking database;
- Online application forms;
- Phone surveys;
- Applicable deemed values developed for Avista's technical reference manual (TRM);[1] and
- Billing analyses.

As shown in Table 4, Cadmus employed up to three basic evaluation methods and activities for each program.

[1] In the first quarter of 2011, Cadmus created a TRM for use in deemed measure savings. We updated the TRM when necessary or when new results are available.

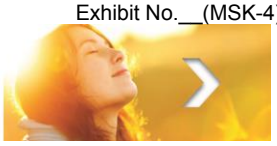

Table 4. Evaluation Methodology

	Program	Document/Database Review	Surveys	Billing Analysis
Residential	ENERGY STAR Products	✓	✓	
	Heating and Cooling Efficiency	✓	✓	
	Weatherization/Shell	✓	✓	✓
	Water Heater Efficiency	✓	✓	
	ENERGY STAR Homes	✓		
	Manufactured Homes Duct Sealing	✓		✓
	Simple Steps, Smart Savings	✓		

1.1.2. Energy Savings

Table 5 shows aggregated, adjusted gross savings and resulting realization rates by program.

Table 5. PY 2013 Reported and Adjusted Gross Savings

Program Name	Reported Savings (therms)	Adjusted Gross Savings (therms)	Realization Rate
ENERGY STAR Products	695	590	85%
Heating and Cooling Efficiency	212,308	209,714	99%
Weatherization/Shell	38,326	40,242	105%
Water Heater Efficiency	1,096	1,566	143%
ENERGY STAR Homes	1,009	1,017	101%
Manufactured Homes Duct Sealing	41,978	29,973	71%
Simple Steps, Smart Savings	718	2,395	334%
Total	**296,130**	**285,497**	**96%**

Table 6 shows the reported measure counts. We verified savings of 285,497 therms through the installation of 3,958 measures during PY 2013. Overall, residential gas programs achieved an adjusted gross realization rate of 96%.

Table 6. Avista PY 2013 DSM Programs' Reported Measure Counts

Program	Washington Measure Count
ENERGY STAR Products	139
Heating and Cooling Efficiency	2,038
Weatherization/Shell	313
Water Heater Efficiency	174
ENERGY STAR Homes	5
Manufactured Homes Duct Sealing	1,042
Simple Steps, Smart Savings	247
Total	**3,958**

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1.2. Methodology

1.2.1. Sampling

Cadmus randomly sampled program participants to complete surveys. Cadmus also randomly sampled participant applications to review for this evaluation. The following subsections describe the methods we used to select the required samples.

Record Review Sampling

To determine the percentage of measures incented that qualified for the program, Cadmus designed sample sizes to yield result at the 90% level of confidence and ±10% precision level for each application type, across both states and both fuel types. Cadmus randomly selected participant measures for a record qualification review from the 2012 and 2013 gas and electric program populations. We sampled participants using a single measure record. However, if a customer applied for multiple rebates on the same application form during the program year, we checked all measures included in the application for qualification, whether the fuel was electric or gas.

Table 7 shows the number of record reviews we completed of unique accounts and unique measures.

Table 7. Measure-Level Record Reviews Completed

Record Review	Count
Total Participants Reviewed	445
Total Measures Qualified	554

Survey Sampling

Cadmus conducted the participating customer surveys in two rounds, one in March and April 2013 and a second in February 2014. This approach ensured that respondents had a clear recollection of their participation experience. Table 8 summarizes unique customers (identified using Avista account number) and surveys completed in each effort.

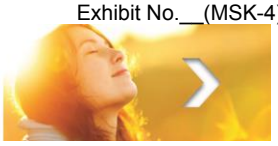

Table 8. Residential Participant Details and Survey Sample—Washington and Idaho

Measure Type	2012			2013		
	Participants	Surveys	%	Participants	Surveys	%
Natural Gas and Electric Programs						
ENERGY STAR Products	6,429	149	2%	782	65	8%
Heating and Cooling Efficiency	3,747	142	4%	2,490	70	3%
Water Heater Efficiency	629	88	14%	316	60	19%
Weatherization/Shell	692	102	15%	313	60	19%
Electric-Only Programs						
2nd Refrigerator & Freezer Recycling	1,351	133	10%	1,319	65	5%
Space and Water Conversions	171	34	20%	156	37	24%
Total	**13,019**	**648**	**5%**	**5,376**	**357**	**7%**

Cadmus designed participant survey completion targets to yield results with 90% confidence and ±10% precision, for measure-category-level survey results. In PY 2012, we expanded this approach to yield results at the measure category and state level. Cadmus deemed this necessary as data collected through these surveys—specifically installation rates—were used to inform an impact assessment of Avista's residential programs. Cadmus drew upon multiple additional factors in selecting the participant survey sampling plan, including the feasibility of reaching customers, program participant populations, and research topics of interest.

Cadmus did not conduct participant surveys with Simple Steps, Smart Savings customers, as that program has an upstream focus and therefore there is no tracking of participant contact information. Similarly, for ENERGY STAR Homes, Cadmus did not survey residential customers who purchased a rebated home because Avista pays program rebates to builders, not to end-use customers. Cadmus also did not focus evaluation resources on new programs that were reviewed by the implementation organizations (i.e., Residential Behavior) or temporary programs (e.g., Home Audit & Manufactured Homes Duct Sealing).

Within each program stratum, Cadmus randomly selected participant contacts included in survey sample frames. A review of collected data shows geographic distribution of survey respondents clustered around urban centers, specifically the cities of Spokane, Coer d'Alene, Pullman, Moscow, and Lewiston. This aligns with the population distributions in Avista's service territory. Figure 1 provides the distribution of participating customer survey respondents.

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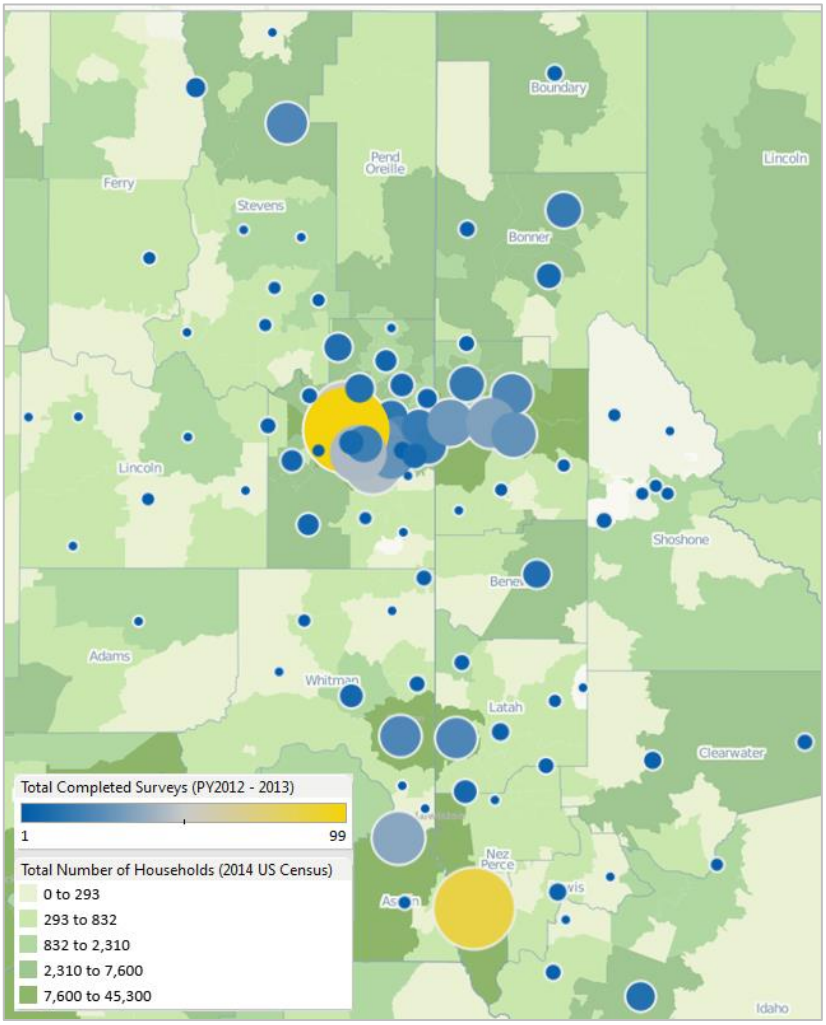
Figure 1. Geographic Distribution of PY 2012-PY 2013 Participating Customer Survey Respondents



1.2.2. Data Collection and Analysis

Record Review

Cadmus reviewed all records for the selected sample of accounts, checking them for completeness and program compliance using the data they contained. Measures qualified if all data found in the application complied with the program specifications. As Cadmus randomly sampled customers by application type (and several measures can be found on different application forms), we tracked qualification rates by the type of application.

The review revealed one improperly issued insulation rebate on a home improvement application, as it had an existing R-value above the participation requirements (the applied qualification rates included this result).

Surveys

Cadmus contracted with Discovery Research Group (DRG), a market research firm, to survey sampled participants. To minimize response bias, DRG called customers during various hours of days and evenings (including weekends), and made multiple attempts to contact individual participants. Cadmus monitored survey phone calls to ensure accuracy, professionalism, and objectivity. We analyzed the survey data at the program level rather than the measure level, and weighted survey results at the portfolio level by program participation to ensure proper representation.

Database Analysis

Cadmus reviewed the participant database Avista provided to check for inconsistencies in reported savings and measure duplications. We did not identify inconsistencies in data tracking. All reported savings were based on the 2012 Avista TRM.

Unit Energy Savings

Cadmus updated the unit energy savings achieved by ENERGY STAR clothes washers based on new survey data of Avista participants. We did not update unit energy savings for other measures.

1.2.3. Verification Rates

Cadmus determined verification rates for each program, but not for each measure. Where applicable, our review covered the following topics:

- Checking that the database tracked the correct measures;
- Accounting for correct quantities; and
- Determining whether units remained in place and were operable.

All the measures we researched remained in place and were operable, resulting in a 100% verification rate.

1.2.4. Measure Qualification Rates

Cadmus considered a measure qualified if it met the various requirements particular to its category, such as receiving an ENERGY STAR certification or achieving program minimum efficiency standards. When necessary, we conducted online database searches for model numbers, and noted necessary characteristics to verify achievement of all qualifications.

Out of the entire verification sample, we identified one nonqualified measure:

- An attic insulation project had a base case condition that prevented it from qualifying.

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1.3. Program Results and Findings

1.3.1. Overview

Cadmus determined the total adjusted gross savings for each measure and each program, as well as the overall realized savings for each program. In the following sections we describe each program, explain our analysis steps, and discuss the results and findings.

Calculating the adjusted gross measure savings required the following steps:

- Reviewing the database to determine whether adjusted measure counts correctly represent the number of measures installed.
- Conducting a phone survey with a sample of customers to verify measure installations.
- Reviewing records to determine measure qualification.
- Calculating verification and qualification rates.
- Calculating deemed measure savings for rebated products.
- Determining adjusted gross savings for each measure by applying the above-calculated rates and deemed savings to measure counts.

1.3.2. ENERGY STAR Products

Program Description

The ENERGY STAR Products Program included the following gas measures:

- Clothes washer (gas)
- Dishwasher (with gas water heater)

Through the program, Avista offered direct financial incentives to motivate customers to use more energy-efficient appliances. The program indirectly encouraged market transformation by increasing demand for ENERGY STAR products. While electric and gas measures were included in the program, this report focuses on gas savings.[2]

Analysis

Energy savings credited to the ENERGY STAR Products Program had to meet multiple criteria:

- Measures had to remain in place and be operating properly at the time of verification;
- The numbers of installed equipment pieces and their corresponding model numbers listed in the applications had to match the database; and
- Units must have been ENERGY STAR-qualified at the time of the program offering.

[2] See Appendix B for the electricity savings achieved through this gas program.

Clothes Washers

To calculate energy savings, Cadmus drew upon a metering study we conducted in 2009,[3] for which we metered more than 100 clothes washers in California homes for three weeks; this was the largest *in situ* metering study of residential clothes washers and dryers conducted in the last decade. The study revealed higher consumption and savings values than are often estimated.

Dryers produced the majority of energy consumption and savings, as high-efficiency washing machines remove more moisture from clothes, allowing shorter drying times. As most energy savings resulted from decreased dryer use, Cadmus estimated the percentage of homes using gas domestic hot water heaters and electric dryers. The Regional Technical Forum (RTF) advocates an 82% assumption, which we used for this evaluation. Consequently, 82% of installations of ENERGY STAR clothes washers in homes with a gas domestic hot water heater achieved significant electricity savings.

To determine adjusted gross savings, Cadmus used the following additional input assumptions:

- Recent independent evaluation surveys from the Residential Building Stock Assessment resulted in 256 washing cycles per year. This value nearly matches 2012 Avista participant surveys, which led to an estimated 262 washing cycles per year.[4] Cadmus adjusted the unit energy-savings values according to the Avista participant survey results, as reflected in the realization rate for this measure.
- Cadmus used the California metering study to estimate consumption per wash and dry cycle for the base and efficient equipment.

Dishwashers

There were no applications processed for this measure in PY 2013.

Results and Findings

Table 9 shows the total reported and qualified counts, savings, and realization rates of gas ENERGY STAR Products Program measures in Washington.

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[3] The Cadmus Group, Inc. *Do the Savings Come Out in the Wash? A Large Scale Study of In-Situ Residential Laundry Systems*. 2010. Available online: http://www.cadmusgroup.com/wp-content/uploads/2013/02/Home-Energy-Magazine-January-2012-Mattison-Korn-article.pdf.

[4] Ecotope Inc. *2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use*. Seattle, Washington. Prepared for Northwest Energy Efficiency Alliance. 2012.

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Table 9. ENERGY STAR Products Program Results in Washington

Program Name	Reported Measure Count	Reported Savings (therms)	Adjusted Savings (therms)	Qualification Rate	Verification Rate	Adjusted Gross (therms)	Realization Rate
Gas Clothes Washer With Natural Gas Water Heater	139	695	590	100%	100%	590	85%

Appendix B addresses electricity savings achieved by the installation of ENERGY STAR products in homes with a gas domestic hot water heater.

The program achieved an 85% realized adjusted gross savings rate, a result driven by an adjustment in the baseline to account for market effects.

1.3.3. Heating and Cooling Efficiency

Program Description

The Heating and Cooling Efficiency Program included the following gas measures:

- Gas boiler
- Gas furnace

Through the program, Avista offered a $400 direct financial incentive to motivate customers to install more energy-efficient heating and cooling equipment. Participants could receive the incentive for installing a high-efficiency natural gas furnace of 90% AFUE (heating efficiency) or greater, or a natural gas boiler of 90% AFUE or greater.

Analysis

In the PY 2010 gas impact evaluation report,[5] Cadmus documented a census billing analysis we performed to determine the change in energy consumption due to the installation of a high-efficiency gas furnace. As the billing analysis provided the best information on this measure, Cadmus continued tracking results for PY 2013.

We calculated the amount of energy savings achieved through installations of high-efficiency gas boilers by adjusting the billing analysis results to the typical participant home installing a high-efficiency boiler.

Results and Findings

Table 10 shows the total reported and qualified counts, savings, and realization rates for gas Heating and Cooling Efficiency Program measures in Washington.

[5] Cadmus. *Avista 2010 Multi-Sector Gas Impact Evaluation Report*. August 2011.

Table 10. Heating and Cooling Efficiency Program Results in Washington

Measure	Reported Measure Count	Reported Savings (therms)	Adjusted Savings (therms)	Qualification Rate	Verification Rate	Adjusted Gross (therms)	Realization Rate
Natural Gas Boiler	20	2,820	1,860	100%	100%	1,860	66%
Natural Gas Furnace	2,018	209,488	207,854	100%	100%	207,854	99%
Program Total	**2,038**	**212,308**	**209,714**	**100%**	**100%**	**209,714**	**99%**

The program achieved a 99% realized adjusted gross savings rate.

