Avista 2012-2013 Washington Electric Impact Evaluation Report

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Avista Corporation
1411 E Mission Avenue
Spokane, WA 99252

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Prepared by:
Danielle Côté-Schiff Kolp, MESM
Andrew Wood
Jeff Cropp
Scott Reeves
Jim Stewart
Matei Perussi
Michael Visser
Andrew Reitz
Madison Busker
Zachary Horvath
M. Sami Khawaja, Ph.D.

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Definitions

Reported Savings – Electricity savings that are reported in Avista's tracking database.

Gross Evaluated Savings – Electricity savings that have been verified through evaluation activities such as records review, verification surveys or site visits, and engineering analysis.

Realization Rate – The ratio of gross evaluated savings over the reported savings.

Net Evaluated Savings – Net savings signify the portion of savings directly attributable to the program; savings that would have otherwise not occurred without program influence. These also include participant and nonparticipant spillover.

Net-to-Gross – The ratio of net evaluated savings to gross evaluated savings.

Savings Goal – The DSM End-Use portion of I-937, Integrated Resource Planning (IRP), or Avista Business Plan savings goal.

Achievement Rate – The ratio of evaluated savings over the savings goal.

Portfolio Executive Summary

For several decades, Avista Corporation has been administering demand-side management (DSM) programs to reduce electricity and natural gas energy use for its portfolio of customers. Most of these programs have been implemented in-house, but for a few Avista uses external implementers. Avista performed a potential study for Washington in 2011 to determine the savings goals for program year (PY) 2012 and PY 2013. Avista contracted with Cadmus to complete process and impact evaluations of the company's PY 2012 and PY 2013 electric DSM programs in Washington; this report presents our impact findings.

Evaluation Activities

We conducted the evaluation using a variety of methods and activities shown in Table 1.

Table 1. PY 2012-PY 2013 Electric Programs' Evaluation Activities

Sector	Program	Document/ Database Review	Verification/ Metering Site Visit	Survey	Billing Analysis	Modeling
Residential	Simple Steps, Smart Savings™	✓				
	Second Refrigerator and Freezer Recycling	✓		✓		
	ENERGY STAR® Products	✓		✓		
	Heating and Cooling Efficiency	✓		✓		
	Weatherization/Shell	✓		✓	✓	
	Water Heater Efficiency	✓		✓		
	ENERGY STAR Homes	✓				
	Space and Water Conversions	✓		✓	✓	
	Manufactured Homes Duct Sealing	✓			✓	
	Behavior Program	✓			✓	
Nonresidential	Prescriptive programs	✓	✓	✓		
	Site-Specific	✓	✓	✓	✓	✓
	EnergySmart Grocer	✓	✓	✓		
Low Income	Low Income programs	✓		✓	✓	
Residential/ Nonresidential	CFL Contingency	✓		✓		

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Savings Results

Overall, the Washington portfolio achieved a 97.0% realization rate, and acquired 120,635,914 kWh in annual gross savings (Table 2).

Table 2. PY 2012-PY 2013 Reported and Gross Evaluated Savings

Segment*	Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Residential	26,655,717	24,070,178	90.3%
Nonresidential	70,809,941	67,649,637	95.5%
Low Income	1,111,766	1,516,238	136.4%
CFL Contingency**	21,179,368	21,179,368	100.0%
Residential Behavior	4,636,392	6,220,493	134.2%
Total	**124,393,184**	**120,635,914**	**97.0%**

* Note that residential Behavior Program and Second Refrigerator and Freezer Recycling Program savings are inherently calculated as net, and are therefore presented here as net.
** Program did not have reported savings, so the verified savings are duplicated as reported savings, thus giving the 100% realization rate.

Goal Achievement

Evaluation of the 2012-2013 portfolio was challenging due to:

- Multiple statements and sources of goals (I-937, Avista's Integrated Resource Plan, and Avista Business Plan).
- Varying definitions of savings (e.g., gross versus net, Regional Technical Forum versus evaluation based estimates).
- Different means of achieving the goals (e.g., fuel conversion counts toward the IRP electric savings but not toward I-937).
- Different programs are not included under certain goals (e.g., Avista Business Plan does not include Contingency CFL savings).

Additional information on these designations can be found in the Portfolio Savings and Goals section.

Table 3 through Table 5 show achieved savings toward each of the three goals. All goals were exceeded. The goals are portfolio-level targets, so in order to conduct sector-level comparisons, Cadmus adopted the Avista Business Plan goals by sector, and applied those proportions to the I-937 and IRP targets. The tables also show saving achievements for the portfolio excluding the CFL Contingency and residential Behavior programs. I-937 and IRP goals are still met, but the more aggressive Business Plan goal falls slightly short.

Table 3. PY 2012-PY 2013 I-937 DSM End-Use Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	22,596,781	44,586,457	197.3%
Nonresidential	51,209,063	70,993,666	138.6%
Low Income	2,396,157	450,233	18.8%
Total	**76,202,000**	**116,030,356**	**152.3%**
Excluding CFL Contingency and Behavior Programs	**76,202,000**	**88,630,495**	**116.3%**

* Achieved savings do not include fuel switching measures.

Table 4. PY 2012-PY 2013 IRP Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	22,483,207	46,617,306	207.3%
Nonresidential	50,951,680	72,539,206	142.4%
Low Income	2,384,113	1,516,238	63.6%
Total	**75,819,000**	**120,672,750**	**159.2%**
Excluding CFL Contingency and Behavior Programs	**75,819,000**	**93,272,889**	**123.0%**

* Achieved savings includes all savings.

Table 5. PY 2012-PY 2013 Avista Business Plan Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	28,391,942	30,327,507	106.8%
Nonresidential	64,342,119	67,649,637	105.1%
Low Income	3,010,674	1,516,238	50.4%
Total	**95,744,735**	**99,493,382**	**103.9%**
Excluding Behavior Program	**95,744,735**	**93,272,889**	**97.4%**

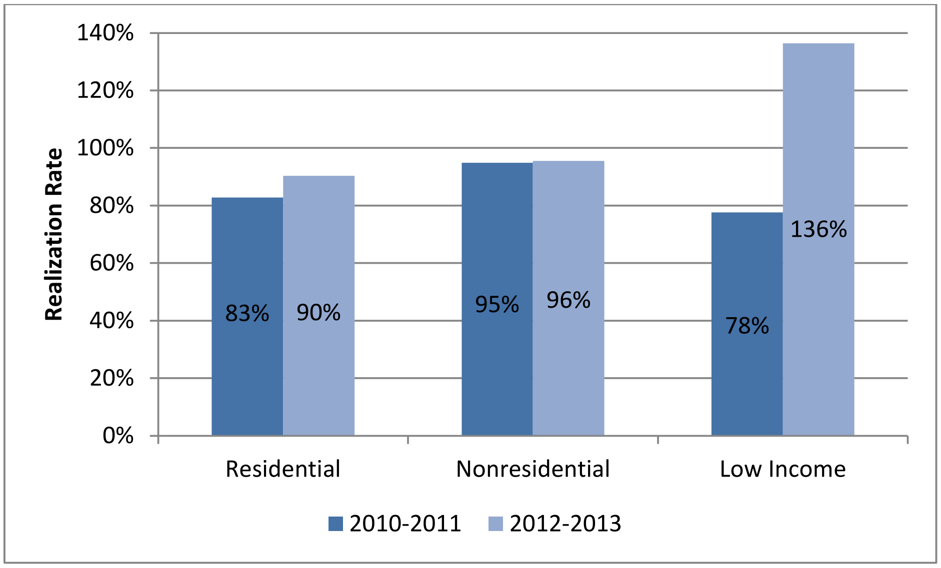
* Achieved savings do not include CFL Contingency.

Key Findings and Conclusions

Portfolio Level

As shown in Figure 1, realization rates have remained steady or increased over the last and current biennia across the various program sectors. Details on the realization rates are given in subsequent chapters.

Figure 1. Realization Rates of Portfolio Savings



The national environment for demand side management (DSM) is becoming more challenging with the implementation of EISA, and more stringent codes and standards. Avista is meeting these challenges with new and innovative measure and program ideas. On the residential side, LEDs have been added to their upstream lighting program, and they are implementing a second year of a direct install manufactured homes duct sealing program. For the nonresidential portfolio in 2014, Avista is starting a large fleet engine block heater program, targeting gas station canopy LED lighting, and an exterior LED signage program.

In future years, Avista may consider devoting additional resources to investigate new technologies and program offerings, and comparing to other utilities. Some initial examples include the following:

- Home Performance with Energy Star; http://www.energystar.gov/index.cfm?fuseaction=hpwes_profiles.showsplash,
- Central air conditioners for residential application (as our general population research supports a sizable load with stated intentions of increasing),
- A refresh of commercial direct install measures (either new, or measures that were done 5-10 years ago),
- Investigate the upcoming Tenant Star for leased commercial space,
- Commercial retrocommissioning or continuous commissioning (primarily for larger, complex facilities such as hospitals and college campuses; for example, http://www.pge.com/en/mybusiness/save/rebates/retrocommissioning/index.page),
- Comprehensive compressed air system audits and upgrades to address both demand and supply-side operation (based on Compressed Air Challenge best practices; http://www.compressedairchallenge.org/),

- Strategic energy management (similar to Energy Trust of Oregon's SEM program; http://energytrust.org/library/GetDocument/1876).

Residential

For PY 2012 and PY 2013, Avista's residential electric programs produced 46,617,306 kWh in savings, yielding a 98% overall realization rate of reported savings, and 207% of equivalent residential IRP goals.

- Overall, residential electric customers responded well to the programs, often installing several measures within the same year.
- Tracking databases proved adequate for evaluation purposes, providing sufficient contact information and measure and savings information. During the database review, Cadmus confirmed the information was reliable and accurate.
- All rebated measures had been installed and continued to operate.
- For the residential Behavior Program, homes in Washington saved an average 0.764 kWh (1.56%) per day. The percentage savings were significantly higher than expected (1%).

Nonresidential

For PY 2012-PY 2013, Avista's nonresidential electric programs produced 72,539,206 kWh in savings, yielding a 96% overall realization rate of reported savings, and 142% of equivalent nonresidential IRP goals.

In general, Cadmus determined that Avista implemented the programs well. Cadmus identified the following key issues that led to adjusted energy savings:

- Metering on several industrial process measures indicated that post-installation power consumption was different than expected, leading to adjustments to the energy savings estimates.
- Some participants did not operate the incented equipment correctly or did not complete expected improvements.
- Some participant post-installation heating or cooling loads did not achieve the level of projected consumption.
- Simulation models sometimes did not accurately represent the actual as-built building or system operation.
- Avista implementation staff sometimes may not have conducted a thorough analysis of energy-savings calculations provided by participants or third-party contractors for all projects, and sometimes made errors on entering data to characterize building or measure performance.

Low Income

For PY 2012-PY 2013, Avista's low-income electric programs produced 1,516,238 kWh in savings, yielding a 136% overall realization rate of reported savings and 64% of equivalent low income IRP goals.

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Compared to PY 2010, Avista's PY 2013 low-income program demonstrated an increase in average electric savings per participant, in addition to an increase in the overall program realization rate (from 78% to 136%). 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 simultaneous to program activity.