1.3.4. Weatherization/Shell

Program Description

The following three categories of measures were incented through this program, available to residential customers with gas heated homes served by Avista:

- Insulation—ceiling/attic
- Insulation—floor
- Insulation—wall

Qualifying ceiling and attic insulation (both fitted/batt and blown-in) must have increased the R-value by 10 or more, and were incented at $0.15 per square foot of new insulation. Homes qualified if they had attic insulation of R-19 or less.

Floor and wall insulation (both fitted/batt and blown-in) must have increased the R-value by 10 or more, and were incented at $0.20 per square foot of new insulation. Homes were eligible if they had existing floor and/or wall insulation of R-5 or less.

Analysis

Cadmus conducted a statistical billing analysis to determine adjusted gross savings and realization rates for installed gas weatherization measures in PY 2011, PY 2012, and PY 2013. Our previous billing analysis primarily included PY 2010 customers, although we extrapolated realization rates to PY 2011. We included PY 2011 customers in this billing analysis since they now have complete post-period billing data. This increased the sample size and improved the precision of weatherization savings estimates. We also present results that only include PY 2012 and PY 2013. To increase accuracy of the analysis, we only included participants with at least 10 months of pre- and post-installation billing data. Consequently, the billing analysis includes PY 2011, PY 2012, and early PY 2013 participants.

To estimate weatherization energy savings resulting from the Washington program, Cadmus used a pre- and post-installation combined Conditional Savings Analysis (CSA) and Princeton Score-Keeping Method (PRISM) approach. We calculated overall gas model savings estimates for each measure bundle. We also attempted to estimate the detailed measure-specific savings impacts.

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Billing Analysis Methodology

Avista provided Cadmus with monthly gas billing data for all Washington participants from January 2009 through January 2014. Avista also provided a measure detail file containing participation and measure data. Participant information included:

- Customer details,
- Account numbers,
- Types of measures installed,
- Rebate amounts,
- Measure installation costs,
- Measure installation dates, and
- Deemed savings per measure.

Cadmus first matched weatherization measure information with the gas billing data. We obtained Washington daily average temperature weather data from January 2009 through January 2014 for eight National Oceanic and Atmospheric Administration (NOAA) weather stations, representing all the ZIP codes in Avista's Washington service territory. From daily temperatures, we determined base 65 heating degree days (HDDs) for each station. Using a ZIP code mapping for all U.S. weather stations, we determined the nearest station for each ZIP code. We then matched billing data periods with the HDDs from the associated stations.

Cadmus specified the pre- and post-periods for each customer account using two specifications:

- ***The Customer-Specific Measure Install Date:*** For each customer's unique installation date, this specification compares the year ending just before the install date with the year beginning on the installation month.
- ***The Fixed Dates:*** For this method, we selected the earliest and latest dates of available billing data. In effect, we used January 2010 through December 2010 as the pre-period, before any installations occurred. We defined the post-installation period as the latest period of complete billing data: February 2013 through January 2014.

Table 11 shows an example of the pre- and post-periods under the two specifications. For this analysis, Cadmus used a combination of the two specifications. While the first specification allows data from a more compressed timeframe to be used, it relies heavily on the exact installation date. The Fixed Dates specification removes this uncertainty by keeping only the earliest and latest periods of data, which are well outside the installation period. The drawback with using Fixed Dates is that it requires a longer billing data history; however, Cadmus relied on this method by default. To minimize attrition, we used the Customer Specific Measure Install Date specification when possible where there was insufficient billing data to use Fixed Dates.

Table 11. Example of Pre- and Post-Period Under the Two Specifications

Specification of Pre- and Post-Period	Installation Date	Pre-Analysis Period	Post-Analysis Period
Customer Specific Measure Install Date	November 2012	November 2011 - October 2012	November 2012 - October 2013
Fixed Dates		January 2010 - December 2010	February 2013 - January 2014

Data Screening

General Screens

Cadmus removed accounts with fewer than 10 paired months (300 days) of billing data in the pre- or post-period, as these data that could skew weatherization savings estimates.

PRISM Modeling Screens

As the second step in the screening process, Cadmus ran PRISM models on pre- and post-period billing data. These models provided weather-normalized pre- and post-period annual usage for each account, and we used them as an alternate check of the savings determined from the CSA model. The model specifications can be found in Appendix A.

For each participant home, we estimated a heating model in both pre- and post-periods to weather-normalize raw billing data.

After running the models, we applied the following screens to the PRISM model output, removing outlier participants from the billing analysis:

- ***Accounts where the post-weather-normalized (POSTNAC) usage was 70% higher or lower than the pre-weather-normalized (PRENAC) usage.*** Such large changes could indicate property vacancies when adding or removing gas equipment such as pools or spas, which are unrelated to weatherization installations.
- ***Accounts with negative intercepts and, hence, negative base load.*** We included these accounts in the analysis, but truncated them to 0. These negative intercepts typically occurred in homes with gas space heating and without gas water heating. The base load for these homes was expected to be 0; thus, we set the base load to 0.

The Washington weatherization population included 1,878 participants. Once we had screened the data, 1,211 participants (64%) remained for use in the CSA model, outlined below, to determine overall savings.

Table 12 summarizes the attrition from each data screening step listed above. Each row in the table indicates the accounts remaining after attrition. Roughly 26% of the participant accounts were dropped from the analysis because they did not have sufficient pre- and post-period billing data. Another 9%

were dropped based on PRISM screening and the presence of vacancies, seasonal usage, outliers, or equipment changes in the billing data.

Table 12. Weatherization Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Total Washington weatherization accounts	1,878	100%	0	0%
Matched to billing data provided	1,871	100%	7	0%
Less than 10 months of pre- or post-period billing data	1,385	74%	486	26%
PRISM screening*	1,351	72%	34	2%
Accounts deleted due to vacancies, seasonal usage, outliers and equipment changes	1,211	64%	140	7%
Final Analysis Group	**1,211**	**64%**	**667**	**36%**

* Using PRISM screens, Cadmus dropped accounts with: 1) negative heating slopes in the pre- or the post-period or 2) post-period usage that changed by more than 70% from pre-period usage.

CSA Modeling Approach

To estimate weatherization energy savings from this program, we used a pre/post CSA, fixed-effects model with pooled monthly time-series (panel) billing data. This modeling approach corrected for differences between pre- and post-period weather conditions, as well as for differences in usage consumption between participants through the inclusion of a separate intercept for each participant. This approach ensured that model savings estimates would not be skewed by unusually high-usage or low-usage participants. The model specifications can be found in Appendix A.

Program Impact Evaluation Findings

Overall Savings Impacts (Fixed Effects)

Table 13 summarizes the usage and savings associated with the weatherization measures installed in gas heated homes.[6] The results show the annual savings, relative precision on these savings, the PRENAC for each level, and the savings as a percentage of PRENAC. Table 13 also reports *ex ante* savings estimates and the realization rates achieved for the weatherization measures.

Overall, the PY 2011-PY 2013 weatherization measures achieved savings of 81 therms, or 9.3% savings relative to PRENAC. With an average weatherization measure *ex ante* savings estimate of 125 therms, the weatherization measures realized 65% of the expected savings.

[6] Cadmus also estimated measure-level models for PY 2012 and PY 2013 that contain the most recent *ex ante* estimates. For Washington, these revealed that the attic and wall insulation gas model savings were generally close to the current *ex ante* values; however, the floor insulation savings were considerably lower than the *ex ante* savings.

If the billing analysis is limited only to the PY 2012 and PY 2013 participants, the sample sizes drop considerably; however, the *ex ante* estimates reflect a downward adjustment based on the previous billing analysis. Also, there was a program change in the PY 2012 and PY 2013, in which only homes with very low initial R-value insulation levels qualified for the program. The PY 2012 and PY 2013 weatherization participants achieved savings of 100 therms, or 11.5% savings relative to PRENAC. With an average weatherization measure *ex ante* savings estimate of 95 therms, the weatherization measures realized 105% of the expected savings.

Finally, Cadmus estimated savings for only PY 2011 participants. This year forms the predominant sample of the billing analysis; however, the *ex ante* estimates are considerably higher. The PY 2011 weatherization participants achieved savings of 74 therms, or 8.5% savings relative to PRENAC. With an average weatherization measure *ex ante* savings estimate of 135 therms, the weatherization measures realized 55% of the expected savings.[7] Cadmus used the 2012 – 2013 results to determine program savings as the analysis was completed on homes only within this biennium.

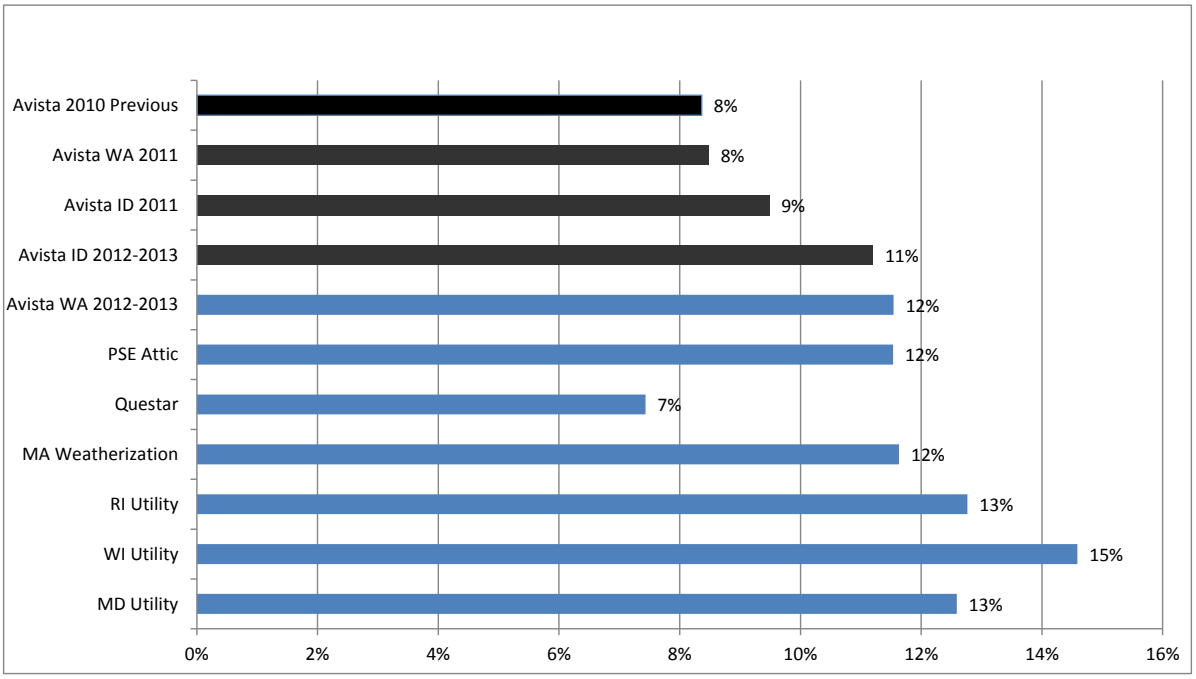
Table 13. Washington Weatherization Gas Savings per Home (Fixed-Effects Model)

Program Years	Number of Homes	Model Savings (therms)	Relative Precision on the Savings	Pre-Normalized Annual Consumption (therms)	Pre-Normalized Heating Annual Consumption (therms)	Savings as Percent of Pre-Period Annual Consumption	Annual *Ex Ante* Savings (therms)	Realization Rate
2011-2013	1,211	81	6%	874	681	9.3%	125	65%
2012-2013	303	100	6%	868	689	11.5%	95	105%
2011	908	74	8%	876	679	8.5%	135	55%

Figure 2 compares the percentage of program savings to similar gas weatherization evaluations. Avista's PY 2012 - PY 2013 percentage savings have improved significantly from PY 2010 and PY 2011. The Washington percentage savings are comparable with the Idaho percentage savings.

[7] The weatherization savings for the PY 2010 and PY 2011 participants, outlined in our previous report, was 72 therms. The combined Idaho and Washington realization rate was 49%. In the previous report, we relied primarily on PY 2010 participants. PY 2011 savings and realization rate are very similar to the PY 2010 estimates.

Figure 2. Gas Weatherization Percentage Savings Benchmarking



Results and Findings

Table 14 shows total reported and qualified counts, savings, and realization rates of gas weatherization efficiency measures in Washington.

Table 14. Weatherization Program Results in Washington

Measure	Reported Measure Count	Reported Savings (Therms)	Adjusted Savings (Therms)	Qualification Rate	Verification Rate	Adjusted Gross (Therms)	Realization Rate
Attic/Ceiling Insulation	190	11,941	12,538	100%	100%	12,538	105%
Floor Insulation	43	8,438	8,860	100%	100%	8,860	105%
Wall Insulation	80	17,947	18,844	100%	100%	18,844	105%
Program Total	**313**	**38,326**	**40,242**	**100%**	**100%**	**40,242**	**105%**

1.3.5. Water Heater Efficiency

Program Description

The Water Heater Efficiency Program includes the following gas measures:

- High-efficiency 40-gallon water heater
- High-efficiency 50-gallon water heater

Through this program, Avista offered a $50 incentive to residential customers who installed eligible high-efficiency water heaters. To qualify for the program, natural gas water heaters with tanks had to have a 0.60 EF or greater for a 50-gallon tank, and a 0.62 EF or greater for a 40-gallon tank.

Analysis

Deemed unit energy savings remained consistent with those used in PY 2011, thus no changes were necessary.

Results and Findings

Table 15 shows total reported and qualified counts, savings, and realization rates of gas Water Heater Efficiency Program measures in Washington.

Table 15. Water Heater Efficiency Program Results in Washington

Measure	Reported Measure Count	Reported Savings (Therms)	Adjusted Savings (Therms)	Qualifi-cation Rate	Verifi-cation Rate	Adjusted Gross (Therms)	Reali-zation Rate
40-Gallon Natural Gas Hot Water	26	208	229	100%	100%	229	110%
50-Gallon Natural Gas Hot Water	148	888	1,337	100%	100%	1,337	151%
Program Total	**174**	**1,096**	**1,566**	**100%**	**100%**	**1,566**	**143%**

1.3.6. ENERGY STAR Homes

Program Description

Through the ENERGY STAR Homes Program, Avista offered incentives to builders constructing single-family or multifamily homes complying with ENERGY STAR criteria (and verified as an ENERGY STAR Home). Avista provided a $900 incentive for customer homes that use electric or electric and natural gas service for space and water heating. Avista provided a $650 incentive for homes that only have natural gas service (both hot water and space heating had to be natural gas).

Analysis

In the PY 2011 gas impact evaluation report, Cadmus documented the simulation modeling we had performed to determine the energy savings achieved by these measures. As the simulation results continue to provide accurate savings estimates, the results were maintained for PY 2012.

Results and Findings

Table 16 shows total reported and adjusted counts, savings, and realization rates for gas measures within ENERGY STAR Homes. The electric and gas program measures were installed in participating homes that use both electric and gas from Avista. The associated electric impact evaluation report will address electric savings associated with these homes.

Table 16. ENERGY STAR Home Program Results

Type of Fuel Used	Reported Measure Count	Reported Savings (Therms)	Adjusted Savings (Therms)	Qualification Rate	Verification Rate	Adjusted Gross (Therms)	Realization Rate
Gas Only	3	609	610	100%	100%	610	100%
Electric/Gas	2	400	407	100%	100%	407	102%
Program Total	**5**	**1,009**	**1,017**	**100%**	**100%**	**1,017**	**101%**

1.3.7. Manufactured Homes Duct Sealing

Program Description

For this program, inspectors performed one of three levels of duct inspection and sealing on manufactured homes. In addition to duct sealing, they installed carbon dioxide monitors, CFLs, and showerheads. The program was offered from October 2012 through June 2013. Below are the description of each level of duct sealing and repair offered through the program.

Level 1 **-** Ducts are sealed from the interior (boots, registers, end caps). Cross-over duct is inspected and if no air leaks are found, no exterior treatment of the cross-over duct is conducted.

Level 2 **-** Ducts are sealed from the interior (boots, registers, end caps). Plenum is sealed. Cross-over duct is inspected and if determined to still be in good condition, but air leaks are identified at the cross-over duct connections to the collars, the collar connections to the main duct runs, or in the cross-over duct. The identified and repairable air leaks are sealed with mastic and/or repairs are made to the cross-over duct as required.

Level 3 **-** Ducts are sealed from the interior (boots, registers, end caps). Cross-over duct is inspected and if found to be disconnected and in good condition, the cross-over duct is reconnected and all connections are sealed with mastic. If the cross-over duct is damaged and in need of replacement, a new R-8 cross-over duct is installed, and cross-over duct connections are sealed with mastic.

Based on the measure data received, the population included 2,216 manufactured homes. Three out of every four customers, or 1,636, used electricity to heat their homes, while the remaining 580 (26%) used gas.

The duct sealing *ex ante* estimates by duct sealing level for the electrically heated homes are as follows:

- Level 1 – 50 therms
- Level 2 – 65 therms
- Level 3 – 80 therms

Showerheads were installed in two out of every three homes, and were expected to save 11 therms in homes with gas water heating.

Analysis

For our impact evaluation, Cadmus sought to estimate the change in energy use after duct sealing measures were installed, for each duct sealing level in electrically heated homes. Secondarily, we used billing analysis to obtain the electric savings of all the lighting and the water heating measures.

We determined the gas savings from the program by applying the evaluated realization rate for duct sealing measures in electrically heated homes to the gas *ex ante* therm savings for the gas heated homes. The methods used to develop the *ex ante* savings for this program were the same for electric and gas heated homes. The performance of the electric homes compared to the original estimation method is assumed to be sufficient for evaluation of gas savings at this time.

Data Collection, Review, and Preparation

To perform the billing and channeling analysis, Cadmus collected the data outlined below.

Monthly Customer Bills

Avista supplied Cadmus with monthly gas and electricity bills between January 2010 and February 2014.

Program Information

Cadmus obtained program measure data from Avista. The original measure data included measures installed, measure-level *ex ante* savings, heating type, and dates of participation in the program, but did not include account numbers. Avista staff completed a matching analysis to determine the account numbers associated with each home.

Weather

Cadmus collected daily temperature data from the National Climatic Data Center for January 2010 through February 2014 for nine weather stations associated with the ZIP codes for all the participating homes.

Data Preparation

To prepare the billing data for analysis, Cadmus conducted the following steps:

- Reformatting and merging the raw billing data for all customers.
- Merging the information from the measure data with the billing data, and selecting the customers with electric heat that received duct sealing measures.
- Matching the account numbers in the measure database to the complete historical measure database to identify homes that received other measures outside the Manufactured Homes Duct Sealing Program.
- Specification of the pre- and post-periods for each customer account. We followed a similar approach to the one described in the 2013 Low Income Gas Impact Report section below.

CADMUS

Data Attrition

Cadmus performed a billing analysis on the population of program homes, excluding a few homes from the estimation sample that satisfied one or more of the following criteria:

- The home had fewer than 10 pre- or post-installation monthly energy bills
- The home did not pass one of the PRISM modelling screens, which are based on the weather normalized pre- and post-period annual usage.

Table 17 outlines the total number of customer accounts that had a conversion measure, along with the final sample we used in the PRISM and regression analyses. Each row in the table indicates the accounts remaining after attrition. Roughly 27% of the accounts were dropped because they had gas heating or did not receive any duct sealing measures. Another 27% were dropped because they did not have sufficient pre- and post-period billing data in the analysis. Another 9% were dropped based on PRISM screening, percentage change screening, or the presence of vacancies, seasonal usage, outliers, and equipment changes in the billing data.

Table 17. Manufactured Homes Duct Sealing Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Total accounts with manufactured homes measures	2,216	100%	0	0%
Electrically heated homes that received duct sealing measures	1,621	73%	595	27%
Matched to billing data provided	1,582	71%	39	2%
Less than 10 months of pre- or post-period billing data	1,033	47%	549	25%
PRISM screens*	1,020	46%	13	1%
Accounts deleted due to vacancies, seasonal usage, outliers, and equipment changes	832	38%	188	8%
Final Analysis Group	**832**	**38%**	**1,384**	**62%**

* Using PRISM screens, Cadmus dropped accounts with: 1) negative heating slopes in the pre- or the post-period or 2) post-period usage that changed by more than 70% from pre-period usage.

Billing Analysis

Based on the final group of 832 manufactured homes, Cadmus used two approaches to estimate the program electricity savings: PRISM and fixed-effects regression. Cadmus first estimated the PRISM model to obtain NAC and identify outliers. Then we estimated a regression model to control for the installation of other measures outside this program. The model specifications can be found in Appendix A.

Program Impact Evaluation Findings

Overall Savings Impacts (Fixed Effects)

Table 18 summarizes the overall fixed-effects results for the three duct sealing levels across all measures installed in electrically heated homes. The results show the annual savings, relative precision of these savings, the pre-period NAC for each group, and the savings as a percentage of the pre-period NAC. The table also reports *ex ante* savings estimates and the achieved realization rates for the measures.

Table 18. Duct Sealing Electric Savings per Home (Fixed-Effects Model)

Duct Sealing Level	Number of Homes	Model Savings (kwh)	Relative Precision on the Savings	Pre-Normalized Heating Annual Consumption (kWh)	Savings as Percent of Pre-Period Heating Consumption	Annual *Ex Ante* Savings (kWh)	Realization Rate
Level 1	171	1,155	16%	13,568	8.5%	1,550	75%
Level 2	555	1,218	8%	13,233	9.2%	1,950	62%
Level 3	106	1,980	16%	14,291	13.9%	2,350	84%
Overall	**832**	**1,303**	**7%**	**13,435**	**9.7%**	**1,919**	**68%**

Results and Findings

Cadmus applied the realization rates calculated from the electrically heated homes billing analysis to the reported gas savings. Table 19 shows total tracked and adjusted counts, savings, and realization rates for measures offered through the Manufactured Homes Duct Sealing Program.

Table 19. Manufactured Homes Duct Sealing Program Results

Measure	Reported Measure Count	Reported Savings (Therms)	Adjusted Savings (Therms)	Qualifi-cation Rate	Verifi-cation Rate	Adjusted Gross (Therms)	Reali-zation Rate
Duct Sealing Level 1	134	6,700	5,025	100%	100%	5,025	75%
Duct Sealing Level 2	384	24,960	15,475	100%	100%	15,475	62%
Duct Sealing Level 3	66	5,280	4,435	100%	100%	4,435	84%
Direct Install Showerhead	458	5,038	5,038	100%	100%	5,038	100%
Program Total	**1,042**	**41,978**	**29,973**	**100%**	**100%**	**29,973**	**71%**

1.3.8. Simple Steps, Smart Savings

Though primarily a lighting program, Simple Steps, Smart Savings also incentivized low-flow, energy-saving shower heads in PY 2013. The evaluation assumes that 48.4% of the units purchased were installed in homes with a gas fueled water heaters. This assumption is based on the responses of over 1,000 of Avista's residential customers in Washington to Cadmus' general population survey. The program sold showerheads with flow rates ranging from 1.5 gallons per minute (gpm) to 2.0 gpm. The

unit energy savings for each flow rate sold are based on the values currently approved by the RTF[8] for "Any Shower" in a home with a gas fueled water heater. The savings for the program are shown in Table 20. The increase in savings is a result of a 56% increase in the saturation of gas water heaters compared to program tracking and a 114% increase in the UES for each assumed gas installation.

Table 20. Simple Steps, Smart Savings Program Results in Washington

Measure	Reported Measure Count	Reported Savings (Therms)	Evaluated Measure Count	Evaluated Savings (Therms)	Realization Rate
Showerheads	247	718	386	2,395	334%

1.4. Residential Conclusions

Overall, the PY 2013 Washington residential gas programs produced 285,497 therms in savings. As shown in Table 21, the evaluation yielded a 96% realization rate.

Table 21. Program Reported and Evaluated Gross Savings and Realization Rates

Program Name	Reported Savings (Therms)	Evaluated Gross Savings (Therms)	Realization Rate
ENERGY STAR Products	695	590	85%
Heating and Cooling Efficiency	212,308	209,714	99%
Weatherization/Shell	38,326	40,242	105%
Water Heater Efficiency	1,096	1,566	143%
ENERGY STAR Homes	1,009	1,017	101%
Manufactured Homes Duct Sealing	41,978	29,973	71%
Simple Steps, Smart Savings	718	2,395	334%
Total	**296,130**	**285,497**	**96%**

1.5. Residential Recommendations

Based on our evaluation results, Cadmus offers the following recommendations:

- If the clothes washer measure is reinstated, Avista should consider moving all rebates to the electric program, as the majority of savings will likely result from a reduction in consumed electricity from the dryer. Qualifying for the program should be based on the presence of an electric dryer in the home. Given the large percentage of savings achieved through reduced dryer energy, and because of the high likelihood that most participants have an electric dryer, this measure predominantly produces electric energy savings.
- Avista should consider increasing the amount of data tracked as part of the Manufactured Homes Duct Sealing Program, including such fields as the Avista customer account number.

[8] http://rtf.nwcouncil.org/measures/measure.asp?id=126

- Avista may consider performing a targeted billing analysis for weatherization participants who use *both* electricity and gas to heat their homes. Our current study analyzes homes based on the program they are tracked in. Customers who use multiple fuels to heat their home may be saving more energy than currently estimated.
- High-efficiency gas furnaces continue to provide the largest portion of savings for the residential portfolio. The last billing analysis we performed was in 2011 on PY 2010 participants, so those results could be re-estimated in the next evaluation.
- Once the gas heated homes participation in the Manufactured Homes Duct Sealing Program has reached sufficient size, consider conducting a billing analysis to estimate savings.

2. 2013 Nonresidential Gas Impact Report

2.1. Introduction

With its nonresidential portfolio of programs, Avista promotes the purchase of industry-proven, high-efficiency equipment for its commercial customers. The company provides rebates to partially offset the cost differences between high-efficiency equipment and standard equipment, reducing first-cost barriers and making the high-efficiency equipment a more viable option for commercial customers.

Five programs make up the nonresidential gas portfolio, divided into two major categories:

- Prescriptive (four programs)
- Site-Specific (one program)

2.1.1. Prescriptive

Prescriptive Commercial HVAC

Beginning in January 2011, Avista has been processing installations of efficient HVAC systems through a prescriptive program, rather than through the Site-Specific Program. The prescriptive program limits eligible measures to the following:

- Furnaces under 225 kBtu with an efficiency level greater than 90% AFUE.
- Furnaces between 225 kBtu and 300 kBtu with an efficiency level greater than 85% AFUE.

Prescriptive Commercial Windows and Insulation

Beginning in January 2011, Avista has been processing installation of commercial insulation through a prescriptive program, in addition to the Site-Specific Program. Projects qualify for the prescriptive program if they have the following, pre-existing conditions:

- Wall insulation levels of less than R-4, improved to R-11 or better.
- Attic insulation levels of less than R-11, improved to R-30 or better.
- Roof insulation levels of less than R-11, improved to R-30 or better.

Prescriptive Energy Smart Grocer

Grocery measures have high potential for energy savings but are often overlooked because of the technical aspects of the equipment. Through the Energy Smart Grocer Program, Avista assists grocery store customers with technical aspects of their refrigeration systems, while providing information about the savings they can achieve. A field energy analyst offers customers' technical assistance, produces a detailed report of the potential energy savings at their facility, and guides them through the Energy Smart Grocer process from inception through the payment of incentives for qualifying equipment.

Prescriptive Food Service Equipment

This program is applicable to nonresidential electric and gas customers with commercial kitchens. Avista provides direct incentives to customers who choose to install high-efficiency kitchen equipment. To

qualify for an incentive, the equipment must meet ENERGY STAR or Consortium for Energy Efficiency tier levels (depending on the unit).

2.1.2. Site-Specific

The Site-Specific Program addresses nonresidential measures that do not fit the prescriptive applications; thus, they are considered based on project-specific information. Measures eligible for consideration must produce demonstrable kWh or therm savings, and are available to commercial, industrial, or pumping customers who receive electric or natural gas service from Avista.

The program includes the following measures:

- Site-Specific HVAC
  - HVAC combined
  - HVAC heating
- Site-Specific Other
  - Appliances
  - Motors (demand controlled ventilation)
- Site-Specific Shell

Avista implements the Site-Specific Program and three of the prescriptive programs, while PECI implements the forth prescriptive program, Energy Smart Grocer. As implementers, both Avista and PECI are responsible for designing and managing program details. Both implementers developed algorithms for use in calculating measure savings and determining measure and customer eligibility.

Avista staff fields inquiries from potential participants and contractors, and maintains a tracking database for projects. Avista manages projects by reviewing and approving applications at all stages of the process, calculating project savings, and populating the database with relevant information.

2.2. Methodology

Cadmus designed the impact evaluation to verify tracked program participation and to estimate energy savings. We determined gross savings using engineering calculations, desk reviews, verification site visits, and some project-level billing analysis.

Cadmus reviewed Avista's tracked gross energy savings and available documentation for a sample of sites, such as audit reports and savings calculation work papers, particularly focusing on calculation procedures and documentation for savings estimates. We also verified the appropriateness of Avista's analyses for calculating savings, and the operating and structural parameters of the analyses. Through site visits or desk reviews of a sample of projects, we collected data on equipment installation and operation and evaluated gross energy savings through engineering calculations.

Cadmus collected baseline, tracking, and program implementation data through on-site interviews with facility staff. During on-site visits, we verified measure installations and determined changes to the

operating parameters occurring since measure installation. We asked facility staff questions regarding the installed systems' operating conditions, additional benefits, and shortcomings. We used the savings realization rates from sample sites to estimate savings for the overall program and to develop recommendations for future studies.

2.2.1. Sampling

Avista reported planning to phase out its gas programs due to cost-effectiveness concerns associated with the declining price of natural gas in 2012. However, Avista later determined it would be preferable to continue delivering gas programs, and therefore we reinstituted gas project sampling.

Cadmus developed a sampling calculation tool to estimate the number of on-site visits required to achieve the rigor levels of the precision target for both Idaho and Washington combined. We used preliminary program population data provided by Avista and determined that we needed to verify 70 projects across the combined PY 2012 and PY 2013 program populations. We anticipated achieving 90/10 precision at the overall nonresidential program level through the targets for each stratum. We calculated the final precision based on the combined program populations for both years following the PY 2013 evaluation.

Table 22 shows the proposed precision targets for the site verification and desk review evaluation activities.

Table 22. Proposed PY 2012-PY 2013 Nonresidential Idaho and Washington Gas Evaluation Sample

Measure Category	Proposed Precision Target	Proposed Evaluated Projects
Prescriptive (all four programs)	90/20	40
Site-Specific HVAC	90/20	12
Site-Specific Other	90/20	6
Site-Specific Shell	90/20	12
Total	**90/10**	**70**

We assigned both a census and a random sample for each stratum. The census stratum represented the four 2013 projects with the highest overall gas savings, with all four sites located in Washington. Each census site reported over 9,000 therms in savings and combined to represent 19% of total 2013 program reported savings. For the non-census stratum, we randomly selected additional participants from the remaining project population.