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

Recommendations and Further Analysis

Residential

Cadmus recommends the following changes to Avista's residential electric programs:

- Consider updating its per-unit assumptions of recycled equipment to reflect this evaluation in order to ensure that planning estimates of program savings are in line with evaluated savings.
- If clothes washer rebates are reinstated, Avista should track them all within the electric program unless there is a large penetration of gas dryers.
- Increase measure level detail capture on applications and include in the database. Specific additional information should include energy factors or model numbers, baseline information for insulation, and home square footage, particularly for the ENERGY STAR Homes program.
- Consider tiered incentives by SEER rating as higher SEER systems generally require ECM fan motors to achieve certain SEER ratings.
- Avista should consider completing a lighting logger study within its territory if Avista believes the results of the forthcoming RBSA study do not accurately represent usage in their territory.
- Avista should consider researching the percentage of Simple Steps, Smart Savings bulb purchase that are installed in commercial settings. This could increase the average installed hours of use and increase program savings.
- Perform a billing analysis on ENERGY STAR homes using a non-participant comparison group once enough homes have participated under the new requirements to justify performing the work. This research could be used to demonstrate the achieved savings through energy efficiency construction practices.
- Consider researching the current variable speed motor market activity to determine if this measure should continue as a stand-alone rebate or be packaged with other equipment purchases.

Nonresidential

We have the following recommendations for improving program energy-savings impacts and evaluation effectiveness:

- Create a quality control system to double-check all projects with savings over 300,000 kWh.
- Consider working with participants to accelerate the process of claiming energy savings and paying the project incentive. Preferably this should happen within one year of measure installation, depending on Avista’s requirements for post-installation data on the particular project.
- Avista may want to consider tracking and reporting demand reduction to better understand measure load profiles and peak demand reduction opportunities.
- Update prescriptive measure assumptions and sources on a regular basis.
- Streamline its file structure to enable reviewers more easily identify the latest documentation.
- 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 when the paid invoice does not include installation labor.
- Avista may consider adding a flag to their tracking database to automatically calculate the unit of energy savings per dollar (kWh/$ or therm/$) to provide a quick check to identify extreme outliers.
- In the case of redundancy, Avista may want to consider incenting pump projects through the Site-Specific Program to more accurately characterize the equipment operating hours.
- Avista may want to adopt modeling design guidelines to set minimum standards, such as The Energy Trust of Oregon guidelines.

Low Income

Cadmus recommends the following enhancements in order to improve low-income program impact results:

- Consider including a control/comparison group in future billing analyses.
- Consider options for increasing 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 quantitative, non-energy benefit analyses.

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1. Residential Impact Evaluation

1.1. Introduction

We designed our impact evaluation to verify reported program participation and energy savings. We used data collected and reported in the tracking database, online application forms, phone surveys, billing analyses, RTF savings review, and applicable updated deemed savings values.

1.2. Methodology

1.2.1. Sampling

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

Table 6. 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 would have a clear recollection of their participation experience. Table 7 provides a summary of unique customers (identified using Avista account number) and surveys completed in each effort.

Table 7. Residential Participant Details and Survey Sample—Combined Washington and Idaho

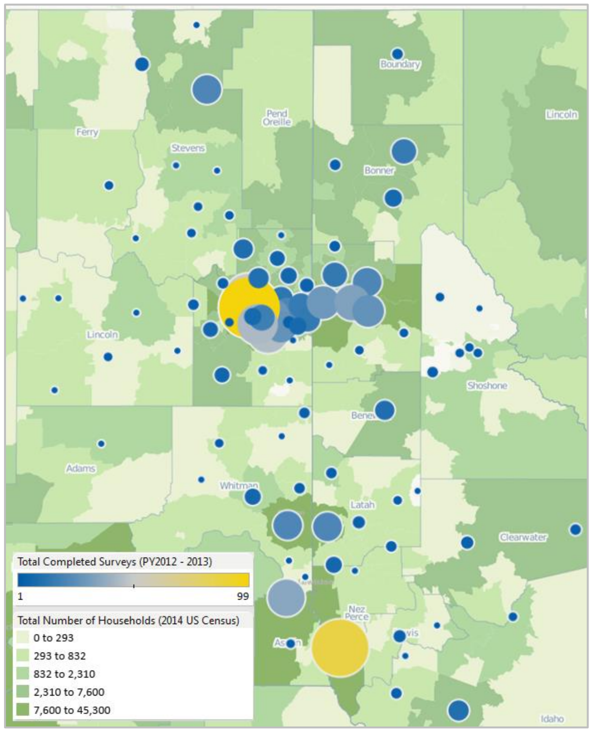
Measure Type	2012			2013		
	Participants	Surveys	Percent	Participants	Surveys	Percent
Natural Gas and Electric Programs						
ENERGY STAR Products	6,429	149	2%	782	65	8%
Heating and Cooling Efficiency	3,747	142	4%	2,490	70	3%
Water Heating	629	88	14%	316	60	19%
Weatherization and Shell Measures	692	102	15%	313	60	19%
Electric-Only Programs						
Second Refrigerator and 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 levels at the measure-category level. In 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. The participant survey sampling plan also drew upon multiple factors, including 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 does not track participant contact information. Similarly, for ENERGY STAR New Homes, Cadmus did not survey residential customers purchasing rebated homes as the rebates were paid to the builders. Cadmus also did not survey new program participants (i.e., Residential Behavior) or temporary programs (e.g., Home Audit and Manufactured Homes Duct Sealing).

Within each program stratum, Cadmus randomly selected program 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, Coeur d'Alene, Pullman, Moscow, and Lewiston. This aligns with population distributions in Avista's service territory. Figure 2 provides the distribution of participating customer survey respondents.

Figure 2. Geographic Distribution of PY2012 - PY2013 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 market-research firm Discovery Research Group (DRG) to conduct surveys with the selected participants. To minimize response bias, DRG called customers during various hours of the day and evening, as well as on weekends, and made multiple attempts to contact selected participants. Cadmus monitored survey phone calls to ensure accuracy, professionalism, and objectivity. We analyzed the survey data at the program level, rather than at the measure level. Survey results at the portfolio level are weighted by program participation to ensure proper representation.

Database Analysis

Cadmus reviewed the participant database provided by Avista to check for inconsistencies in reported savings and measure duplications. This review is necessary as Avista uses the database to track both achieved savings and rebates paid. Our review revealed multiple cases for the tracked savings did not follow the 2012 Avista TRM. These differences are described later in the report.

Unit Energy Savings

Cadmus reviewed every high impact prescriptive measure except the weatherization and shell measures for which we determined savings from a billing analysis. During each program year, Avista updates unit energy savings (UES) to reflect the gross energy savings achieved by a measure's installation. Details on each measure are included in the program sections below.

Billing Analysis

Cadmus conducted a statistical billing analysis of monthly meter data to determine the adjusted gross savings and realization rates for the following electric measures: weatherization, conversions to air source heat pump, conversions to natural gas, and manufactured homes duct sealing. We used a pre- and post-installation combined Conditional Savings Analysis (CSA) and Princeton Score Keeping Method (PRISM) approach. Verification Rates

Cadmus determined verification rates for each program. Where applicable, we administered verification site visits and surveys, which included:

- Checking correct measures were tracked in the database;
- Correct quantities were accounted for; and
- Units remained in place and were operable.

We equally weighted site visit and survey observations. All measures researched were in place and operable, resulting in 100% verification rates for the programs.

1.2.3. Measure Qualification Rates

Cadmus considered a measure qualified if it met the requirements in its category, such as being ENERGY STAR-certified or meeting the minimum efficiency standards for the program. We ensured all qualifications were met and, when necessary, conducted online database searches of the model numbers and noted qualifying characteristics.

Only two non-qualified measures were found of the entire qualification sample. One was a floor insulation project in which the base case condition listed on the application should have prevented the project from qualifying. The second was a high-efficiency heat pump installation for which the installed equipment did not meet the required efficiency threshold. Neither project impacted the overall residential qualification rate. Any savings for these two measures would have been determined using either a billing analysis or a metering study, which adjust for the disqualification. Since all other measures had qualification rates of 100%, the total qualification rate for all residential electric programs was therefore 100%.

1.3. Program Results and Findings

1.3.1. Overview

Cadmus analyzed data records, maintained by either Avista or an implementation contractor, to determine appropriate unit energy savings (UES) and measure counts for each supported measure within each program. The end result is the total adjusted gross savings for each measure and program, as well as the overall realized savings for each program.

We followed the same steps for calculating adjusted gross measure savings for all programs except Simple Steps, Smart Savings™, Second Refrigerator and Freezer Recycling, and Residential Weatherization:

- Review program database to determine if the adjusted measure counts correctly represent the number of installations.
- Conduct a phone survey or site visit to verify that the installation is within Avista's service territory.
- Calculate verification and qualification rates.
- Calculate deemed measure savings for products rebated during the program period.
- Apply verification and qualification rates and deemed savings to the measure counts to determine the adjusted gross savings for each measure.

Details on the calculation methods used for Simple Steps, Smart Savings™, Second Refrigerator and Freezer Recycling, and Residential Weatherization are included in their specific sections below.

1.3.2. Simple Steps, Smart Savings™

Program Description

Avista's Simple Steps, Smart Savings ™ is an upstream incentive program that is an effective alternative to traditional mail-in incentives because of its ease of participation, widespread accessibility, and low administrative costs. This type of program allows utilities' incentives to pass directly from manufacturers to retailers, which then reduce bulb prices to their customers. The program motivates retailer participation by reducing bulb prices without a loss in profits. For the customer, participation may be so seamless they are unaware they have purchased an incentivized bulb or participated in a utility program.

Upstream programs, however, pose particular evaluation challenges because calculating metrics, such as in-service rates (ISR) and attributions, traditionally relies on surveying purchasers of incentivized products. As part of our determination of program savings, we referred to the Northwest Regional Technical Forum (RTF) UES assumptions, Avista's program records, and the compact fluorescent bulb (CFL) Contingency Program (discussed in Chapter 5).

This program incents various CFL products from standard twist to specialty bulbs that include 3-way, reflector, dimmable, globe, and other specialty bulbs. There are unique assumptions for standard twist bulbs and specialty bulbs; therefore, each was analyzed separately. Based on program funding, 70% of all bulb sales are assumed to be associated with residential sockets in Washington.

Analysis

This program has six different parameters to inform the calculation of gross savings for the lighting component: CFL wattage, delta watt multiplier (DWM), hours-of-use (HOU), days-per-year, waste heat factor (WHF), and ISR. The following algorithm shows the annual energy lighting savings:

CFL Watts × DWM × HOU × DAYS × WHF × ISR = Annual Energy Savings

Where:

Measure Watts	=	Wattage of the purchased CFL or LED
DWM	=	The difference in wattage between the baseline bulb and the measure bulb divided by the wattage of the measure bulb
HOU	=	Daily lighting operating hours
DAYS	=	Days per year, 365.25
WHF	=	An adjustment representing the interactive effects of lighting measures on heating and cooling equipment operation
ISR	=	In-service rate, or percentage of units installed

The annual savings algorithm is derived from industry-standard engineering practices, consistent with the methodology used by the RTF for calculating energy use and savings for residential lighting. Each methodology component is discussed in detail below.

CFL Wattage

Table 8 shows the reported and evaluated bulb and fixture sales for this program. Evaluated sales were determined from vendor provided data documenting sales allocated to Avista's territory. This discrepancy is likely due to monthly adjustments made in the database, which in turn may have led to either an over- or under-counting of the total sales volume.

Table 8. Total Reported and Evaluated CFLs Sold by Year

PY	Type	Reported	Evaluated
2012	Twist	229,145	227,244
	Specialty	90,577	76,400
	Total	**319,722**	**303,644**
2013	Twist	300,908	302,651
	Specialty	83,188	92,359
	LED Bulb	22,042	22,042
	LED Fixture	20	20
	Total	**406,158**	**417,072**

Avista sales data included CFL wattage, units sold, and bulb type. Savings for each bulb type is analyzed separately. For 3-way bulbs, the middle wattage was used for the analysis. The average weighted CFL wattage sold in PY 2012 for standard twist and specialty was 16.23 and 15.53 watts, respectively. The average weighted CFL wattage sold in PY 2013, for standard twist, specialty, LED bulb, and LED fixture, was 16.15 watts, 14.23 watts, 10.19 watts, and 13.94 watts, respectively.