In Table 23, we show the precision achieved for the actual number of evaluation activities for gas measures, which exceeds our targeted precision estimate. Subsequent sections of this report will explain the differences between our initial proposed and actual sampling plan for evaluation activities. For example, in our initial sampling plan we categorized ENERGY STAR appliances in the site-specific other category. As the impact evaluation progressed, we determined these measures were more appropriate for the prescriptive category.

Table 23. Actual PY 2012-PY 2013 Nonresidential Idaho and Washington Gas Evaluation Sample

Measure Category	Achieved Precision	Evaluated Projects
Prescriptive (all four programs)	90/12	34
Site-Specific HVAC	90/3	23
Site-Specific Other	90/1	11
Site-Specific Shell	90/1	10
Total	**90/4**	**78**

Cadmus found that the database extract from Avista provided program-level details, but not measure-level information. Therefore, we sought to verify savings for every incented measure at each site, regardless of whether it achieved gas or electric savings. To establish whether we evaluated an accurate distribution of specific measure types within each program would have required an exhaustive review of project files, which fell outside of the evaluation scope.

2.2.2. Data Collection

Cadmus collected data from 30 sites during project verifications in Washington. For each selected project, we first conducted a document review to determine measure types, quantities, operational parameters, and calculation methodologies.

Document Review

Avista provided Cadmus with documentation on the selected sites' energy-efficiency projects, including program forms, the tracking database, audit reports, and savings calculation work papers for each rebated measure. When reviewing calculation spreadsheets and energy simulation models, Cadmus paid particular attention to calculation procedures and documentation for savings estimates.

Cadmus reviewed each application for the following information:

- ***Equipment replaced:*** descriptions, schematics, performance data, and other supporting information.
- ***New equipment installed:*** descriptions, schematics, performance data, and other supporting information.
- ***Savings calculation methodology:*** the methodology type used, specifications of assumptions, sources for these specifications, and the correctness of calculations.

Site Visits

During on-site visits, Cadmus sought to accomplish three primary tasks:

- Verify the implementation status of all measures for which customers received incentives. This required verifying that the energy-efficiency measures had been installed correctly and functioned properly. We also verified the operational characteristics of the installed equipment, such as temperature setpoints and operating hours.
- Collect physical data, such as boiler capacities or operational temperatures, and analyzing the energy savings realized from the installed improvements and measures.
- Interview facility personnel to obtain additional information regarding the installed systems, thus supplementing data from other sources.

Desk Reviews

For some prescriptive and site-specific projects in PY 2013, we analyzed and evaluated energy savings by reviewing calculation spreadsheets and documentation submitted with the rebate applications. We verified equipment efficiency based on equipment model numbers provided in rebate applications and on savings calculation methodologies. We chose projects for desk review that realized smaller therm savings than the census-level projects we selected for site visits. Cadmus applied the on-site verification details to all 2013 sample projects rather than conducting a desk review after Avista confirmed they would continue offering nonresidential gas programs in PY 2013.

2.2.3. Engineering Analysis

The nonresidential prescriptive programs required a significantly different method of analysis than the Site-Specific Program.

Overview

Cadmus chose what procedures to use for verifying savings through an engineering analysis based on the type of measure analyzed. For this evaluation, we used the following analytical methods, with descriptions included in their respective program detail sections below:

- Prescriptive deemed savings
- Billing analysis
- Calculation spreadsheets
- Energy simulation modeling

Prescriptive Deemed Savings

For most prescriptive measures, we verified the deemed savings estimates that Avista used for savings calculations, then compared these with the values we developed for the TRM. We focused our verification activities on:

- The installed quantity;
- Equipment nameplate data;

- Proper installation of equipment; and
- Operating hours.

Where appropriate, we used data from site verification visits to reanalyze prescriptive measure savings using Avista's Microsoft Excel® calculation tools, ENERGY STAR calculation tools, RTF deemed savings, and other secondary sources.

Billing Analysis

Cadmus analyzed Avista's metered billing data for one site-specific HVAC project. Using a pre- and post-modeling approach, we developed retrofit savings estimates for the site. This modeling approach accounted for differences in HDDs, and determined savings based on normalized weather conditions, as actual weather conditions may have been milder or more extreme than the TMY3 15-year normal weather averages from 1991–2005, obtained from NOAA.

NOAA also provided daily weather data for each weather station associated with the participant projects, and we calculated the base 65 reference temperature HDDs. We matched participant billing data to the nearest weather station by ZIP code, and matched each monthly billing period to the associated base 65 HDDs.

In developing the analysis model, we followed a modified PRISM approach, which normalized all dependent and independent variables to the days in each billing period, and allowed model coefficients to be interpreted as average daily values. This methodology accounted for differences in the length of billing periods. For each project, we modeled average daily consumption in therms as a function of some combination of the average standing base load and HDDs.

For each site, Cadmus estimated two demand models: one for the pre-installation period; and one for the post-installation period. We chose this methodology over a single standard treatment effects model to account for structural changes in demand that might have occurred due to retrofits.

After estimating model coefficients for each site, Cadmus calculated two scenarios:

- We estimated a reference load for the previous 12 billing cycles using the pre-installation period model. This scenario extrapolated the counterfactual consumption (i.e., what consumption would have been absent the program).
- We estimated a normalized scenario using the post-installation period model. We used 15-year TMY3 data as the annual HDD and mean annual values for the usage data. The difference between this scenario and the counterfactual assumption represented the expected long-term annual savings.

Calculation Spreadsheets

Avista developed calculation spreadsheets to analyze energy savings for a variety of measures, including envelope measures (such as ceiling and wall insulation). These calculation spreadsheets required entering relevant parameters, such as square footage, efficiency values, HVAC system details, and

location details. From these data, energy savings could be estimated using algorithms programmed by Avista. For each spreadsheet, we reviewed input requirements and output estimates, and determined if the approach proved reasonable.

Energy Simulation Modeling

Avista determined savings for many site-specific HVAC and shell projects using energy simulation modeling (which they chose due to the complex interactions between heating and cooling loads and the building envelope). Avista provided the original energy simulation models, which we reviewed to determine the relevant parameters and operating details (such as temperature setpoints) for the applicable measures. We updated the models as necessary based on site verification data.

2.3. Results and Findings

Cadmus adjusted gross savings estimates based on our evaluated findings. The following sections discuss further details by program.

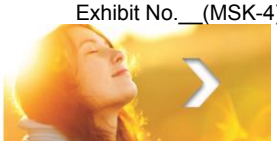
For most projects, the documentation was readily available and the measures performed close to expectations. However, some project files contained an excessive amount of documentation. In certain cases, projects evolved over time based on participant capital availability and interest level. These project files often included the different iterations of project development, but did not clearly identify the final reported project energy savings and analysis documentation. When Cadmus contacted the participants regarding these measures, the lack of clarity sometimes caused them to be confused and dismayed.

2.3.1. Prescriptive Programs

We evaluated savings for a sample of sites across the four prescriptive programs. Table 24 shows the savings and realization rates by program for Washington projects in PY 2013. Cadmus used total program results (both states, two years) for final extrapolation because the sample was built using a combined sampling methodology. Further evaluation details for each program follow.

Table 24. Evaluated Results for PY 2013 Nonresidential Gas Prescriptive Sample—Washington

Prescriptive Program	Total PY 2013 Measure Installations	Evaluated Sample	Gross Reported Savings (Therms)	Gross Evaluated Savings (Therms)	Realization Rate
Commercial HVAC	36	5	2,497	2,620	105%
Commercial Windows and Insulation	54	7	17,047	14,823	87%
Energy Smart Grocer	7	3	6,387	6,693	105%
Food Services Equipment	5	1	3,600	3,600	100%
Total	**102**	**16**	**29,531**	**27,736**	**94%**



Cadmus identified several adjustments necessary to the tracked savings for the prescriptive programs. The calculations often require reported equipment and operations data, which could vary from parameters identified during on-site verification visits and metering.

Our adjustments decreased savings by 6% for Washington projects, the same reduction as for the combined adjustments for both states. This similarity was due to the limited number of Idaho prescriptive gas projects (only one commercial HVAC project). Typical adjustments corrected equipment efficiencies, fuel types, operating schedules, and operating parameters, as described below:

- On one large commercial insulation project, Cadmus found that a portion of the area was not heated. We adjusted the savings calculator appropriately. This adjustment resulted in lower savings and an 81% realization rate.
- One medium commercial insulation project reported savings in PY 2013, but the work was not complete. Cadmus confirmed that the project was still incomplete when we called to schedule the on-site verification. The project documentation showed that the business was newly established. The invoice only covered materials, with installation labor being conducted by the participant. The project did not achieve savings in PY 2013.
- Cadmus applied a PECI benchmarking work paper[9] to evaluate savings for two Energy Smart Grocer projects in which doors were added on medium temperature walk-in cases. The adjustment resulted in an increase in gas savings, for a realization rate of 117%.
- We adjusted calculation parameters on several small projects to account for variance in furnace efficiency, furnace capacity, window square footage, and heating load hours. The adjustments increased savings, on average.

2.3.2. Site-Specific

Cadmus evaluated the savings for 14 Site-Specific Program projects in Washington in PY 2013, representing a variety of measure types. We calculated an overall realization rate for all randomly selected (non-census) projects in Washington, then applied the resulting realization rate to the non-census population for each state and major measure type. Table 25 shows our evaluated results for the program. Cadmus used total program results (both states, two years) for final extrapolation because the sample was built using a combined sampling methodology.

[9] http://rtf.nwcouncil.org/meetings/2011/0830/WP_PECIREF_CA%20DRAFT.pdf.

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Table 25. Evaluated Results for PY 2013 Nonresidential Gas Site Specific Sample—Washington

Site-Specific Program	Total PY 2013 Measure Installations	Evaluated Sample	Gross Reported Savings (therms)	Gross Evaluated Savings (therms)	Realization Rate
HVAC	26	8	80,499	71,349	89%
Other	5	3	10,808	11,378	105%
Shell	27	3	20,503	20,503	100%
Total	**58**	**14**	**111,810**	**103,230**	**92%**

Cadmus identified several adjustments to the tracked savings from Site-Specific Program projects. Site-specific projects tend to be more complex, making energy-savings parameters and impacts more difficult to estimate. In addition, the calculations often rely on participant-supplied building, equipment, and operations data, which may vary from the parameters identified during an on-site verification visit.

In aggregate, the Site-Specific Program performed well, achieving an overall combined realization rate of 93%. We made the following specific adjustments to Washington projects, based on our review of rebate applications and billing data:

- A census-level HVAC project disconnected a building heating system from a campus-wide central plant. We accepted the reported baseline consumption, then used actual billing data to determine the retrofit consumption. The actual retrofit consumption was higher than the expected value used in savings calculations. The reduced the difference between baseline and retrofit consumption, resulting in lower gas savings and an 86% realization rate.
- One large multifamily project included estimated savings for apartment furnace units. Avista based the reported savings on a furnace capacity of 60,000 Btu/hour/unit. Cadmus found that the actual capacity was 44,000 Btu/hour/unit. This reduced gas savings, with a resulting realization rate of 77%.
- We analyzed the energy savings for one large HVAC project through a billing analysis, as shown by the pre- and post-installation linear regressions in Figure 3 and Figure 4, respectively. The resulting regression analysis revealed that the project achieved less gas savings than reported, for a realization rate of 72%.
- Cadmus analyzed one census-level site-specific project through a calibrated simulation analysis with the utility billing data. This analysis revealed that the project achieved more energy savings than reported. The resulting realization rate was 108%.

Figure 3. Large Site-Specific HVAC Project Pre-Installation Linear Regression

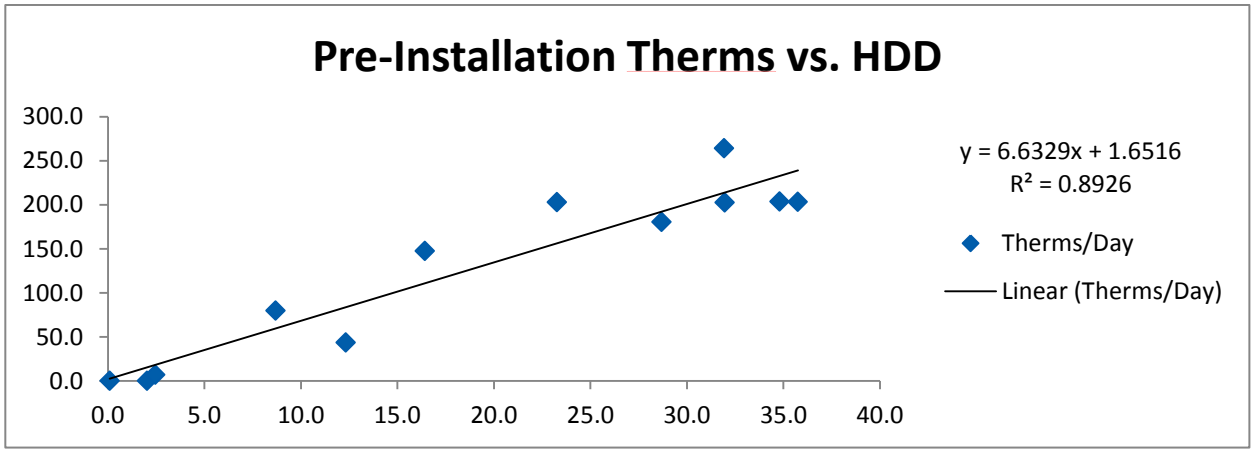
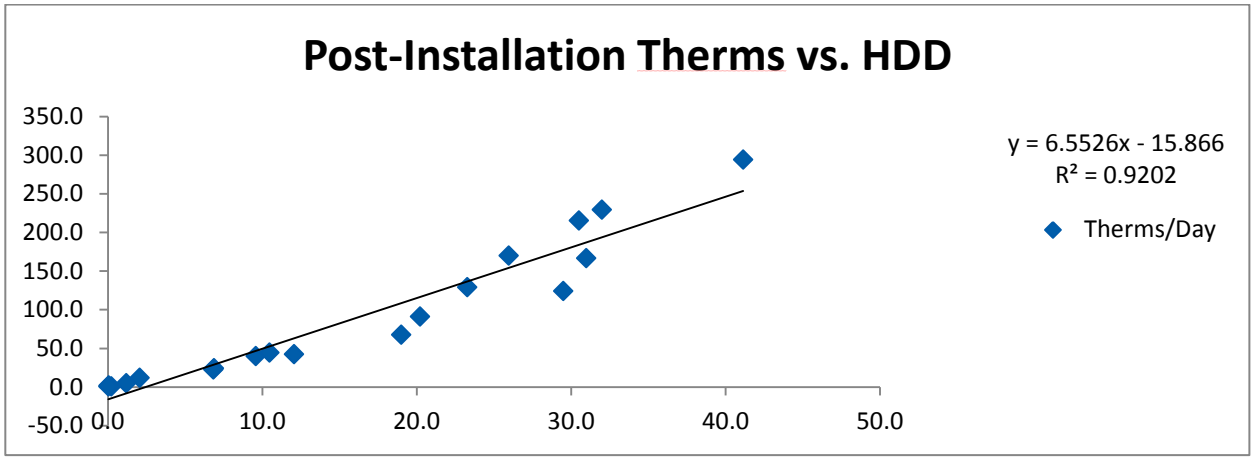


Figure 4. Large Site-Specific HVAC Project Post-Installation Linear Regression



2.3.3. Extrapolation to Program Population

For our evaluation of the nonresidential gas programs, we selected sites that could provide the most significant impacts. We designed the site visits to achieve a statistically valid sample for the major strata, as discussed previously. For measures in the random (non-census) sample, we calculated realization rates (the ratio of tracked-to-evaluated savings) and applied these to the remaining non-sampled sites. We did not apply measure-level realization rates to the census population. These realization rates are weighted averages, based on the random verification sample and using the following four equations.

We calculated realization rates for each individual site in the sample based on measure type:

$$RR_{ij} = \frac{Evaluated_{ij}}{Tracked_{ij}};\ for\ measure\ j\ at\ site\ i$$

Where:

RR = Realization rate

i = Sample site

j = Measure type

Then we calculated the realization rates for the measure types using the ratio of the sum of evaluated savings to the sum of reported savings from the randomly selected sample for each measure type:

$$RR_j = \frac{\sum_i Evaluated_i}{\sum_i Tracked_i}; \text{ for measure } j \text{ across all sample sites}$$

We calculated non-census population evaluated savings by multiplying the measure-type realization rate (RR_j) from the random sample by the reported savings for the non-census population of each measure type:

$$\sum_k Evaluated_k = RR_j x \sum_k Tracked_k; \text{ for measure } j \text{ across all sites in measure population}$$

Where:

k = The total population for measure type 'j'

Finally we added the reported and evaluated savings from census stratum measures to calculate the total reported and evaluated savings for each program. The program realization rate derived from the ratio of all evaluated to all reported savings:

$$RR_l = \frac{\sum_k Evaluated_k}{\sum_k Tracked_k}; \text{ for the population (all sites and measures)}$$

Table 26 summarizes of the results of all prescriptive programs and the Site-Specific Program in Washington; the overall nonresidential portfolio achieved a gross realization rate of 95%.

Table 26. PY 2013 Gas Programs' Gross Realization Rates—Washington

Measure Category	Gross Program Reported Savings (Therms)	Gross Program Evaluated Savings (Therms)	Realization Rate
Prescriptive Programs	91,559	86,792	95%
Site-Specific HVAC	158,023	146,635	93%
Site-Specific Other	14,266	14,858	104%
Site-Specific Shell	55,956	55,796	100%
Total	**319,804**	**304,081**	**95%**

2.3.4. Fuel Conversion and HVAC/Lighting Interactive Impacts

The Avista natural gas portfolio reported savings do not include increases in gas consumption due to fuel conversions from electric heating to gas heating, or from increased lighting efficiency. Lighting systems convert a large portion of their input energy to useful light output, but a substantial portion also converts to heat. Any reduction in lighting input energy also reduces waste heat. Reducing waste heat lowers the site's required cooling load, but increases the site's heating load.

Cadmus noted that Avista tracked and recorded these gas consumption effects for many projects to determine electric program cost-effectiveness. Most of the tracked interactive effects involved prescriptive or site-specific lighting projects, although some therm penalties resulted from the Energy Smart Grocer (in Avista's electric portfolio) and site-specific HVAC projects.

In addition, Avista did not include interactive effects into its portfolio energy-savings goals (which would have reduced goals).

2.4. Nonresidential Conclusions

Cadmus evaluated 30 of 160 measures installed through the program in Washington for PY 2013, representing 44% of tracked savings.

Through evaluation, we determined that Avista generally implemented the programs well. Cadmus identified the following key issues that reduced evaluated energy savings below the reported values:

- Some calculations provided by participants/contractors contained information that varied from what Cadmus engineers found on-site.
- One prescriptive project had not actually been installed as reported.
- Retrofit natural gas consumption varied from predicted values for some site-specific projects.

2.5. Nonresidential Recommendations

Cadmus offers the following recommendations, based on the evaluation results:

- Avista should streamline the file structure to enable internal and external reviewers to more easily identify the latest documentation.
- Avista should continue to perform follow-up measure confirmation and/or site visits on a random sample of projects (at least 10%).
- Avista should consider flagging sites for additional scrutiny for which the paid invoice does not list installation labor.

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3. 2013 Low Income Gas Impact Report

3.1. Introduction

Cadmus conducted a statistical billing analysis to determine adjusted gross savings and realization rates for energy-efficient measures installed through the low-income weatherization program for 2013 customers. Cadmus examined energy savings at the household or participant level, rather than at the measure level. We performed billing analysis on 2012 participants who had a full year of energy consumption data both before (2011) and after (2013) the weatherization period. Then Cadmus applied 2012 billing analysis results to 2013 program participants. We deemed gas savings using a tiered approach for conversion participants using model results from the billing analysis.

To estimate energy savings resulting from the program, Cadmus used a pre- and post-installation, combined Conditional Savings Analysis (CSA), and a Princeton Score-Keeping Method (PRISM) approach, using monthly billing data. We analyzed energy-savings estimates for program participants and ran a series of diagnostic tests on the data. These tests included reviewing savings by pre-consumption usage quartile, checking to ensure households have a sufficient amount of billing data, and creating a graphical outlier analysis. Below is a detailed discussion of the regression model used for this billing analysis along with resulting savings.

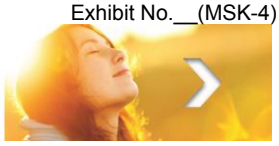
3.1.1. Program Description

Five components, listed in Table 27, are included in the low-income weatherization program. Local Community Action Partners (CAPs) within Avista's Washington service territory implemented these low-income projects. CAPs holistically evaluate homes for energy-efficiency measure applicability, combining funding from different utility and state/federal programs to apply appropriate measures to a home, based on the results of a home energy audit.

Table 27. Low-Income Weatherization: 2013 Gas-Efficiency Installations by Program Component*

Low-Income Program Component	Measure Description	Measure Installations
Shell/Weatherization	Insulation, window/door, air infiltration, programmable thermostat	463
Fuel Conversion*	Electric furnace, heat pump, water heater replacement with gas units	N/A
Hot Water Efficiency	High-efficiency water heater/high-efficiency boiler replacement	35
ENERGY STAR Appliance	High-efficiency refrigerator replacement	N/A
HVAC Efficiency	High-efficiency furnace/ high-efficiency boiler replacement	84

* The Avista portfolio considers (and reports) fuel conversion measures as electric-saving measures.



3.2. Data Collection and Methodology

Cadmus obtained impact evaluation data from multiple sources, including:

- ***Program participant database:*** Avista provided information regarding program participants and installed measures. Specifically, these data included a list of measures installed per home and reported savings from each completed installation. The data did not, however, include the quantity of measures installed (such as the number of square feet of installed insulation) or per-unit savings estimates.
- ***Billing records:*** Avista provided participant meter records from January 2011 through December 2013.
- ***Weather data***: Cadmus collected Washington weather data from seven representative NOAA stations, drawn for the corresponding time period.

3.2.1. Sampling

The analysis started with a census of 2012 program participants. Cadmus screened the 2012 program participants data by specific criteria for use in the final analysis (ensuring sufficient monthly billing data, not classified as an outlier). In all, 48 non-conversion Washington gas participants were included in the billing analysis; while we evaluated an additional 105 electric-to-gas conversion participants outside of the billing analysis model. Cadmus defined conversion customers as any participant who received a new gas furnace, water heater, or heat pump that replaced an electric unit.

3.2.2. Billing Analysis

Avista provided monthly billing data for all participants from January 2011 through December 2013. Avista also provided the participant database, which contained participation and measure data for the 2012 and 2013 program years, including all gas and electric measures installed per home by CAPs.

Cadmus obtained daily average temperature weather data from 2011 to 2013 for the seven NOAA weather stations representing all 2012 electric participant ZIP codes in Avista's Washington service territory. From daily temperatures, we determined base 65-degree HDDs for each station, then matched billing data periods with the HDDs from stations closest to each participant.

As we received billing data through December 2013, we could only perform the billing analysis for the 2012 program year. We defined the analysis pre-period as 2011, before all participation installations occurred, and defined the analysis post-period as 2013, following all installations occurring in 2012. We then applied the analysis results for 2012 participants to the 2013 participant population, thus reporting overall impacts for the 2013 program year. Given consistency in delivery infrastructure, measure offerings, and program design, using billing analysis and extrapolating evaluated impacts from the previous year to 2013 seems appropriate. Furthermore, performing billing analysis for whole-house programs is considered an industry best-practice, cited in several evaluation protocols (IPMVP, UMP), allowing to account for measure interaction, participant take-back, and effects of energy-education on participant usage behavior.

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3.3. Data Screening

Cadmus conducted a series of steps to screen participant usage data, ensuring that we used a clean, reliable dataset for analysis.

3.3.1. General Screens

The following screens removed non-conversion gas accounts that could have skewed the savings estimation:

- Accounts with fewer than three months (90 days) of billing data, in either the pre- or post-period;
- Accounts with annual usage outside of reasonable bounds (i.e., less than 150 therms or more than 2,000 therms) in either the pre- or post-period and;
- Accounts with abnormal changes in usage from the pre- to post-period (an absolute change of 70% or more).[10]

3.3.2. Weather Normalization Screens

To screen data, Cadmus used PRISM-like models for weather-normalizing pre- and post-billing data for each account, and to provide an alternate verification of measure savings obtained from the CSA model. For more detail on the model specification, see Appendix D.

Cadmus applied the following screens to the PRISM model output and removed participants from the billing analysis:

- ***Accounts with a PRISM model r-squared of less than 0.50.*** These accounts indicate a bad fit of the monthly gas usage with actual HDDs, which is unexpected when gas appliances are used in both the pre- and post-periods.
- ***Accounts with a HEATNAC of less than 100 therms in either the pre- or post-period.*** If the annual heating usage accounts for less than 100 therms, the gas heating system was likely not used at all or was only used for backup secondary heating. This screen also removed accounts with negative heating slopes, since it is unlikely the usage would have decreased during the heating months.
- ***Accounts where the pre-period base load was 0 and the post-period base load was greater than 0.*** Since the base load indicates the usage that occurs during non-winter shoulder months, or those months outside of the heating season, this outcome suggests that a gas water heater, gas dryer, or gas range was added to the participant home. In this situation, the additional base

[10] Changes in usage of this magnitude are probably due to vacancies, home remodeling or addition, seasonal occupation, or fuel switching. Changes of usage over a certain threshold are likely not program effects and can confound the analysis of consumption.

load usage in the post-period should not correspond to the weatherization measures installed through the program.

Table 28 summarizes gas account attrition from the screens listed above.

Table 28. Low-Income Weatherization: Non-Conversion Gas Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Gas Accounts	130	100%	0	0%
Overlap Participation within Pre- or Post-Period	99	76%	31	24%
Matched to Billing Data Provided	99	76%	0	0%
Insufficient Pre- and Post-Period Months	83	64%	16	12%
Insufficient Pre- and Post-Period Days	83	64%	0	0%
Low or High Usage in Pre- or Post-Period	78	60%	5	4%
Changed Usage from the Pre- to Post-Period (> 70%)	60	46%	18	14%
PRISM Screen: Low R-Squared, Low Heating Usage	56	43%	4	3%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	48	37%	8	6%
Final Analysis Group	**48**	**37%**	**82**	**63%**

After applying these screens, Cadmus included 48 Washington gas participants in the statistical billing analysis.

3.4. Conditional Savings Analysis Modeling Approach

To estimate energy savings from this program, Cadmus used a pre/post CSA fixed-effects model, which uses pooled monthly time-series (panel) billing data. The fixed-effects modeling approach corrects for differences between pre- and post-installation weather conditions, as well as for differences in usage consumption between participants (with the inclusion of a separate intercept for each participant). This modeling approach ensures that model savings estimates are not skewed by unusually high usage or low usage participants. For more detail on the model specification, see Appendix D.

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3.5. Estimating Conversion Participant Savings

Cadmus used a similar approach for calculating gas savings for conversion participants as we did in 2012 (reflected in the *Avista 2012 Washington Gas Portfolio Impact Evaluation Report)*. An alternative impact approach to billing analysis was necessary for gas-saving conversion participants, since this the net increase in gas consumption (due to the fuel conversion) made any potential gas savings occurring via non-conversion measures imperceptible. We assigned savings to conversion participants (n=105) based on three distinct customer categories:

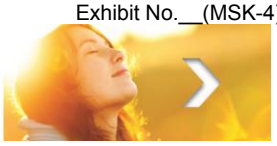
- ***Full model savings*** (150 therms), assigned to participants (n=27) who received three or more distinct gas-saving measures (including a high-efficiency furnace).
- ***Partial model savings*** specific to participants (n=64) who installed a high-efficiency gas furnace or high-efficiency gas water heater in place of a standard-efficiency unit. These participants fell into three subgroups:
  - Customers who received a high-efficiency furnace replacement and a high-efficiency water heater and no other gas saving measures (70 therms; n=21),
  - Customers who received either a high-efficiency furnace and one non-conversion gas measure (61 therms; n=41)
  - Customers who received a high-efficiency water heater and no more than one additional non-conversion gas-saving measure (9 therms; n=2). For participants in this group with one additional, non-conversion gas-savings measure, we passed through Avista's claimed savings associated with the non-furnace measures.
- ***No model savings*** for customers (n=14) who received at most one gas-saving measure and no high-efficiency furnace. For these customers, we passed through Avista reported savings if they received a gas-savings measure.

To account for gas savings from high-efficiency furnace replacements, we used savings calculated for the 2010 evaluation of Avista's Residential Furnace Replacement Program (84 therms), scaled to reflect low-income participant home square footage, which resulted in 61 therms.[11] Savings from high-efficiency hot water heater replacements came from the *Avista 2011 Multi-Sector Gas Impact Evaluation Report.*

3.6. Non-Conversion Results and Findings

This section presents the evaluated savings the program derived from the billing analysis. Several detailed tables are presented to contextualize the evaluated impacts, including measure distributions and benchmarking comparisons.

[11] Low-income participants averaged 1,250 square feet per home, while single-family participants averaged 1,728 square feet per home.



Cadmus included PRENAC in these results to characterize the average energy consumption prior to any participation. PRENAC is a helpful metric for comparison and for assessing the magnitude of program impacts, since this ratio normalizes savings relative to consumption levels.

3.6.1. Billing Analysis Results

Table 29 summarizes model savings results of the Washington low-income weatherization program for gas non-conversion participants.

Table 29. Gas Non-Conversion Model Savings Summary

n	PRENAC	Model Savings Per HDD	Normal HDDs	Model Savings (therms)	Precision 90%
48	780	(0.02)	6,178	150	25%

The per-participant model savings averaged 150 therms for non-conversion participants, with a precision estimate of 25%.

Table 30 compares the evaluated average participant savings to reported savings, along with realization rates.

Table 30. Gas Non-Conversion Model Realization Rate Summary

n	PRENAC	Model Savings (therms)	Average Reported Savings Per Participant (therms)	Realization Rate	Model Savings as Percent of Pre-Usage	Expected Savings as Percent of Pre-Usage
48	780	150	112	133%	19%	14%

The analysis of non-conversion participants has a realization rate 133% with 19%savings over pre-usage, which is 5% higher than the reported savings (as a percentage of pre-usage).

Table 31 provides a distribution of the gas measures Avista paid for participants in the final model group.

Table 31. Measure Distribution of Final Model Sample

Measure	Count	Percent
Attic insulation	40	83%
Wall insulation	20	42%
Floor insulation	37	77%
Duct insulation	2	4%
Air infiltration controls	39	81%
Doors	21	44%
Windows	14	29%
High-efficiency furnace replacement	4	8%
High-efficiency water heater replacement	2	4%
Sample (n)	**48**	**100%**

As shown in the table, there was a high concentration of shell measures, with 83% and 81% of program participants, respectively, receiving attic insulation and air infiltration controls. Conversely, few gas participants received a high-efficiency furnace replacement (8%) or high-efficiency water heater replacement (4%).