Delta Watt Multiplier

Cadmus followed the lumens equivalence method as laid out in the Uniform Methods Project (UMP) to evaluate the baseline wattage and the DWM for each wattage and type of bulb sold. The evaluation team matched the reported SKU numbers against the ENERGY STAR lighting database[1] to determine the lumens associated with each bulb. Once the lumens value was determined, the baseline wattage was evaluated in accordance with the guidelines outlined in the Energy Independence and Security Act (EISA) of 2007.

In PY2012 Cadmus was able to match 91% of the 433,777 bulbs sold using ENERGY STAR database. For the remaining 9% of bulbs, the first equation below was used to estimate the bulb's lumen output. This equation was developed by Cadmus using the ENERGY STAR lighting database, and is takes advantage of the relationship between CFL wattage and lumen output.

$$CFL\ Lumens\ in\ PY\ 2012 = 68.739 \times CFL\ Wattage - 56.25$$

In PY 2013, Cadmus was able to match 83.1% of the roughly 600,000 bulbs incented through the program. For the remaining 16.9% of bulbs, we determined the lumens value with an interpolation equation that is based on the relationship between CFL wattage and lumen output from the ENERGY STAR lighting database:

$$CFL\ Lumens\ in\ PY\ 2013 = 70.952 \times CFL\ Wattage - 86.11$$

Figure 3 and Figure 4 compare the lumens determined by lookup to the lumens determined using the regression model, along with the percent of PY 2012 sales for each wattage and type. The figures show

[1] http://www.energystar.gov/ia/products/prod_lists/compact_fluorescent_light_bulbs_prod_list.xls

that the regression method provides a better match standard twist CFLs than for specialty bulbs. Cadmus accepted the lumen output estimated by the regression for both types of bulbs due to the low percentage of sales volume used in the regression analysis.

Figure 5 and Figure 6 show a comparison of the lumens determined by lookup to the lumens determined by regression model, along with the PY 2013 sales data for the given wattage. The figures shows that the regression equation used in PY 2013 is a good estimate of the lumens output for a given measure wattage, especially considering the low percentage of total program sales.

Figure 3. Results of PY 2012 Lumens Determination, Standard Twist CFLs

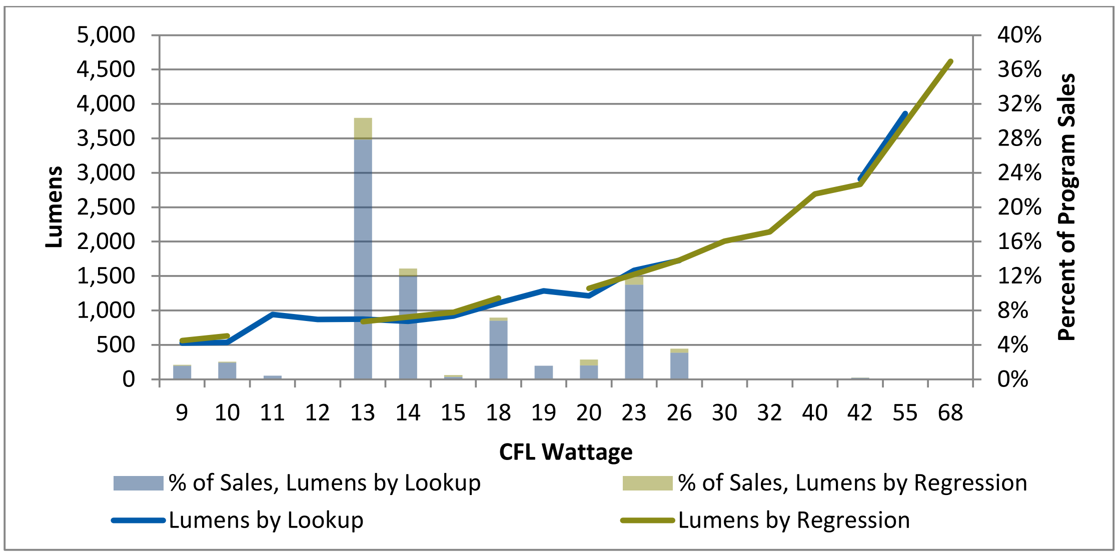


Figure 4. Results of PY 2012 Lumens Determination, Specialty CFLs

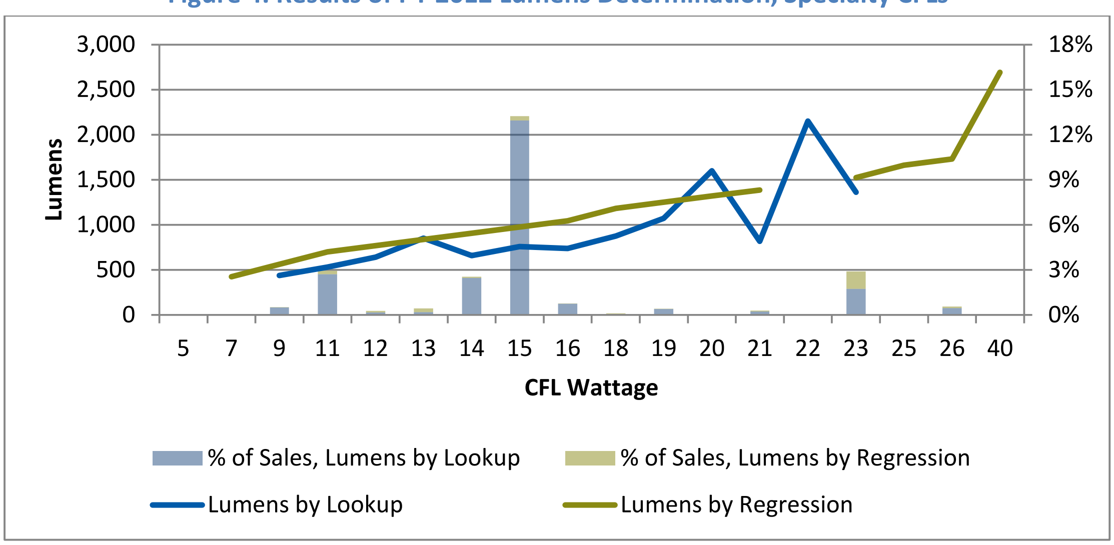


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Figure 5. Results of PY 2013 Lumens Determination, Standard Twist CFLs

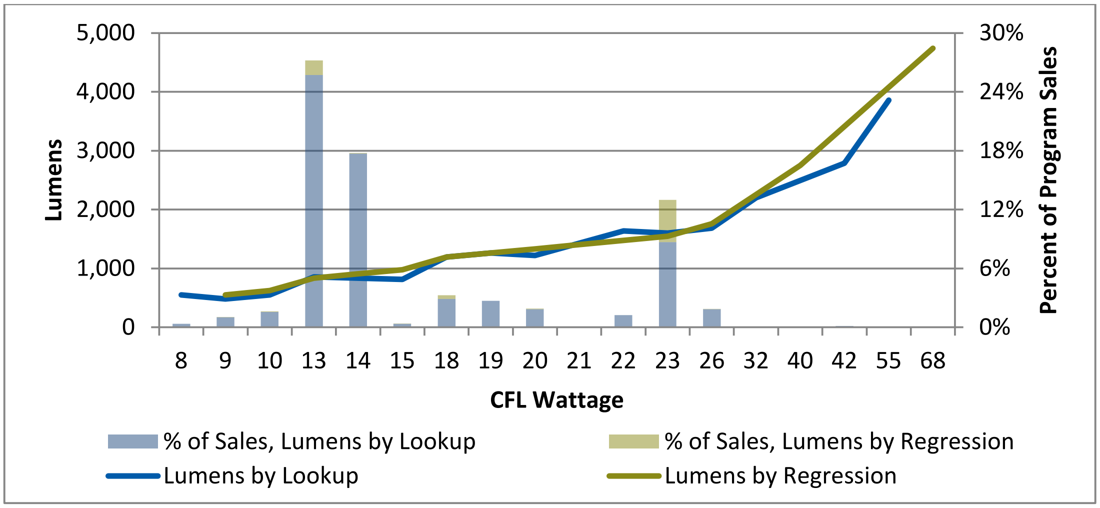
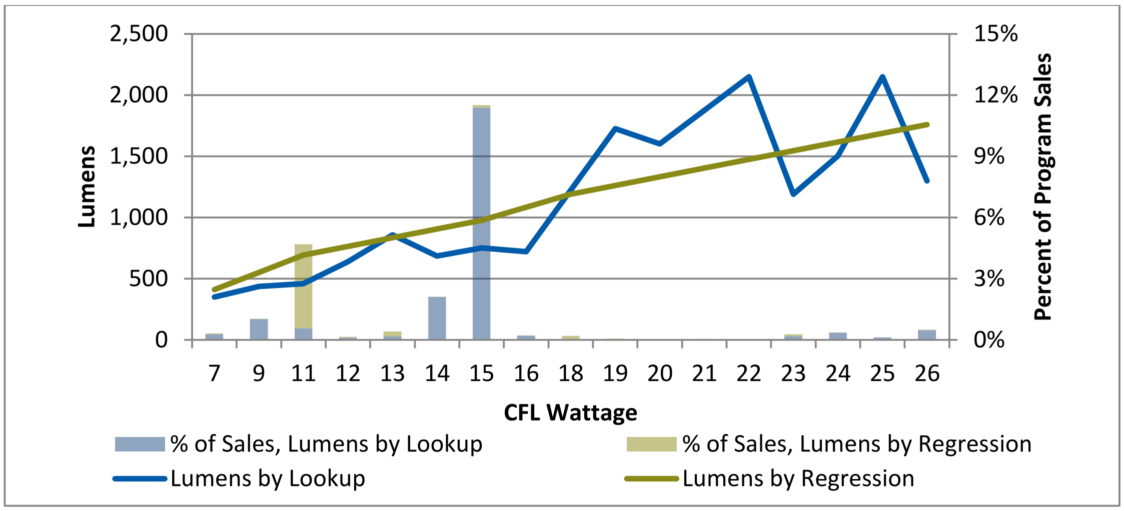


Figure 6. Results of PY 2013 Lumens Determination, Specialty CFLs



Cadmus then determined the baseline wattage for each bulb based on the lumen output and whether the bulb includes a reflector (which is not impacted by EISA).[2] Table 9 and Table 10 show the schedules Cadmus used to determine the baseline wattage for bulbs included in PY 2012 and PY 2013, for reflector and non-reflector bulbs, respectively. We then calculated the DWM for each bulb using the baseline wattage and purchased CFL wattage.

2 Federal exemptions for some reflector style bulbs were set to expire in late 2012. In order to maintain consistency between this evaluation and the 2012 program year evaluation, Cadmus assumed that the exemptions expired on January 1, 2014. The impact of these exemptions on the 2013 program would have caused a 0.69% decrease in overall savings.

Table 9. Baseline Wattage Based on Measure Lumens, Non-Reflector Bulbs

Lumens Range	Incandescent Baseline [W]			Average CFL Wattage	Bulbs Rebated	% of Program Sales
	CFL or LED Sold Before 1/1/12	CFL or LED Sold on or After 1/1/12	CFL or LED Sold on or After 1/1/13			
0 - 309	25	25	25	0.00	0	0.0%
310 - 749	40	40	40	9.55	75,356	12.6%
750 - 1,049	60	60	60	13.43	283,365	47.6%
1,050 - 1,489	75	75	53	18.85	47,596	8.0%
1,490 - 2,600	100	72	72	23.27	96,976	16.3%
2,601 - 3,300	150	150	150	41.77	954	0.2%
3,301 - 4,815	200	200	200	62.34	593	0.1%

Table 10. Baseline Wattage based on Measure Lumens, Reflector Bulbs

Lumens Range	Incandescent Baseline [W]	Average CFL Wattage	Bulbs Rebated	% of Program Sales
0 - 419	30	11.00	509	0.1%
420 - 560	45	13.24	1,060	0.2%
561 - 837	65	14.82	77,336	13.0%
838 - 1,203	75	16.65	4,116	0.7%
1,204 - 1,681	90	23.92	6,943	1.2%
1,682 - 2,339	120	24.26	1,013	0.2%
2,340 - 3,075	175	0.00	0	0.0%

Hours-of-Use

For the 2012 RBSA, the Northwest Energy Efficiency Alliance (NEEA) completed field visits to residential homes in the Northwest in order to better understand how energy-consuming equipment is used in the region. Part of the study was to assess the location in homes where CFLs were installed. This study represents the best source for the likely installed locations of bulbs purchased through this program; therefore, Cadmus used this information along with the RTF room type HOU assumptions to estimate an average of 1.93 HOU per day for all bulbs (see Table 11).

Cadmus used the HOU for specialty CFLs from approved RTF assumptions.[3] We applied the same HOU in both PY 2012 and PY 2013.

Cadmus believes that the HOU assumptions used for this analysis are conservative and results in an underestimation of energy savings. Cadmus maintains an HOU model that aggregates all of the primary

[3] Version 2.2 of the RTF CFL workbook.

data we have collected on residential lighting use. The model calculates HOU using a regression statistical model that combines multistate, multiyear data. Cadmus used the multistate model's estimate of HOU by room type, weighting this based on Avista's survey results to determine an overall HOU average of 2.38, 23% longer than the value currently used by the RTF.

Table 11. Calculation of Hours-of-Use

Room Type	Percent of CFLs Installed in Room Type	Total Bulbs in Room Type	Total CFLs in Room Type	Likelihood CFL is Installed in Room	HOU
Bathroom	22.0%	12,977	2,855	13.34%	1.3
Bedroom	29.4%	9,847	2,895	13.53%	1.5
Closet	24.6%	1,747	430	2.01%	1.4
Dining Room	18.0%	4,314	777	3.63%	1.7
Exterior	24.3%	8,174	1,986	9.28%	3.8
Family Room	28.4%	4,724	1,342	6.27%	2.3
Garage	13.3%	5,474	728	3.40%	1.8
Hall	28.6%	6,270	1,793	8.38%	1.3
Kitchen	26.9%	9,665	2,600	12.15%	2.4
Laundry Room	27.9%	2,284	637	2.98%	1.5
Living Room	31.0%	7,662	2,375	11.10%	2.3
Master Bedroom	28.8%	4,015	1,156	5.40%	1.5
Office	28.1%	2,879	809	3.78%	1.3
Other	18.5%	5,477	1,013	4.74%	1.5
All Room Types	**25.0%**	**85,509**	**21,396**	**100%**	**1.93**

Waste Heat Factor

The WHF accounts for the change in annual HVAC energy, either lost or gained, due to the reduction in facility lighting energy. The most recent WHF approved by the RTF[4] is 84.6%.

The Council's method used to determine WHF is inherently conservative because it assumes a closed shell (i.e., that all interior lamps, including ceiling recessed cans, are contained in a closed system such that any heat output from bulbs goes into the building). In reality, wasted heat could transfer out of the conditioned space, thereby increasing the savings achieved through installation.

Cadmus based the WHF calculation on Avista's share of electric heating equipment,[5] along with its associated efficiencies and its surveys of interior and exterior distribution, to obtain a WHF of 89.8%.[6]

[4] See: http://rtf.nwcouncil.org/measures/measure.asp?id=142.

In-Service Rate

Cadmus used the same CFL ISR accepted and approved by the RTF of 74.48%.[7] This a storage rate of 24% and a removal rate of 2%. The Council's method to determining ISR is inherently conservative, because it assumes that the remaining 24% of bulbs in storage never provide energy savings. However, research has revealed that almost all program bulbs are installed within three years of purchase. Cadmus used the same LED ISR accepted and approved by the RTF of 100%.[8]

Results and Findings

Overall Program Savings

Avista's total reported savings and evaluated savings for in PY 2012 are shown in Table 12.

Table 12. Simple Steps, Smart Savings PY 2012 Reported and Evaluated Total Savings

2012	Reported			Evaluated			Realization Rate
	Twist	Specialty	Total	Twist	Specialty	Total	
Bulbs Purchased	229,145	90,577	319,722	227,244	76,400	303,644	95%
Program Savings (kWh)	5,499,480	1,494,524	6,994,004	5,124,466	1,752,158	6,876,624	98%
Savings Per Bulb (kWh)	24.0	16.5	21.9	22.6	22.9	22.6	104%

In PY 2013, Avista added LED bulbs and fixtures to the program. Avista's total reported and evaluated savings for PY 2013 are shown in Table 13.

5 Saturations of Avista equipment types are based on the 2011 participant survey for the CFL Contingency Program.

6 The RTF WHF is 86.4%; the adjusted Avista WHF is 89.8%.

7 See: http://rtf.nwcouncil.org/measures/measure.asp?id=142.

8 See: http://rtf.nwcouncil.org//measures/measure.asp?id=198

Table 13. Simple Steps, Smart Savings PY 2013 Reported and Evaluated Total Savings

2013	Reported Savings			Evaluated Savings		
	Bulbs Purchased	Program Savings (kWh)	Savings Per Bulb (kWh)	Bulbs Purchased	Program Savings (kWh)	Savings Per Bulb (kWh)
Twist	300,908	7,221,782	24.0	302,651	6,491,684	21.4
Specialty	83,188	1,372,602	16.5	92,359	1,965,742	21.3
LED Bulb	22,042	458,188	20.8	22,042	543,038	24.6
LED Fixture	20	487	24.0	20	454	22.4
Total	**406,158**	**9,053,059**	**22.3**	**417,072**	**9,000,917**	**21.6**
Realization Rate				**103%**	**99%**	**97%**

The total savings achieved by this program over the two years is shown in Table 14. Overall the program is delivering savings in line with the 6th Power plan values used to track and report savings.

Table 14. Simple Steps, Smart Savings, 2012 – 2013 Lighting Savings

2012 - 2013	Reported Total	Evaluated Total	Realization Rate
Bulbs Purchased	725,880	720,716	99%
Program Savings (kWh)	16,047,063	15,877,541	99%
Savings Per Bulb (kWh)	22.1	22.0	100%

Showerheads

Though primarily a lighting program, Simple Steps, Smart Savings also incentivized low-flow, energy-saving shower heads in PY 2013. The evaluation assumes that 51.6% of the units purchased were installed in homes with an electric water heater and 48.4% of the units were installed in homes with a gas water heater. 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 net savings values currently approved by the RTF[9] for showerheads purchased through a "Retail" program and installed in "Any Shower" in the home. Evaluated savings follow the RTF methodology and include the electricity savings due to reduced water and sewer requirements for all units purchased through the program. The assumptions used and unit energy savings (UES) calculated for this evaluation are shown in Table 15.

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

Table 15. Showerhead Assumptions

Evaluated Showerhead Savings – Washington	
Units Sold	
2012 Showerheads Sold	1,410
2013 Showerheads Sold	798
Total	2,208
Survey Results, Fuel Distribution	
Percent Gas DHW	48.4%
Percent Electric DHW	51.6%
Water Heater Savings – Fuel Specific	**UES**
2012 Electric Water Heater Savings (kWh)	150.7
2013 Electric Water Heater Savings (kWh)	139.2
2012 Gas Water Heater Savings (therms)	6.7
2013 Gas Water Heater Savings (therms)	6.2
Water & Sewer Savings - All Units Sold	**UES**
2012 Water & Sewer Savings (kWh)	6.7
2013 Water & Sewer Savings (kWh)	6.2

The total savings for these units are shown in Table 16. Avista did not provide Cadmus with reported electric savings for 2012 purchases. Cadmus has therefore chosen to not calculate a realization rate for these installations. The Electric Savings per Unit Purchased shown in the table apply to all units purchased through the program as it accounts for the saturation or electric and gas equipment as well as the water and sewer savings.

Table 16. Simple Steps, Smart Savings, 2012 – 2013 Showerhead Savings

2012 - 2013	Evaluated Total
Units Purchased	2,208
Program Savings (kWh)	181,540
Electric Savings Per Unit Purchased (kWh)	82.22

1.3.3. Second Refrigerator and Freezer Recycling

Summary of Program Participation

Cadmus reviewed the participant database, maintained by JACO, the program implementer, to test the reliability of program data. As shown in

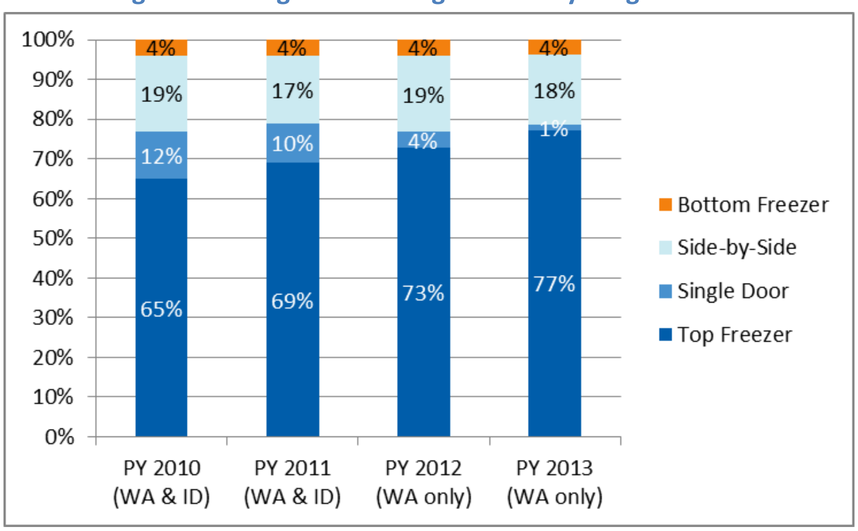
Table 17, 1,092 units were recycled through the program during PY 2012, and 1,067 units were recycled during PY 2013. Some participants recycled more than one appliance through the program.

Table 17. Washington Program Participation by Measure

Year	Measure	Participation
2010	Recycled Refrigerator	1,150
	Recycled Freezer	301
	Total	**1,451**
2011	Recycled Refrigerator	1,152
	Recycled Freezer	363
	Total	**1,515**
2012	Recycled Refrigerator	800
	Recycled Freezer	292
	Total	**1,092**
2013	Recycled Refrigerator	815
	Recycled Freezer	252
	Total	**1,067**
Total	Recycled Refrigerator	3,917
	Recycled Freezer	1,208
	Total	**5,125**

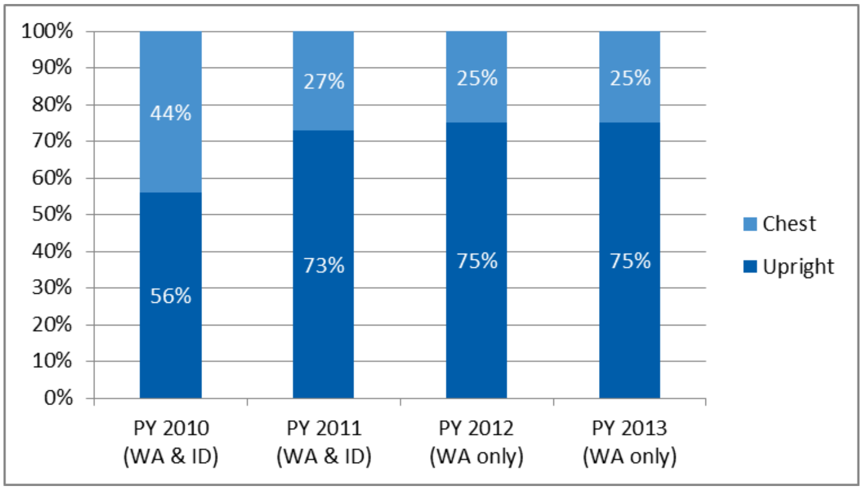
As shown in Figure 7, single-door refrigerators made up a smaller percentage of program participation in PY 2012 and PY 2013 than in PY 2010 and PY 2011. Decreasing quantities of single-door refrigerators, which are generally older units manufactured before the 1970s, is typical of maturing appliance recycling programs (ARPs). The PY 2010 and PY 2011 evaluations combined both Washington and Idaho data, so the decreasing quantities of single-door refrigerators observed in Washington in PY 2012 and PY 2013 may also be due to differences by state.