3.6.2. Overall Gas Non-Conversion Program Savings

Table 32 presents evaluated gas savings for PY 2013 non-conversion gas participants. Cadmus extrapolated savings from the billing analysis results by multiplying the modeled realization rate by the reported savings.

Table 32. Low-Income Weatherization: Total 2013 Gas Non-Conversion Evaluated Program Savings

Total Non-Conversion Participants	Average Model Savings per Participant (therms)	Total Evaluated Non-Conversion Savings (therms)	Total Reported Savings (therms)	Realization Rate
132	150	15,738	11,840	133%

3.7. Comparison to Previous Billing Analysis

The results from our billing analysis of 2012 program participants revealed greater energy savings than the billing analysis completed for 2010 participants. Table 33 compares these model results.

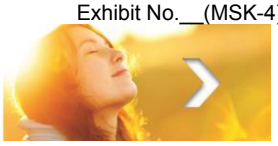


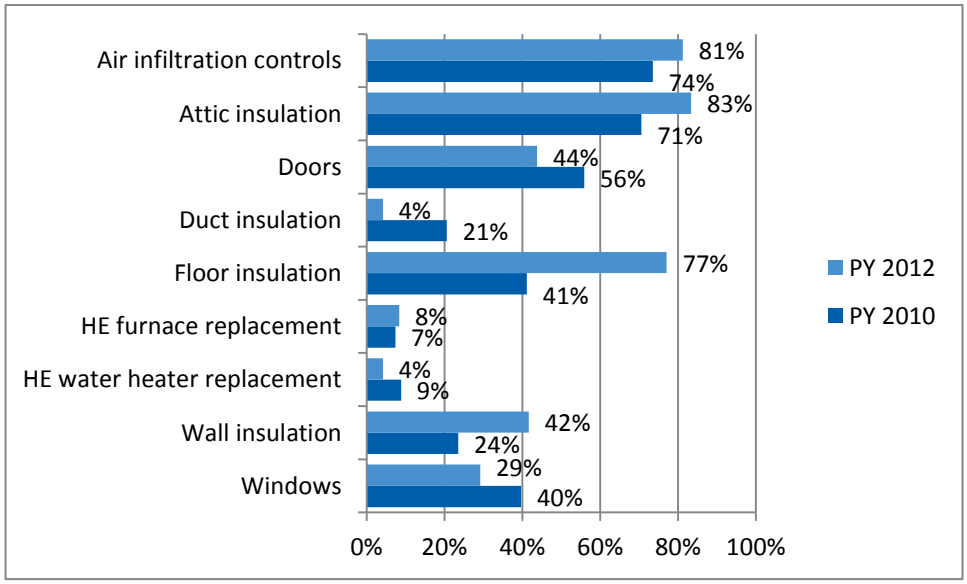
Table 33. Low-Income Weatherization: Comparison of Gas Model Results*

Billing Analysis Year	n	PRENAC	Model Savings (therms)	Average Reported Savings Per Participant (therms)	Realization Rate	Model Savings as Percent of Pre-Usage	Reported Savings as Percent of Pre-Usage
2010	68	753	104	347	30%	14%	46%
2012	48	780	150	112	133%	19%	14%

* These model results are not statistically different.

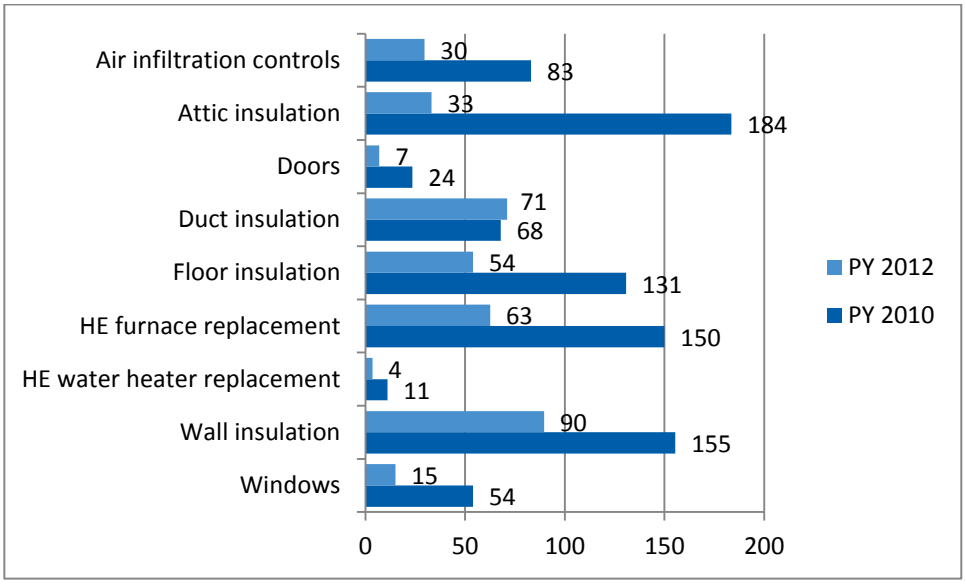
One factor contributing to increased average savings is an increase in the percentage of program participants who received high-saving measures, such as air infiltration and shell insulation. Figure 5 shows the percentage of Avista-funded measures for gas model participants in both program years.

Figure 5. Percent of Installed Measures for Gas Model Participants by Program Year



The gas non-conversion realization rate is also substantially higher in 2012 than in 2010. One factor contributing to this increase is the difference in reported savings reported by Avista for gas saving measures between years. Figure 6 presents average reported therm savings by measure for both program years.

Figure 6. Average Reported Therm Savings of Gas Saving Measures by Program Year



Aside from duct insulation, reported savings for every measure is lower in PY 2012. Several high-savings measures showed substantial changes in average reported savings between years, in particular insulation, air infiltration, and furnace replacements.

Two additional factors that may account for changes in modeled savings include: (1) non-Avista funded measures installed by agencies through the program, and (2) lack of control or comparison group.

3.8. Benchmarking

To place Avista program savings estimates in context, we compared them to billing analysis results from other low-income program efforts from across the country.[12] Figure 7 shows a comparison of the percentage energy savings, relative to PRENAC, of Avista's program, along with numerous other gas billing analyses of low-income weatherization programs. This metric allows for a fair comparison of programs given variation in weather, costs, program delivery, and measure offerings.

[12] The comparable studies include Oak Ridge National Laboratory Metaevaluation of Low-Income Weatherization Programs, Ohio Home Weatherization Assistance Program, People Working Cooperatively Low-Income Weatherization Program in Ohio, Massachusetts Low-Income Program, and Rhode Island Income-Eligible Services program.

Figure 7. Savings Percentage of Pre-Period Consumption

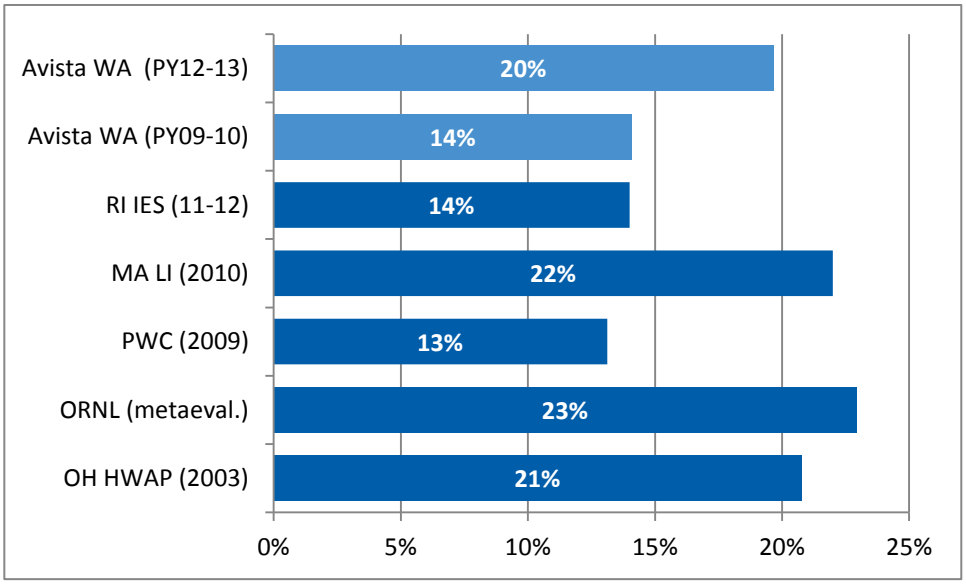
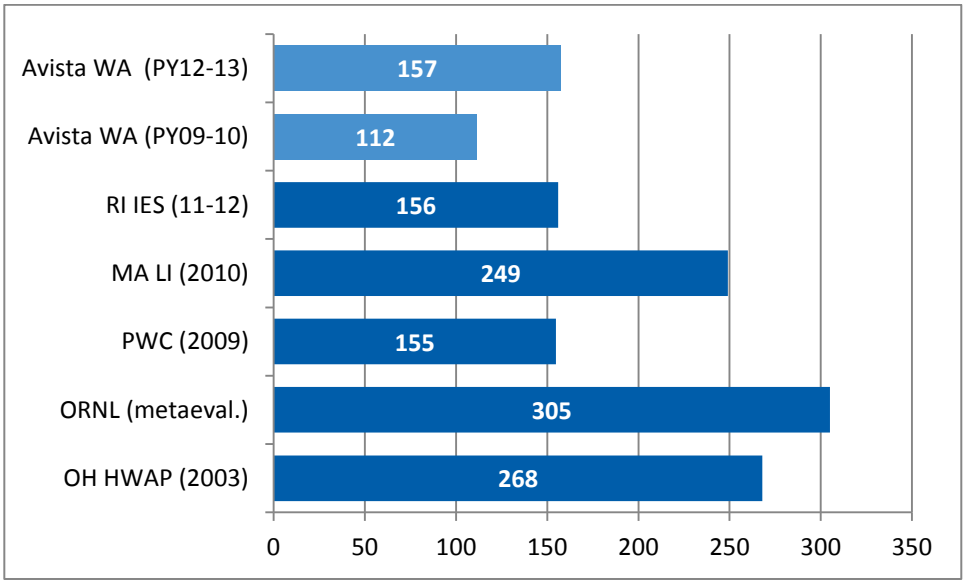


Figure 8 presents average household therm savings from comparable low-income programs.

Figure 8. Household Therm Savings



3.9. Conversion Participant Results and Total Program Savings

There were 105 Washington program participants who received electric-to-gas conversion measures, including electric-to-gas furnaces and water heaters. Cadmus considered these participants separately, as the methodology for estimating evaluated savings differed slightly from the non-conversion participant group.

In total, Cadmus estimated an additional 8,472 therms of savings from gas conversion participants, presented in Table 34.

Table 34. Conversion Participant Gas Savings

Conversion Customer Tier	N	Average Applied Per-Participant Savings (therms)	Total Evaluated Savings (therms)
Full Model Savings	27	150	4,050
Partial Savings*	64	70/61/9	4,357
No Model Savings*	14	N/A	65
Total	**105**		**8,472**

*Total evaluated savings may include instances of pass-through measure-level savings.

All conversion customers experienced a net increase in therm usage. However, based on Avista's approach to correcting for these impacts through its cost-effectiveness analysis, Cadmus calculated therm savings associated with the following:

- Installation of gas-savings weatherization measure bundles.
- Furnace and water heater conversion replacements, using high-efficiency gas equipment compared to standard gas equipment.[13]

Table 35 provides a distribution of all Avista-funded measure installations for conversion participants in PY 2013, including Avista-designated electric-saving measures.

Table 35. Measure Installations for Conversion Participants

Measure Description	Count
Electric air infiltration controls	6
Electric doors	2
Electric refrigerator replacement	7
Electric windows	2
Electric attic insulation	2
Electric duct insulation	1
Electric floor insulation	4
Electric furnace conversion	81
Electric water heater conversion	86
Electric heat pump conversion	8
Electric variable speed motor	1
Gas air infiltration controls	25
Gas doors	18

[13] Electric savings associated with conversion measure installations are outlined in the *2014 Avista Washington Portfolio Electric Impact Report*.

Measure Description	Count
Gas windows	1
Gas water heater replacement	35
Gas boiler replacement	2
Gas furnace replacement	79
Gas attic insulation	17
Gas duct insulation	5
Gas floor insulation	22
Gas wall insulation	7

Of the 81 conversion participants receiving a gas furnace replacement, 79 had a high-efficiency gas furnace installed. Fewer high-efficiency gas water heaters replaced electric water heaters: of the 86 participants receiving a gas water heater replacement, only 35 installed a high-efficiency unit. Avista also funded a large number of non-conversion measures for conversion participants: energy savings from electric measures are accounted for in the *2014 Avista Washington Portfolio Electric Impact Report*.

3.9.1. Overall Program Savings

Table 36 presents overall gas savings for both non-conversion and conversion participants.

Table 36. Overall Gas Savings for PY 2013

Participant Type	n	Total Reported Savings	Total Evaluated Savings	Realization Rate
Non-Conversion	132	11,840	15,738	133%
Conversion	105	11,836	8,472	72%
Total	**237**	**23,676**	**24,210**	**102%**

3.10. Low Income Conclusions

Compared to the PY 2010 billing analysis, Avista's PY 2013 low-income program demonstrated an average increase in gas savings per participant, in addition to an increase in the overall program realization rate (from 31% to 102%). Several factors may have contributed to the increase in participant savings, including:

- An increased frequency of installing high-saving measures (e.g., shell) in the evaluation period,
- Changes in agency delivery protocols or energy-saving installations made with non-utility funding, and
- Exogenous effect (e.g., economic, rate changes) that may have occurred simultaneously with program activity.

One factor contributing to higher realization rates is lower average reported savings occurring in the PY 2013 evaluation period compared to previous years.

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3.11. Low Income Recommendations

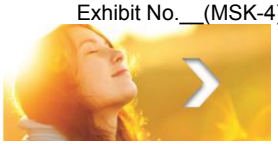
Cadmus recommends the following enhancements to improve program impact results:

- ***Use a control or comparison group in future billing analyses.*** Cadmus recommends using a comparison group in subsequent impact evaluations to analyze the treatment group of program participants. Use of a control or comparison group of nonparticipants would allow controlling for exogenous factors (e.g., macroeconomic, rate changes, technological trends) that could result in trends that affect consumption. Controlling for these trends using a control/comparison group is a robust and defensible method for estimating accurate energy-savings impacts.
- ***Consider using the combined state programs to increase model sample sizes.*** Smaller sample sizes in state-specific models attributed to decreased precision in the 2012 model estimates. Increasing the sample sizes by using a combined state model in future evaluations will mitigate this cause of decreased precision.
- ***Obtain a full list of weatherization measures from agencies.*** The billing analysis results do not allow Cadmus to disaggregate energy savings specific to Avista-funded measures. In addition, a complete list of participants' installed measures would allow Cadmus to conduct a measure-level billing analysis specific to measure types. This granularity could help Avista improve future program offerings and help fully characterize the energy savings modeled through billing analysis.
- ***Include high-use customers in program targeting.*** While prioritization guidelines for targeting low-income weatherization participants are set at the federal level, some utilities, for targeting purposes, actively track customer usage and provide agencies with lists of customers that have particularly high energy consumption.

  Notably, DOE protocols list high-energy consumption as a factor allowed in participant prioritization. In such cases, along with other targeting criteria (e.g., families with children, senior citizens), agencies may incorporate energy-consumption characteristics into their program participant prioritization. Not only would weatherizing high-use customers likely result in higher energy savings, but could provide these customers with some financial relief for higher energy bills due to their housing characteristics.

  Avista should identify high-usage customers while controlling for factors that contribute to consumption (e.g., square footage, income, numbers of people per household).