Figure 7. Refrigerator Configurations by Program Year



As shown in Figure 8, freezer configurations did not change substantially from PY 2010 and PY 2011 to PY 2012 and PY 2013.

Figure 8. Freezer Configurations by Program Year



In PY 2012 and PY 2013, recycled refrigerators averaged 28.2 years old, with 18.0 cubic feet of internal capacity. Recycled freezers averaged 33.5 years old, also with 18.0 cubic feet of internal capacity.

Determining Average Annual Gross Savings

Cadmus developed a multivariate regression model to estimate the gross savings of retired refrigerators and freezers. We estimated the model coefficients using an aggregated *in situ* metering dataset composed of over 600 appliances (which we metered as part of five California, Wisconsin, and Michigan evaluations conducted between 2009 and 2012). These evaluations reflected a wide distribution of appliance ages, sizes, configurations, usage scenarios (primary or secondary), and climate conditions.

UMP and RTF Protocols

Recent guidelines developed by the U.S. Department of Energy (DOE) informed Cadmus' impact evaluation methodology for PY 2012 and PY 2013. In 2011, DOE launched the UMP, intending to "strengthen the credibility of energy savings determinations by improving EM&V, increasing the consistency and transparency of how energy savings are determined."[10]

The UMP identifies seven common residential and commercial DSM measures, reporting results from an enlisted set of subject matter experts who drafted evaluation protocols for each measure category. Refrigerator recycling was one of the seven identified measures. The DOE recruited Cadmus to manage the UMP process and to serve as the lead author for the refrigerator recycling protocol.

Through a collaborative process that included reviews by a technical advisory group and a steering committee, as well as a public review and response period, the UMP resulted in a set of protocols

[10] U.S. Department of Energy. *About the Uniform Methods Project*.. Accessed April 24, 2014. Available online: http://energy.gov/eere/about-us/uniform-methods-project-determining-energy-efficiency-program-savings/about-uniform-methods.

capturing the collective consensus of the evaluation community. Each protocol establishes broadly accepted best practices for evaluating key measures in that category, including methods for identifying and explaining key parameters, data sources, and gross- and net-related algorithms.

For the first Avista ARP evaluation in PY 2012, Cadmus followed the complete UMP methodology for Idaho. To evaluate the Washington PY 2012 and PY 2013 program, Cadmus followed the methodology outlined in the UMP refrigerator recycling protocol. This protocol largely mirrored the method Cadmus used for the PY 2010 and PY 2011 program evaluation, except for making changes recommended in the UMP.

The two most notable changes are discussed in greater detail below.

1. ***Prospective Part-Use***. The UMP recommends assessing part-use based on how the recycled appliance would likely have been used if not recycled (not based on how it was previously used). For example, if a primary refrigerator would have become a secondary refrigerator independent of the program, Cadmus based its PY 2012 and PY 2013 part-use factors on the average usage of secondary refrigerators, rather than the average usage of primary refrigerators (as we did for the PY 2010 and PY 2011 evaluation).
2. ***Secondary Market Impacts.*** The UMP recommends using a grid-level approach to estimating net program savings. Therefore, to evaluate PY 2012 and PY 2013, Cadmus considered the program's impact on the used appliance market. The secondary market impact adjustment accounted for changes in the availability of used appliances resulting from the program. The PY 2010 and PY 2011 evaluation did not account for secondary market impacts.

The DOE website[11] provides more information about the UMP Refrigerator Regression Model. Table 18 shows the variables we used to estimate refrigerators' annual energy consumption, along with the estimated parameters.

[11] U.S. Department of Energy. "Uniform Methods Project for Determining Energy Efficiency Program Savings.". Accessed April 24, 2014. http://energy.gov/eere/about-us/initiatives-and-projects/uniform-methods-project-determining-energy-efficiency-program-savings.

Table 18. Refrigerator UEC Regression Model Estimates (Dependent Variable = Average Daily kWh, R-square = 0.30)

Independent Variables	Coefficient	p-Value
Intercept	0.805	0.166
Age (years)	0.021	0.152
Dummy: Manufactured Pre-1990	1.036	<.0001
Size (cubic feet)	0.059	0.044
Dummy: Single Door	-1.751	<.0001
Dummy: Side-by-Side	1.120	<.0001
Dummy: Primary	0.560	0.008
Interaction: Unconditioned Space x HDDs	-0.040	0.001
Interaction: Unconditioned Space x CDDs	0.026	0.188

The results of our analysis indicated the following:

- Older refrigerators experienced higher consumption due to year-on-year degradation.
- Refrigerators manufactured before the 1990 National Appliance Energy Conservation Act (NAECA) standard consumed more energy.
- Larger refrigerators consumed more energy.
- Single-door units consumed less energy, as these units typically did not have full freezers.
- Side-by-side refrigerators experienced higher consumption due to greater exposure to outside air when opened and due to the through-door features common in these units.
- Primary appliances experienced higher consumption due to increased usage.
- At higher temperatures, refrigerators in unconditioned spaces consumed more energy.
- At colder temperatures, refrigerators in unconditioned spaces consumed less energy.

Freezer Regression Model

Table 19 shows the freezer model details.

Table 19. Freezer UEC Regression Model Estimates (Dependent Variable = Average Daily kWh, R-square = 0.38)

Independent Variables	Coefficient	p-Value
Intercept	-0.955	0.237
Age (years)	0.045	0.001
Dummy: Manufactured Pre-1990	0.543	0.108
Size (cubic feet)	0.120	0.002
Dummy: Chest Freezer	0.298	0.292
Dummy: Primary	-0.031	<.0001
Interaction: Unconditioned Space x HDDs	0.082	0.028
Interaction: Unconditioned Space x CDDs	-0.955	0.237

The results of our analysis indicated the following:

- Older freezers experienced higher consumption due to year-on-year degradation.
- Freezers manufactured before the 1990 NAECA standard consumed more energy.
- Larger freezers consumed more energy.
- Chest freezers experienced higher consumption.
- At higher temperatures, freezers in unconditioned spaces consumed more energy.
- At colder temperatures, freezers in unconditioned spaces consumed less energy.

Extrapolation

After estimating the final regression models, Cadmus analyzed the corresponding characteristics (the independent variables) for participating appliances (as captured in the JACO database). Table 20 summarizes program averages for each independent variable.

As an example, using values from Table 19 and Table 20, Cadmus calculated the estimated annual UEC for PY 2012 and PY 2013 freezers as:

$$\text{2012 \& 2013 Freezer UEC} = 365.25\ days * (-0.955 + 0.045 * [33.45\ years\ old] + 0.543 * [90\%\ units\ manufactured\ pre - 1990] + 0.120 * [17.97\ ft.^3] + 0.298 * [25\%\ units\ that\ are\ chest\ freezers] + 0.082 * [0.59\ Unconditioned\ CDDs] - 0.031 * [10.45\ Unconditioned\ HDDs]) = \ 1{,}098\ kWh/year$$ [12]

Figure 9 compares distributions of estimated UEC values for refrigerators and freezers.

[12] The UEC shown is higher than what would be calculated from the coefficients and means shown in the UEC equation, because those coefficients and means are rounded. Cadmus used unrounded coefficients and means for calculating the evaluated UEC.

Table 20. 2012 Participant Mean Explanatory Variables

Appliance	Independent Variables	WA PY 2012 and PY 2013 Participant Population Mean Value
Refrigerator	Age (years)	28.24
	Dummy: Manufactured Pre-1990	0.73
	Size (cubic feet)	17.98
	Dummy: Single Door	0.03
	Dummy: Side-by-Side	0.19
	Dummy: Primary	0.41
	Interaction: Unconditioned Space x HDDs	6.71
	Interaction: Unconditioned Space x CDDs	0.38
Freezer	Age (years)	33.45
	Dummy: Manufactured Pre-1990	0.90
	Size (cubic feet)	17.97
	Dummy: Chest Freezer	0.25
	Interaction: Unconditioned Space x HDDs	10.45
	Interaction: Unconditioned Space x CDDs	0.59

Figure 9. PY 2012 and PY 2013 Distribution of Estimated Annual UECs by Appliance Type

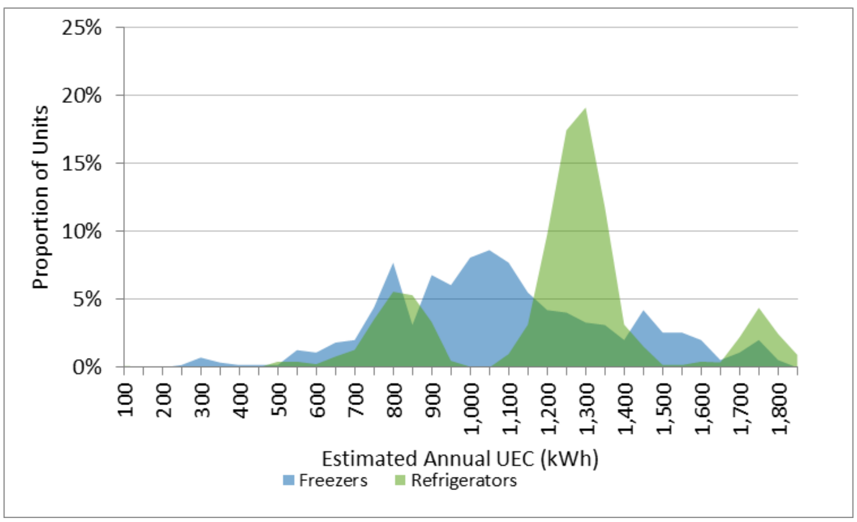


Table 21 presents the estimated, per-unit, average annual energy consumption for refrigerators and freezers recycled by Avista in PY 2012 and PY 2013. After the table, we describe how we adjusted these estimates to arrive at gross per-unit saving estimates for participant refrigerators and freezers.

Table 21. Estimate of Per-Unit Annual Energy Consumption

Appliance	*Ex Post* Annual UEC (kWh/year)	Relative Precision(90% confidence)
Refrigerators	1,225	8%
Freezers	1,098	18%

Table 22 presents the PY 2012 and PY 2013 UEC results for Avista, compared to other utilities located in Canada and the U.S. Avista's UECs are similar to the other utilities we benchmarked and to results from previous Avista evaluations.

Table 22. Benchmarking: Average UEC Values

Utility	Years Implemented	Average UEC (kWh/Year)	
		Refrigerator	Freezer
Avista (WA, PY 2012 and PY 2013)	**8**	**1,225**	**1,098**
Avista (ID, PY 2012)	7	1,199	1,117
Avista (WA & ID, PY 2011)	6	1,147	1,074
Avista (WA & ID, PY 2010)	5	1,158	1,073
Rocky Mountain Power (UT, 2011-2012)	10	1,323	1,082
Rocky Mountain Power (ID, 2011-2012)	8	1,217	1,111
Pacific Power (WA, 2011-2012)	8	1,239	1,087
Ontario Power Authority (2012)	6	1,153	1,270
Ontario Power Authority (2011)	5	1,240	1,172
Rocky Mountain Power (WY, 2011-2012)	4	1,256	1,098

Part-Use

Part-use is as an adjustment factor specific to appliance recycling, which is used to convert the UEC into average per-unit gross savings value. The UEC itself does not equal gross savings value, due to the following:

- The UEC model yields an estimate of annual consumption.
- Not all recycled refrigerators would have operated year-round if they had not been decommissioned through the program.

As Cadmus applied the UMP methodology, the determination of PY 2012 and PY 2013 part-use differs slightly from that used in the previous Washington evaluation of PY 2010 and PY 2011 (though it is the same as that used in the Idaho PY 2012 evaluation). Specifically, in the previous evaluation we assumed that the way customers operated participating appliances prior to the program served as a reasonable proxy for how the same appliances would likely be operated in the future, had they not been recycled through the program (either by the participant or, if the appliance was transferred, by the would-be recipient).

While the UMP part-use methodology uses information from surveyed customers regarding pre-program usage patterns, the final part-use estimate reflects the way appliances would likely be operated if they had not been recycled (not how they were previously operated). For example, a primary refrigerator operated year-round could become a secondary appliance and be operated part-time.

This updated methodology accounts for potential shifts in usage types. Specifically, it calculates part-use using a weighted average of the following, prospective part-use categories and factors:

- Appliances that would have run full-time (part-use = 1.0).
- Appliances that would not have run at all (part-use = 0.0).
- Appliances that would have operated for a portion of the year (part-use between 0.0 and 1.0).

Using information gathered through the participant surveys, Cadmus used the following multistep process to determine part-use, as outlined in the UMP:

We used the surveys to determine if recycled refrigerators were primary or secondary units (with all stand-alone freezers considered secondary units).

For participants indicating they recycled a secondary refrigerator, we asked if the refrigerator was unplugged, operated year-round, or operated for a portion of the preceding year (and assuming all primary units operated year-round). We asked all freezer participants the same question.

Cadmus asked participants who indicated that their secondary refrigerator or freezer operated for only a portion of the preceding year to estimate how many months during that time their appliance was plugged in. This subset of participants estimated 6.36 and 5.16 months for secondary refrigerators and freezers, respectively. Dividing both values by 12 provided the annual part-use factors of 0.53 for all secondary refrigerators and 0.43 for all freezers operated for only a portion of the year (Table 25).

Table 23. Historical Part-Use Factors by Category

Usage Type and Part-Use Category	Refrigerators			Freezers		
	Percent of Recycled Units	Part-Use Factor	Per-UES (kWh/Yr)	Percent of Recycled Units	Part-Use Factor	Per-UES (kWh/Yr)
Secondary Units Only			**n=42**			
Not in Use	8%	0.00	-			
Used Part Time	10%	0.53	649			
Used Full Time	82%	1.00	1,225			
Weighted Average	**100%**	**0.87**	**1,063**			
All Units (Primary and Secondary)			**n=87**			**n=24**
Not in Use	5%	0.00	-	9%	0.00	-
Used Part Time	6%	0.53	649	16%	0.43	467
Used Full Time	89%	1.00	1,225	75%	1.00	1,098
Weighted Average	**100%**	**0.92**	**1,131**	**100%**	**0.82**	**902**

Cadmus then asked participants how the appliances would likely have been operated if they had not been recycled through the program. For example, if surveyed participants indicated they would have kept a primary refrigerator independent of the program, we asked if they would have continued to use the appliance as their primary refrigerator or would have relocated it and used as a secondary

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refrigerator. We did not ask similar questions of participants who indicated they would have discarded their appliance independent of the program, as the future usage of their appliance would be determined by another customer.

Combining the historically based, part-use factors shown in Table 23 with participants' self-reported action had the program *not* been available resulted in the distribution of likely future usage scenarios and corresponding part-use estimates. Table 24shows the weighted average of these future scenarios, revealing the program part-use factor for refrigerators (0.89) and freezers (0.82).[13]

Table 24. Part-Use Factors by Appliance Type

Use Prior to Recycling	Likely Use Independent of Recycling	Refrigerator		Freezer	
		Part-Use Factor	Percent of Participants	Part-Use Factor	Percent of Participants
Primary	Kept (as primary unit)	1.00	3%		
	Kept (as secondary unit)	0.87	15%		
	Discarded	0.92	18%		
Secondary	Kept	0.87	45%	0.82	48%
	Discarded	0.92	19%	0.82	52%
Overall		**0.89**	**100%**	**0.82**	**100%**

Table 25 presents the part-use factors compared with other utilities located in Canada and the U.S. Cadmus found that Avista Washington has a similar part-use factor for refrigerators, and a slightly lower part-use factor for freezers than other utilities.

Table 25. Benchmarking: Part-Use Factors by Appliance Type

Utility	Years Implemented	Part-Use Factors	
		Refrigerator	Freezer
Avista (WA, PY 2012 and PY 2013)	**8**	**0.89**	**0.82**
Avista (ID, PY 2012)	7	0.95	0.74
Avista (WA & ID, PY 2010 and PY 2011)	6	0.94	0.82
Southern California Edison (2012)	12	0.94	
Rocky Mountain Power (UT, 2011-2012)	10	0.93	0.90
PG&E (2012)	10	0.94	
Rocky Mountain Power (ID, 2011-2012)	8	0.84	0.93
Pacific Power (WA, 2011-2012)	8	0.93	0.90
Ameren Illinois	5	0.88	0.88

13 As the future usage type of discarded refrigerators cannot be known, Cadmus applied the weighted part-use average of all units (0.89) to all refrigerators that would have been discarded independent of the program. This approach acknowledged that discarded appliances could be used as primary or secondary units in a would-be recipient's home.

Net-to-Gross

Cadmus used the following formula to estimate net savings for recycled refrigerators:

$$Net\ savings = Gross\ Savings - Freeridership\ and\ Secondary\ Market\ Impacts - Induced\ Replacement$$

Where Gross Savings are the evaluated *in situ* UEC for the recycled unit, adjusted for part-use, Freeridership and Secondary Market Impacts are program savings that would have occurred in the program’s absence, And Induced Replacement is average, additional energy consumed by replacement units purchased due to the program

Applying the UMP protocol introduced an additional parameter related to net savings—secondary market impacts—and required the use of a decision-tree approach to calculate and present net program savings. Cadmus did not include this adjustment for the PY 2010 and PY 2011 impact evaluation; therefore, changes in net savings could be partially attributed to changes in the evaluation methodology.

The decision tree—populated by responses of surveyed participants—presented savings under all possible scenarios of the participants’ actions with the discarded equipment. Cadmus used a weighted average of these scenarios to calculate net savings attributable to the program. This section includes specific portions of the decision tree to highlight specific aspects of the net savings analysis.

Freeridership

For our freeridership analysis, Cadmus first asked participants if they considered discarding the participating appliance prior to learning about the program. If the participant did not indicate a previous consideration to dispose of the appliance, Cadmus categorized them as a non-freerider and excluded them from the subsequent freeridership analysis.

Next, Cadmus asked all remaining participants (i.e., those who had considered discarding their existing appliance before learning about the program) a series of questions to determine the distribution of participating units likely to have been kept versus those likely to have been discarded absent the program. Three scenarios independent of program intervention could have occurred:

- The unit would be discarded and transferred to someone else.
- The unit would be discarded and destroyed.
- The unit would be kept in the home.

To determine the percentage of participants in each of the three scenarios, Cadmus asked surveyed participants about the likely fate of their recycled appliance had it not been decommissioned through the program. Cadmus categorized their responses into the following options:

- Kept the appliance.
- Sold the appliance to a private party (either an acquaintance or through a posted advertisement).

- Sold or gave the appliance to a used appliance dealer.
- Gave the appliance to a private party, such as a friend or neighbor.
- Gave the appliance to a charity organization, such as Goodwill Industries or a church.
- Had the appliance removed by the dealer who provided the new or replacement unit.
- Hauled the appliance to a landfill or recycling center, or had someone else pick it up for junking or dumping.

Cadmus also asked surveyed participants if they had considered getting rid of their old appliance before they heard about the program. The distribution of their responses to this question are summarized in Table 26.

Table 26. Distribution of Participants' Pre-Program Disposal Intentions

Had Considered Disposing Recycled Appliance Prior to Hearing About the Program	Indicative of Freeridership	Refrigerators (n=87)	Freezers (n=26)
Yes	Varies by Discard Method	77%	77%
No	No	23%	23%
Total		**100%**	**100%**

Once Cadmus determined the final assessments of participants' actions independent of the ARP, we calculated the percentage of refrigerators and freezers that would have been kept or discarded (Table 27).

Table 27. Final Distribution of Kept and Discarded Appliance

Stated Action Absent Program	Indicative of Freeridership	Refrigerators (n=83)	Freezers (n=25)
Kept	No	31%	36%
Discarded	Varies by Discard Method	69%	64%
Total		**100%**	**100%**

Cadmus benchmarked these values against Avista Idaho's PY 2012 evaluation and those of other ARP programs in Idaho, Washington, Utah, and Wyoming, as shown in Table 28. Avista's PY 2012 and PY 2013 result for Washington is most similar to Rocky Mountain Power's Idaho result, and is generally higher than the other benchmarked programs.

Table 28. Benchmarking Kept Appliances

Utility	Years Implemented	Percent Likely to Have Been Kept Independent of the Program	
		Refrigerator	Freezer
Avista (WA, PY 2012 and PY 2013)	**8**	**31%**	**36%**
Avista (ID, PY 2012)	7	25%	17%
Rocky Mountain Power (UT, 2011-2012)	10	20%	24%
Rocky Mountain Power (ID, 2011-2012)	8	32%	29%
Pacific Power (WA, 2011-2012)	8	22%	22%
Rocky Mountain Power (WY, 2011-2012)	4	16%	27%

Secondary Market Impacts

If, absent the program, a participant would have directly or indirectly (through a market actor) transferred the program-recycled unit to another Avista customer, Cadmus determined what actions the would-be acquirer might have taken with that unit.

Some would-be acquirers would find another unit; others would not. This reflects that some acquirers would be in the market for a refrigerator (and would acquire another unit), while others were not (and would have taken the unit opportunistically). Absent program-specific information, it is difficult to quantify changes in the total number of refrigerators and freezers in use (overall and specific to used appliances) before and after implementing the program. Without this information, the UMP recommends evaluators assume that one-half of the would-be acquirers would obtain an alternate unit. Without information to the contrary, Cadmus applied the UMP recommendation to this evaluation.

Next, Cadmus determined whether the alternate unit would likely be another used appliance (similar to those recycled through the program) versus a new, standard-efficiency unit (presuming fewer used appliances remained available due to program activity).[14]

As discussed, estimating this distribution definitively proves difficult. The UMP recommends taking a midpoint approach when primary research is unavailable: evaluators should assume that one-half of the would-be acquirers would obtain a similar used appliance, and one-half would acquire a new, standard-efficiency unit.

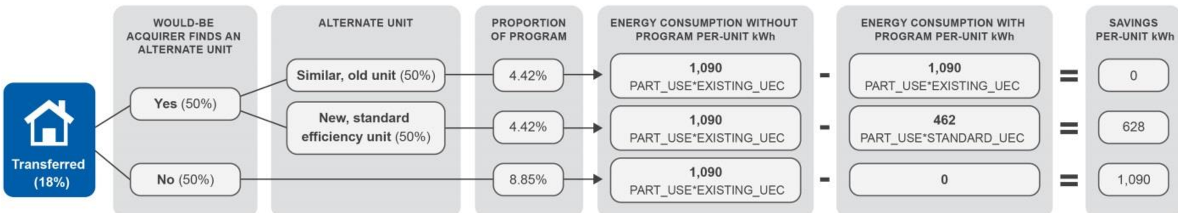
Cadmus used the ENERGY STAR website[15] to determine the energy consumption of new, standard-efficiency appliances. Specifically, Cadmus averaged the reported energy consumption of new, standard-efficiency appliances of comparable sizes and configurations as the program units.