  Given reductions in federal funding for weatherization and associated reduced agency capacities resulting in more limited leveraging opportunities, Avista has an opportunity to lead new efforts for the continued delivery of energy-savings resources to low-income residential customers. Potential exists to secure cost-effective energy savings through high-usage targeting, while continuing to support weatherization for income-qualified customers. Efficient targeting balances efforts to provide whole-house weatherization, and allows for leveraging the agency network as a resource for outreach and delivery.



- ***Track and compile additional data from agency audits.*** These data include information on primary and secondary heating and cooling, and on the size of a home. As an inexpensive alternative to gas heat, gas customers may turn to electric room heaters and wood stoves, reducing the impacts of installed weather-sensitive measures (e.g., insulation). Collecting information on customers' primary heating usage during weatherization would lead to more reasonable savings estimates.

  Cadmus recommends that Avista work with CAP agencies to develop explicit, on-site tracking protocols for collecting information on participant heating sources. The CAPs should collect the following information to better inform heating and cooling sources:

  - Visual inspections of all heating equipment found on site;
  - Participant-reported primary and supplemental heating sources used;
  - Quantities of secondary heating, if applicable (e.g., numbers of electric room heaters); and
  - Any indicators suggesting discrepancies between actual and reported primary heating.
- ***Consider performing quantitative, non-energy benefit analyses.*** Cadmus recommends that Avista consider pursuing additional analyses aimed at quantifying non-energy benefits associated with low-income weatherization, applicable to the Total Resource Cost (TRC) test. Specifically, analyses of economic impacts and payment pattern improvements (including reduced arrearages and collections costs) can provide program stakeholders with the monetized value of energy-efficiency measures. Other Northwest utilities have used such analyses to report low-income weatherization cost-effectiveness (in Idaho and Washington). Standard cost-effectiveness TRC testing accounts for all program costs and only includes energy savings as a program benefit. The TRC test omits some non-energy benefits genuinely experienced by participants, such as decreased mortality and morbidity, as well as environmental benefits such as reduced emissions of carbon dioxide and other pollutants listed in the Clean Air Act.

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Appendix A: Residential Weatherization and Manufactured Homes Duct Sealing – Billing Analysis Model Specification

For each participant home, we estimated a heating model in both pre- and post-periods to weather-normalize raw billing data.

The PRISM model specification used was:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and month 't':

ADC_{it}	=	Average daily therm consumption in the pre- and post-periods
α_i	=	Participant intercept; represents the average daily therm base load
β_1	=	Model space heating slope (therms per HDD)
$AVGHDD_{it}$	=	Base 65 average daily HDDs for the specific location
ε_{it}	=	Error term

From the above model, we computed weather-normalized annual consumption (NAC) as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \varepsilon_i$$

Where for each customer 'i':

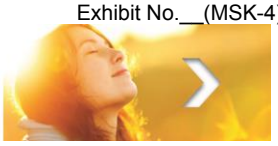
NAC_i	=	Normalized annual therm consumption
$\alpha_i * 365$	=	Annual base load therm usage (non-weather sensitive)
$LRHDD_i$	=	Annual, long-term HDDs of a typical meteorological year (TMY3) in the 1991–2005 series from NOAA, based on home location
$\beta_1 * LRHDD_i$	=	The weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC

The fixed-effects model specification using the average daily consumption (ADC) of gas in home 'i' during month 't' is defined as:

$$\mathrm{ADC_{it}} = \alpha_i + \gamma_i \mathrm{HDD_{it}} + \beta_1 \mathrm{POST_{it}} + \beta_2 \mathrm{POST_{it}} * \mathrm{HDD_{it}} + \beta_3 * Other_{it} + \varepsilon_{it}$$

Where:

α_i	=	Average daily base load energy use in home 'i' that is not sensitive to weather. Cadmus' analysis controlled for non-weather-sensitive and time-invariant energy use with home fixed effects.
$\boldsymbol{\gamma}_i$	=	Average daily heating usage per HDD in home 'i.' This controls for weather-sensitive energy use with home fixed-effects interacted with HDDs.



HDD	=	Average daily HDDs (heating load) during the billing cycle.
β_1, β_2	=	Coefficients that estimate the weatherization measure program effect on gas usage.
POST	=	An indicator variable for whether the month is before or after the measure installation. This variable equals 1 in the months and years following the measure installation, and 0 otherwise. The variable is defined using the combination of Customer Specific Measure Install Date and Fixed Date specifications.
β_3	=	Coefficient that estimates the savings attributable to the other measures.
Other	=	An indicator variable for whether the month is before or after other measures were installed. This variable equals 1 in the months following the maximum install date for all other measures, and equals 0 for months prior to the minimum install date.
ε_{it}	=	Error term for home 'i' in month 't.'

Cadmus estimated the savings for the weatherization measures using estimated coefficients on all the post-period indicator variable components listed in the above fixed-effects regression model. The overall gross weatherization model savings are given by:

$$\text{Savings} = \hat{\beta}_1 * 365 + \hat{\beta}_2 \text{AnnualHDD}$$

Where:

Annual HDD	=	Average annual normal TMY3 HDDs for the participants.

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Appendix B: Electricity Savings Achieved by Residential Gas Programs

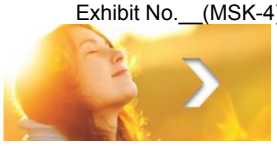
Table 37 shows electricity saved in kWh by the PY 2013 gas energy-efficiency programs. High penetration of electric dryers in homes with gas domestic hot water heating likely resulted in electric savings accompanying ENERGY STAR clothes washer installation.

The 2010 gas furnace billing analysis showed a portion of participants choose to install an air source heat pump at the same time they install a new high-efficiency furnace. This switch from all-gas heating to dual-fuel heating results in an electric penalty.

Table 37 shows values for all measure installations in Washington, both inside and outside Avista's electric service territory.

Table 37. Electricity Savings for Gas Program in Washington

Measure Name	Measure Count	UES (kWh)	Total Savings (kWh)
Gas Clothes Washer With Natural Gas Water Heater	139	99.1	13,774
Natural Gas Furnace	2,018	-165	-332,970
TOTAL	**2,157**	**NA**	**-319,196**



Appendix C: Low-Income Weatherization Participant Survey

In May 2013, Cadmus coordinated a phone survey of 150 residential low-income weatherization program participants. Cadmus developed the participant survey instrument and defined the sample. Cadmus subcontracted the administration of the surveys to an implementation firm.

Table 38 provides details regarding the telephone survey planned and achieved completes.

Table 38. Participant Telephone Survey Sampling Plan

	Quantity
Total Participants	434
Screened out due to change in occupancy or bad phone number	78
Eligible Participants in Call List	356
Completed Surveys	150
Sample Size Goal	150

Cadmus selected a random sample of participants from the 2012 Q3 to 2013 Q1 participant population available in April 2013 (434 participants). Cadmus aimed and achieving 150 completed survey responses, which achieved at the 90% confidence with ±5.1% precision at the program level. The survey achieved a high response rate in fielding, using only 75% the sample frame to accomplish its targeted completes.

We asked participants about their experiences with the program, addressing the following topics:

- Changes in energy usage associated due to the following:
  - Behavior impacts attributed to energy-education
  - Heating usage, including equipment and fuel
  - Changes in occupancy
- Use of supplemental heating or cooling systems
- Functionality of equipment prior to repair or replacement
- Demographics and Home Characteristics

PROGRAM AWARENESS AND WAIT TIME

Most survey respondents said they heard about the program through family or friends. Figure 9 presents all ways survey respondents heard about the program.

Figure 9. How Respondents Heard About the Program (n=125)

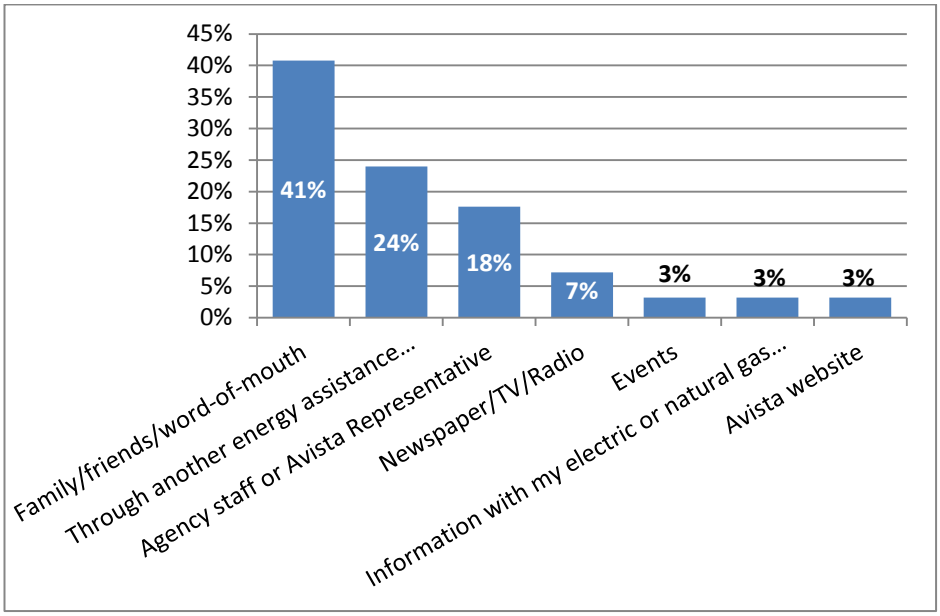
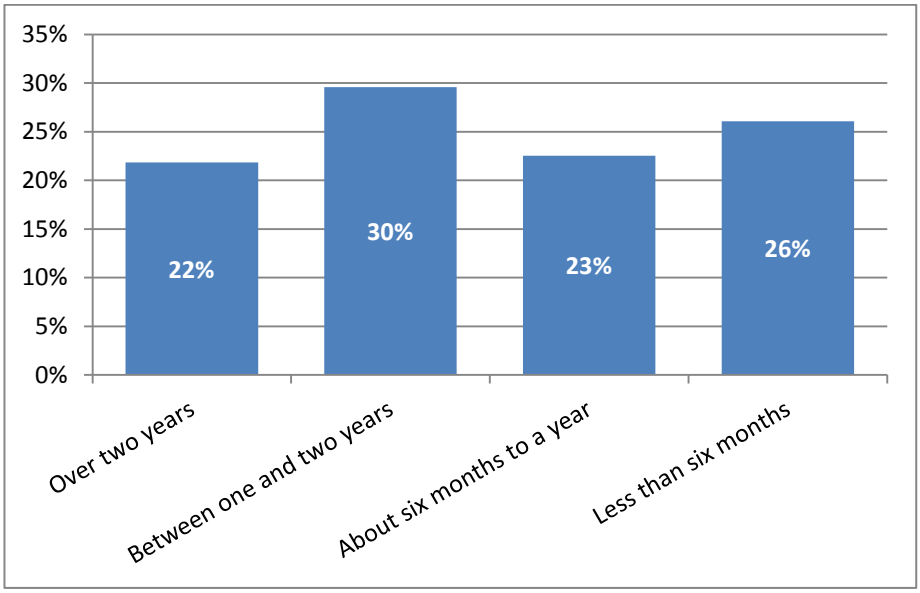
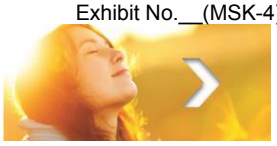


Figure 10 shows how long respondents were on the waiting list for the program.

Figure 10. How Long Respondents Were On the Waiting List (n=142)



As shown above, about half the respondents said they were on the waiting list for the program one year or less, with 26% indicating they were on the waitlist for less than six months. Thirty percent of the respondents indicated that they waited between one and two years, and 22% waited for over two years for the program's services



PREVIOUS AND NEW EQUIPMENT

Table 39 shows the distribution of installed equipment and the condition of the replaced equipment. Table 39 also indicates for respondents who received programmable thermostats if the installer programmed the thermostat, the participants just received education on how to install it, or received neither programming or education.

Table 39. Equipment Installed and Equipment Condition

Equipment installed	% Installed	Worked Fine	Had Problems	Did not Work
Refrigerator (n=150)	16%	54%	38%	8%
Furnace (n=146)	60%	24%	61%	15%
Water Heater (n=148)	51%	50%	43%	7%
Windows (n=148)	45%	29%	71%	n/a
Doors (n=149)	62%	8%	92%	n/a
Equipment installed	**% Installed**	**Programmed**	**Just education**	**Neither**
Thermostat (n=143)	50%	87%	7%	6%

For those respondents who said their previous equipment had problems or did not work, Table 40 shows how long the equipment was experiencing those issues.

Table 40. Equipment Problem Duration

Problem Equipment	Months	Year	> 1 Year
Refrigerator (n=10)	30%	10%	60%
Furnace (n=59)	15%	24%	61%
Water Heater (n=34)	26%	32%	41%

Table 41 details the fuel type of old and replaced furnaces and water heaters for respondents who received this new equipment.

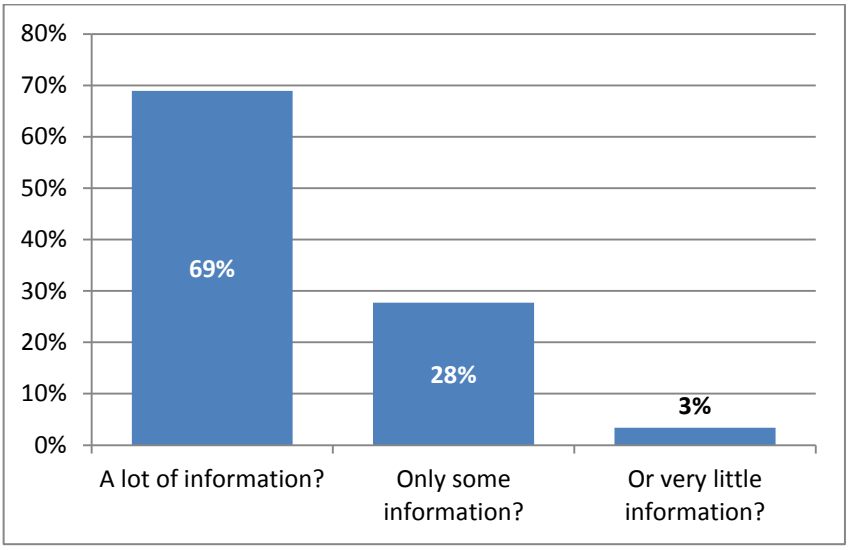
Table 41. Furnace and Water Heater Fuel

Equipment Type	Fuel	Previous	New
Furnace (n=61)	Electric	42%	10%
	Gas	53%	90%
	Oil	5%	0%
Water Heater (n=67	Electric	76%	25%
	Gas	24%	75%

PROGRAM EDUCATION

Only a small number (3%) of respondents said they received little information, and over two thirds said they received a lot of information, as shown in Figure 11.

Figure 11. How Much Information Respondents Said They Were Provided (n=119)



As shown in Table 42, almost 90% of respondents said they received educational pamphlets, and 97% of those respondents said they read them.