[14] The would-be acquirer could also select a new ENERGY STAR unit. However, Cadmus assumed that most customers in the market for a used appliance would upgrade to the next lowest price point (a standard-efficiency unit).

Figure 10 details Cadmus' methodology for assessing the program impact on the secondary refrigerator market and for applying the recommended midpoint assumptions when primary data were unavailable. As shown, accounting for market effects resulted in three savings scenarios:

- Full per-unit gross savings;
- No savings; and
- Partial savings (i.e., the difference in energy consumption between the program unit and the new, standard-efficiency appliance that was acquired instead).

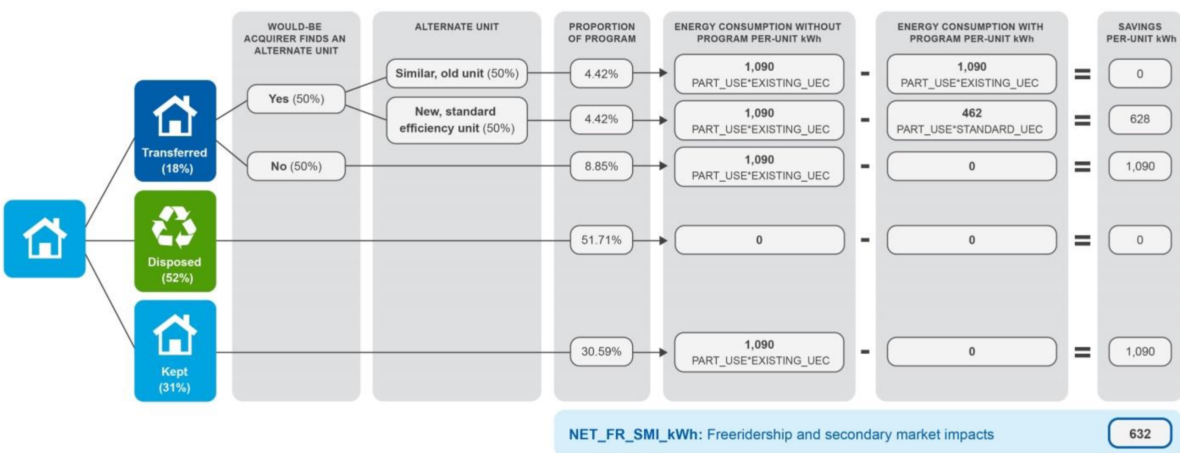
Figure 10. Secondary Market Impacts—Refrigerators



Integration of Freeridership and Secondary Market Impacts

After estimating the parameters of the freeridership and secondary market impacts, Cadmus used the UMP decision tree to calculate the average, per-unit program savings, net of their combined effect. Figure 11 shows how Cadmus integrated these values into an estimate of savings, net of freeridership and secondary market impacts. Again, Cadmus applied secondary market impacts to maintain consistency with the UMP: in previous Avista Washington appliance recycling evaluations, Cadmus did not account for this.

Figure 11. Savings Net of Freeridership and Secondary Market Impacts—Refrigerators



[15] http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator.

Induced Replacement

The UMP states that evaluators must account for the energy consumption of replacement units *only* when the program induced that replacement (i.e., when the participant would *not* have purchased the replacement refrigerator without the recycling program).

In the case of non-induced replacements, the energy consumption of the replacement appliance does not prove germane to the savings analysis, as the appliance would have been purchased or acquired regardless of the program. The acquisition of another appliance in conjunction with participation in the program does not necessarily indicate induced replacement. Again, this is consistent with the methods outlined in the UMP.

Cadmus used the results of the participant surveys to determine which replacement refrigerators and freezers program participants acquired due to the program. Survey results indicated that the program reduced the total number of used appliances operating within Avista's Washington service territory, and that the program raised the average efficiency of the active appliance stock.

Cadmus then used participant survey results to estimate the proportion of replacements induced by the customer's participation in the program. Specifically, Cadmus asked each participant that indicated they replaced the participating appliance: "*Would you have purchased the replacement appliance without the $30 incentive you received for recycling the old one*?"

As a $30 incentive will likely not provide sufficient motivation for most participants to purchase an otherwise unplanned for replacement unit (which can cost $500 to $2,000), Cadmus asked a follow-up question of participants who responded "*No*." Intended to confirm the participant's assertion that only the program caused them to replace their appliance, the question was: "*Just to confirm: you would not have replaced your old refrigerator/freezer without the Avista incentive for recycling, is that correct*?"

To further increase the reliability of these self-reported actions, we also considered whether the refrigerator was the primary unit in the induced replacement analysis and the participant's stated intentions in the program's absence.

For example, if a participant would have discarded their primary refrigerator independent of the program, the replacement could not be program induced (since it is extremely unlikely a participant would live without a primary refrigerator). However, for all other usage types and stated intention combinations, induced replacement was a viable response.

As expected, results indicated the program only induced a portion of the total replacements: the program induced 7% of all refrigerator participants and 11% of freezer participants to acquire a replacement unit, as shown in Table 29.

Table 29. 2011-2012 Induced Replacement Rates

Appliance	Induced Replacement Rates
Refrigerator	7%
Freezer	11%

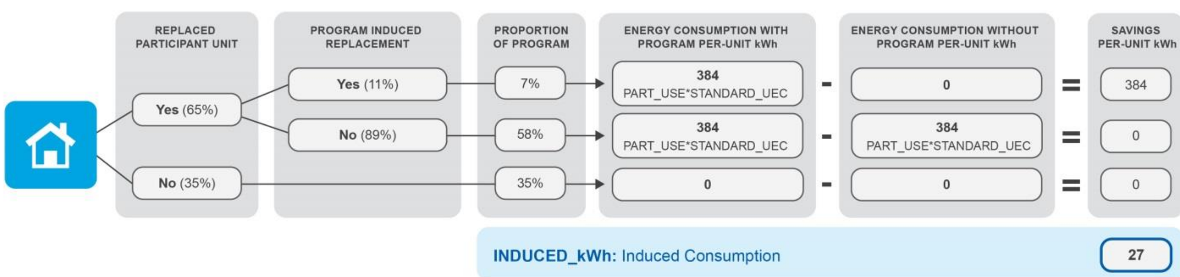
As shown in Table 30, Avista's induced replacement was higher than both the comparison utilities and higher than Avista's previous evaluations, and was most similar to Rocky Mountain Power's 2011-2012 results in Idaho.

Table 30. Benchmarking: Induced Replacement

Utility	Years Implemented	Induced Replacement Refrigerators	Induced Replacement Freezers
Avista (WA, PY 2012 and PY 2013)	**8**	**7%**	**11%**
Avista (ID, PY 2012)	7	0%	0%
Avista (WA & ID, PY 2010 and PY 2011)	6	4%	4%
Rocky Mountain Power (UT, 2011-2012)	10	3%	4%
Rocky Mountain Power (ID, 2011-2012)	8	7%	7%
Pacific Power (WA, 2011-2012)	8	4%	5%
Rocky Mountain Power (WY, 2011-2012)	4	2%	5%

Figure 12 shows Cadmus calculated induced replacement within the decision tree.

Figure 12. Induced Replacement Refrigerators



Final NTG

As summarized in Table 31, Cadmus determined final net savings as gross savings and spillover savings less freeridership, secondary market impacts, and induced replacement.

Table 31. PY 2012 and PY 2013 NTG Ratios

Appliance	Gross Per-Unit Savings (kWh)	Freeridership and Secondary Market Impacts (kWh)	Induced Replacement (kWh)	Induced Additional Savings (Spillover) (kWh)	Net Per-Unit Savings (kWh)	NTG
Refrigerator	1,090	632	27	12	443	41%
Freezer	902	366	55	12	493	55%

As noted, the application of the UMP protocol introduced two parameters related to net savings—secondary market impacts and induced replacements—that were not included in the previous evaluation. The application of these factors, through adherence with the UMP, contributed to a decreased program NTG for refrigerators compared to previous years. The NTG for freezers, however, increased relative to PY 2010 and PY 2011.

Summary of Impact Findings

Using the above per-unit values, Cadmus calculated the total program savings for the PY 2012 and PY 2013 Second Refrigerator and Freezer Recycling Program in Washington as 983,369 kWh, after adjustments (as shown in Table 32).

Table 32. Washington PY 2012 and PY 2013 Second Refrigerator and Freezer Recycling Program Savings

Measure	Evaluated Participation	Evaluated Gross Savings (kWh)	Evaluated Net Savings (kWh)	Precision at 90% Confidence
Refrigerator Recycling	1,615	1,760,081	715,176	23%
Freezer Recycling	544	490,689	268,193	38%
Total	**2,159**	**2,250,770**	**983,369**	**20%**

As shown in Table 33, Avista's NTG for refrigerators is less than most other benchmarked programs. This NTG result was driven downward from the previous evaluation, primarily due to the ratio of appliances that would have been discarded absent the program, as well as to the mature nature of the program relative to other programs. The NTG for freezers, however, is similar to the other programs benchmarked.

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Table 33 Benchmarking NTG Ratio's

Utility	Years Implemented	NTG Ratio	
		Refrigerator	Freezer
Avista (WA, PY 2012 and PY 2013)	**8**	**41%**	**55%**
Avista (ID, PY 2012)	7	46%	33%
Avista(WA & ID, PY 2010 and PY 2011)	6	57%	56%
Rocky Mountain Power (UT, 2011-2012)	10	56%	56%
Rocky Mountain Power (ID, 2011-2012)	8	54%	48%
Pacific Power (WA, 2011-2012)	8	51%	51%
Ontario Power Authority (2012)	6	47%	48%
Ontario Power Authority (2011)	5	53%	53%
Rocky Mountain Power (WY, 2011-2012)	4	39%	51%
Pacific Power (CA, 2009-2010)	3	64%	67%

1.3.4. ENERGY STAR Products

Program Description

The ENERGY STAR Products Program includes the following measures:

- Clothes Washer (Electric and Gas)
- Dishwasher (with Electric or Gas Water Heater)
- Freezer (Electric)
- Refrigerator (Electric)

Through the program, Avista offers direct financial incentives to motivate customers to use more energy-efficient appliances; this indirectly encourages market transformation by increasing the demand for ENERGY STAR products. The program includes electric and gas measures, but Cadmus only considers electric savings in this report.

Analysis

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

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

Clothes Washers, Dishwashers, Refrigerators, and Freezers

Cadmus evaluated the energy savings for clothes washers based on the RTF analysis that was applicable during the evaluation period.[16], [17], [18], [19]

Results and Findings

Table 34 shows total reported and qualified counts, savings, and realization rates for electric ENERGY STAR Products Program measures in Washington.

Table 34. ENERGY STAR Products Program Results

Program Name	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
Electric Clothes Washer With Electric Water Heater	1,359	662,101	56,630	100%	100%	56,630	9%
Electric Freezer	170	7,863	6,805	100%	100%	6,805	87%
Electric Refrigerator	2,065	129,338	89,910	100%	100%	89,910	70%
Electric Dishwasher With Electric Water Heater	311	19,280	2,743	100%	100%	2,743	14%
Program Total	**3,905**	**818,582**	**156,087**	**100%**	**100%**	**156,087**	**19%**

The program achieved a 19% realized adjusted gross savings rate; this low realization rate is due to savings being adjusted to match the RTF-approved savings.