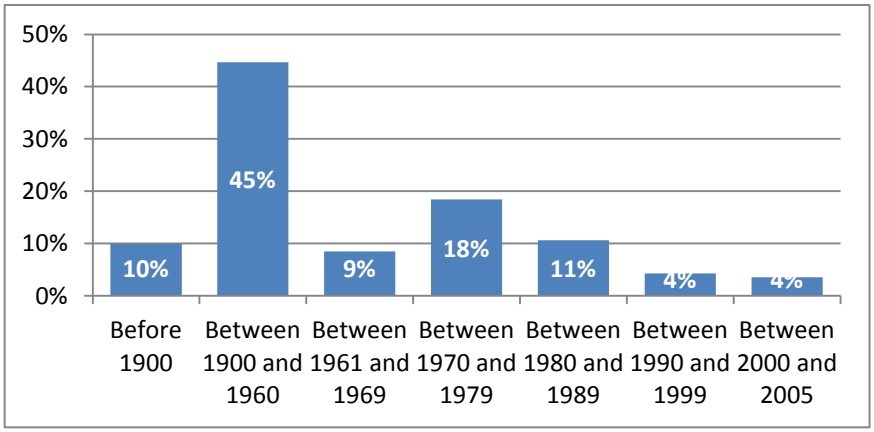
Table 42. How Many Respondents Received and Read Pamphlets

	Received Pamphlet (n=132)	Read Pamphlet (n=116)
Yes	89%	97%
No	11%	3%

HOME CHARACTERISTICS

Figure 12 shows the years that the respondent's homes were built.

Figure 12. Year Respondents' Homes Were Built (n=141)



Most respondents lived in a single family home or a mobile home or trailer, as shown in Figure 13.

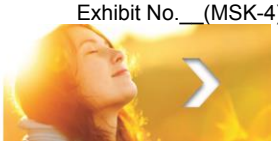


Figure 13. Home Types (n=147)

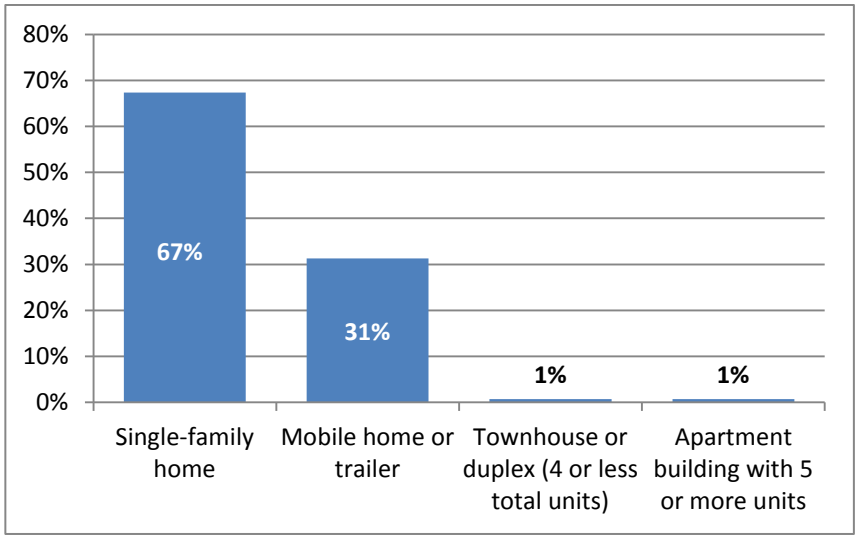


Figure 14 shows that most respondents heat their home by natural gas, followed by electricity.

Figure 14. Heating Fuel (n=147)

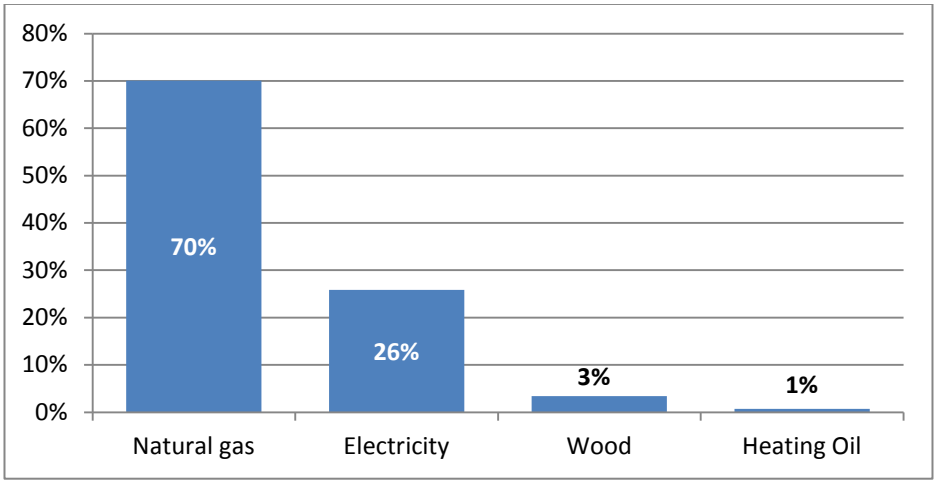
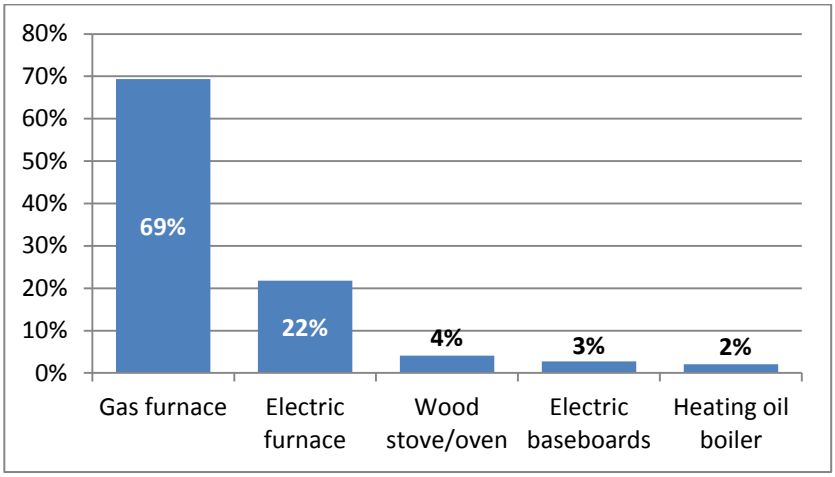


Figure 15 presents the distribution of respondent's primary heating equipment. Most respondents (69%) said their primary heater was a natural gas furnace, followed by an electric furnace (22%).

Figure 15. Primary Heater Type (n=147)



Most respondents said that after the program equipment was installed, they either did not change or turned down the temperature setting on their thermostat, as shown in Figure 16.

Figure 16. Post-installation Thermostat Changes (n=135)

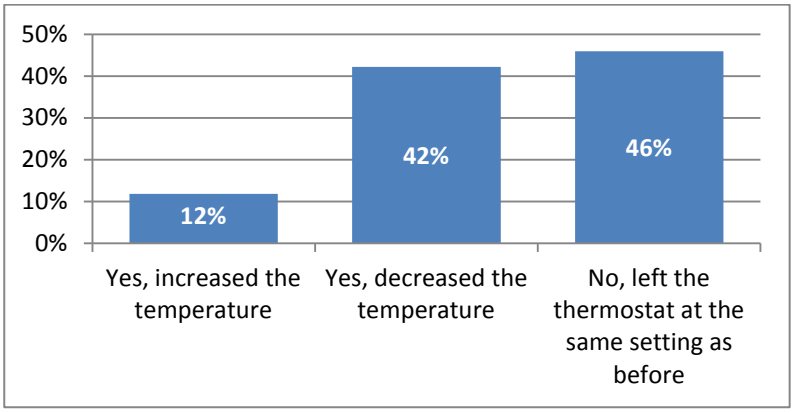


Figure 17 shows what respondents use as a supplemental heating source. Most indicated they use an electric room heater or a wood burning device.

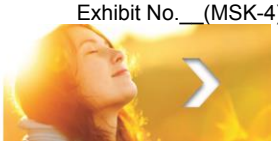
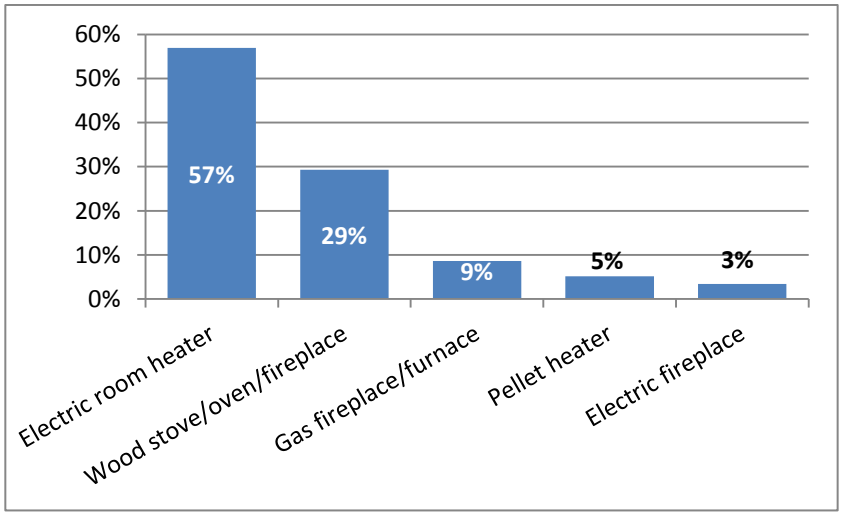


Figure 17. Supplemental Heater Types (n=58)



Respondents who use a supplemental heating source said they used it less or about the same after the program equipment was installed, as shown in Figure 18.

Figure 18. Post-installation Supplemental Heater Use (n=56)

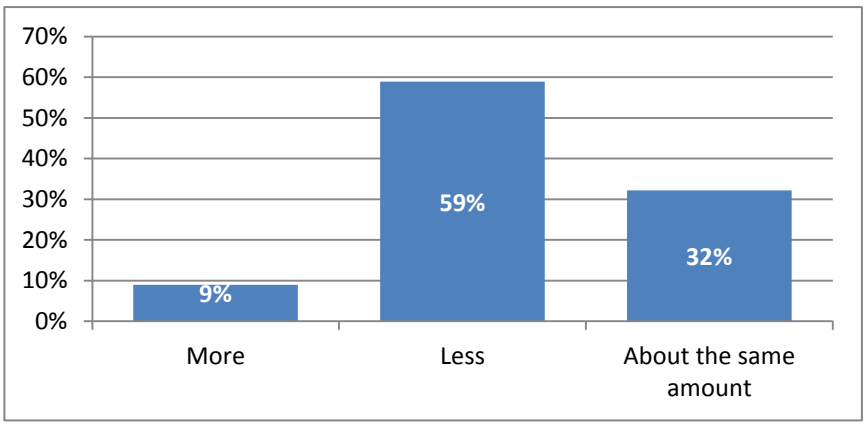


Figure 19 presents the distribution of equipment used to cool respondent's homes. When asked if they would change the way they cool their home after participating in the program, only 8% said they changed.

Figure 19. Summer Cooling Equipment Types (n=140)

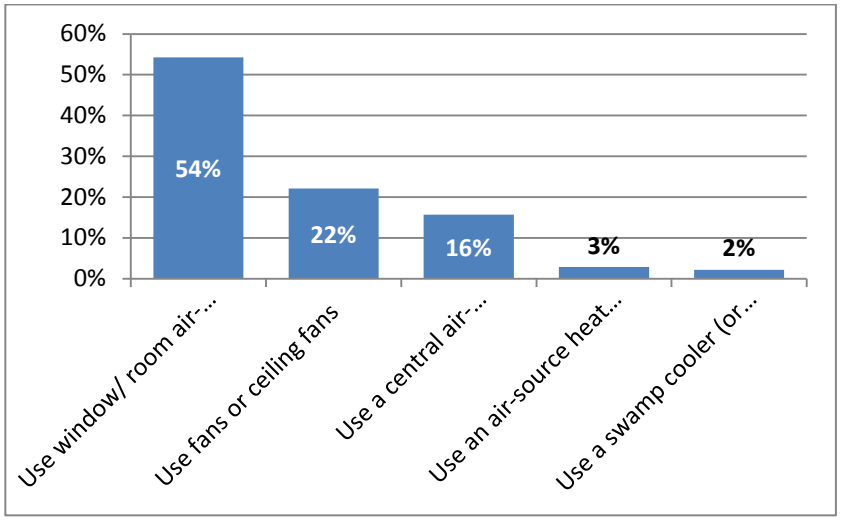
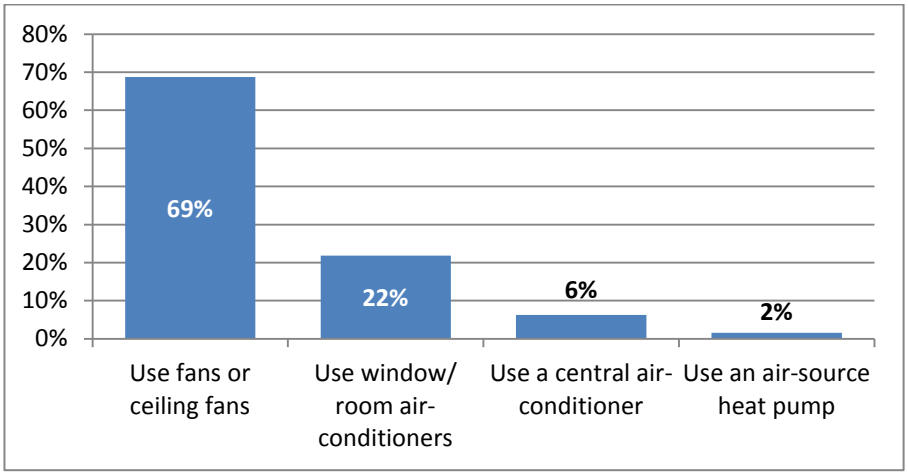
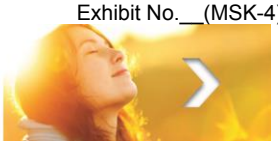


Figure 20 shows what supplemental equipment respondents use to cool their home.

Figure 20. Supplemental Cooling Equipment Types (n=64)





Appendix D: Low-Income Weatherization – Billing Analysis Model Specification

For each participant home, Cadmus estimated a heating model in both the pre- and post-periods to weather-normalize raw billing data. Cadmus used the following PRISM model specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and calendar month 't':

ADC_{it}	=	The average daily therm consumption in the pre- or post-program period
α_i	=	The participant intercept; represents the average daily therm base load
β_1	=	The model space heating slope
$AVGHDD_{it}$	=	The base 65 average daily HDDs for the specific location
ε_{it}	=	The error term of the regression

From the model above, we computed the weather-normalized annual consumption (NAC) as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \varepsilon_i$$

Where, for each customer 'i':

NAC_i	=	Normalized annual therm consumption
α_i	=	The intercept that is the average daily or base load for each participant, representing the average daily base load from the model
$\alpha_i * 365$	=	Annual base load therm usage (non-weather sensitive)
β_1	=	The heating slope; in effect, usage per heating degree from the PRISM model
$LRHDD_i$	=	The annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location
$\beta_1 * LRHDD_i$	=	The weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC
ε_i	=	The error term of the regression

Cadmus used the following fixed-effects CSA model specification to determine program-level savings:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 POST_{it} * AVGHDD_{it} + \beta_{3\ldots13} M_t + \varepsilon_{it}$$

Where, for customer 'i' and monthly billing period 't':

ADC_{it}	=	Average daily therm consumption during the pre- and post- periods
α_i	=	The average daily therm base load intercept for each participant (part of the fixed-effects specification)
β_1	=	The model space heating slope
$AVGHDD_{it}$	=	The average daily base 65 HDD, based on home location
β_2	=	The model space cooling slope
$POST_{it}$	=	An indicator variable that is 1 in the post-period (after measure installations) and 0 in the pre-measure period
M_t	=	An array of billing month dummy variables (Feb, Mar, …, Dec), 0 otherwise
ε_{it}	=	Error term of the regression

The model estimated the therm savings per HDD in Washington as coefficient β_2. In order to calculate actual savings under normal weather conditions, Cadmus applied the 1991-2005 TMY3 normal HDDs from NOAA.