1.3.5. Heating and Cooling Efficiency

Program Description

The electric Heating and Cooling Efficiency Program included the following equipment:

- Ductless Heat Pumps (DHP)
- Air-Source Heat Pumps (ASHP

[16] http://rtf.nwcouncil.org/measures/measure.asp?id=118#

[17] http://rtf.nwcouncil.org/measures/measure.asp?id=119

[18] http://rtf.nwcouncil.org/measures/measure.asp?id=122

[19] http://rtf.nwcouncil.org/measures/measure.asp?id=120

- Variable Speed Furnace Fans
- Air Conditioner Replacements

Analysis

The PY 2010 and PY 2011 electric impact evaluation report[20] documented analysis Cadmus performed to determine the change in energy consumption resulting from the installation of electric heating and cooling measures. As that analysis continues to provide the best information on these measures, Cadmus retained those results for PY 2012.

Results and Findings

Table 35 shows total tracked and qualified counts, savings, and realization rates for electric Heating and Cooling Efficiency Program measures in Washington. The program achieved a 98% realized adjusted gross savings rate.

Table 35. Heating and Cooling Efficiency Program Results*

Program Name	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
Electric ASHP	392	140,402	131,916	100%	100%	131,916	94%
Electric Ductless Heat Pump	33	11,048	6,093	100%	100%	6,093	55%
Electric Variable Speed Motor	1,554	681,820	681,507	100%	100%	681,507	100%
Program Total	**1,979**	**833,270**	**819,515**	**100%**	**100%**	**819,515**	**98%**
*Table values may not sum due to rounding							

[20] Cadmus. *Avista 2010–2011 Multi-Sector Electric Impact Evaluation Report.* May 2012.

1.3.6. Space and Water Heat Conversions

Program Description

Through the Space and Water Conversions Program, Avista incents three measures for residential electric customers who currently use electricity to heat their homes and water, but have the opportunity to use natural gas or switch to an alternative more efficient technology that uses the same fuel source. The equipment conversions during PY 2010 through PY 2013 included the following measures:

- Electric Forced Air Furnace to Air Source Heat Pumps (ASHP)
- Electric Forced Air Furnace to Natural Gas Forced Air Furnace (NGF)
- Electric Water Heater to Natural Gas Water Heater (NGWH)

By offering conversion rebates, Avista seeks to achieve energy efficiency by changing the fuel mix used by customers in order to achieve savings from lower-priced fuel (in case of a conversion from an electric to a NGF and electric to a NGWH) and to achieve higher efficiency in overall cooling and heating usage.

With the residential energy-efficiency programs, Avista targets single-family homes and units in multifamily buildings. Avista customers started participating in the conversion rebates in PY 2010. Table 36 shows participation by conversion measure and year, in both Idaho and Washington. Avista phased out conversion rebates in Idaho in PY 2013 for conversion from an electric to a NGWH.

Table 37 shows the number of participant that installed any of the conversion measures, grouped by year of installation.

Table 36. Participation in Fuel Conversion Program by Year and State

Conversion Measure	Application Year	Participants in Idaho	Participants in Washington	Total Participants by Year	Total Participants*
ASHP	2010	123	129	252	624
	2011	61	74	135	
	2012	60	64	124	
	2013	48	65	113	
NGF	2010	51	82	133	429
	2011	27	65	92	
	2012	24	74	98	
	2013	28	78	106	
NGWH	2010	22	95	117	362
	2011	16	79	95	
	2012	15	75	90	
	2013	5	55	60	

* This column includes participants who installed multiple measures.

Table 37. Number of Homes that Participated from PY 2010 through PY 2013

	Air-Source Heat Pump	Natural Gas Furnace	Natural Gas Water Heater	Multiple Conversion Measures*	All Homes
Total Participants	623	375	309	54	1,361

* This primarily consists of all customers who installed a NGF and NGWH.

Impact Evaluation Methodology

With the impact evaluation, Cadmus sought to estimate the change in energy use after installing these conversion measures. More specifically, Cadmus' evaluation of the Space and Water Conversions Program consisted of the following three tasks:

1. Data collection, review, and preparation.
2. Billing analysis.
3. Energy-savings estimations.

Data Collection, Review, and Preparation

To perform the billing and uplift analysis, Cadmus collected the following data.

Monthly Customer Bills

Cadmus collected data about monthly gas and electricity bills between January 2010 and December 2013. The data included approximately 10 to 12 months of bills prior to the measures installations and the same number of months after the installations. These billing data included: account numbers, energy use during the monthly billing cycle, and the last day of the billing cycle. Avista supplied these data to Cadmus.

Program Information

Cadmus obtained measures data from Avista. These data included the following fields: Program Tracking Data for the 2011-2013 participants, account numbers and site IDs for linking to billing data, all the measures installed, rebated amounts of therms and kWh saved, and application dates for the rebates.

Weather

Cadmus collected National Climatic Data Center daily average temperature data from 2010 through January 2014 for eight weather stations: two in Idaho (Lewiston and Coeur D'Alene) and six in Washington (Moses Lake Grant Co., Walla Walla, Spokane, Fairchild, Felts, and Pullman Moscow). These were the stations nearest to all the program homes in the Avista territory.

Data Preparation

Cadmus prepared billing data for analysis using the following steps:

- Reformatting and merging the raw billing data for all customers.
- Separating the gas and electricity datasets and identifying customers that had dual usage (electricity and gas) versus the customers that had only electricity.
- Renaming the market measure description, such as the following the same conversion measure naming convention for all program years.
- Identifying homes that had multiple conversions and assigning them to a separate group.
- Specifying the pre- and post-periods for each customer account:
    - ***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 Full Year:*** In this specification, the install year is taken as the current year and the energy consumption of the full year before the current year is compared to the full year after the current year.

Table 38 shows an example of the specification of the pre- and post-installation periods under the two specifications. In this analysis, Cadmus has used a combination of the two specifications. While the first specification allows the data from a more compressed timeframe to be used, it relies heavily on the exact installation date. The Full Year specification excludes this uncertainty by assuming that the conversion installations occurred any time during the rebate application year. The Full Year specification requires at least three years of data. In cases where this requirement was not met, Cadmus used the first specification.

Table 38. Example of Pre- and Post-Installation Period Under the Two Specifications

Specification of Pre and Post Period	Installation Date	Pre-Analysis Period	Post-Analysis Period
Customer Specific Measure Install Date	June 2010	June 2009 to May 2010	June 2010 to April 2011
Full Year		January 2009 to December 2009	January 2011 to December 2011

Cadmus used daily average temperature and billing cycle information to estimate cooling degree days (CDDs) and heating degree days (HDDs) for each home during the billing cycle. This required using a base temperature of 65 degrees and billing cycle end dates to calculate HDDs and CDDs that exactly matched days in the customer's bill.

Based on the conversion group (electric to NGF only, electric to NGWH only, both electric to NGF and electric to NGWH, and ASHP) and the fuel usage type (electric only and dual fuel: electric and gas), Cadmus estimated six separate models. We discuss the selected sample sizes of these six groups in the next section.

Data Attrition

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

- The home had fewer than 11 pre- or post-program monthly energy bills.
- The home did not pass PRISM modeling screens, which are based on the weather normalized pre- and post-installation annual usage. These are discussed in more detail in the Billing Analysis section.

Table 39 shows the total customer accounts that had a conversion measure and the final sample Cadmus used in the PRISM and the regression analyses. Each row in the table indicates the accounts remaining after attrition.

Table 39. Sample Size Selection for PRISM Analysis

Accounts Remaining After Attrition	Air-Source Heat Pump			Natural Gas Furnace	Natural Gas Water Heater	Multiple Conversion Measures	All Conversion Homes
	Electric Only	Dual	All	Dual	Dual	Dual	
Total accounts with fuel conversion measures	561	62	623	375	309	54	1,361
Low usage (less than 1,000 kWh) in pre- or post-installation period	550	62	612	346	301	50	1,309
Total accounts with sufficient billing data for PRISM analysis	372	47	419	193	203	25	840
PRISM screens*	363	46	409	192	199	25	825
Accounts deleted due to vacancies, seasonal usage, outliers and inoperable heating systems	288*	33	321	164	159	23	667
Percentage of accounts retained for analysis**	**51%**	**53%**	**52%**	**44%**	**51%**	**43%**	**49%**

* These PRISM screens led to Cadmus dropping accounts with: 1) negative heating or cooling slopes in the pre- or the post-installation period and 2) usage that increased by more than 83% between the pre- and post-installation period.

** The numbers in bold are the final sample size used for the per home savings estimation.

Billing Analysis

To estimate program electricity savings, Cadmus used two approaches: PRISM and fixed-effects regression. Cadmus first estimated the PRISM model to obtain weather-normalized annual consumption (NAC) and identify outliers. Cadmus then estimated a regression model to control for the installation of other weatherization measures or efficient equipment. Details on the model specifications can be found in Appendix A.

Program Impact Evaluation Findings

Per Home Savings Impacts (PRISM)

Table 40 summarizes the PRISM results for conversion measures across the six groups. The results show the annual savings, relative precision on these savings, the pre-NAC for each group, and the savings as a percentage of the pre-NAC. Table 40 also reports savings as a percentage of the pre-conversion period heating load.

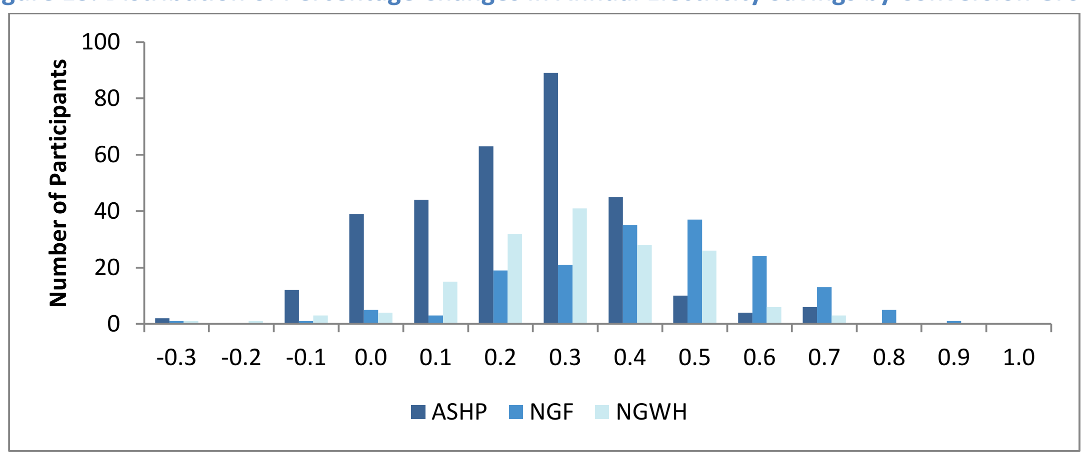
Table 40. Electric Savings per Home (PRISM Results)

Conversion Measure	Home Type	Number of Homes	Annual Savings (kWh)	Relative Precision on the Savings	Pre-Normalized Annual Consumption (kWh)	Savings as Percent of Pre-NAC	Pre-Heating Usage	Savings as Percent of Pre-Heating Usage
NGF	Dual	164	9,563	8%	24,349	39%	13,433	71%
NGWH	Dual	159	4,367	13%	16,305	27%	4,506	97%
Multiple	Dual	23	12,350	19%	25,646	48%	13,558	91%
ASHP	Electric Only	288	4,419	10%	24,955	18%	15,181	29%
	Dual	33	4,994	38%	24,566	20%	12,944	39%
	All Homes	321	4,478	10%	24,915	18%	14,951	30%

The evaluated savings for electric to NGF conversion resulted in annual savings of 9,500 kWh per home (39% of pre-conversion usage and 71% of pre-conversion heating usage) with a relative precision of ±8%. For electric to NGWH conversions, the annual savings are 4,300 kWh per home (27% of pre-conversion usage and 97% of pre-conversion heating usage) with a relative precision of ±13%. The homes with both furnace and water heater conversions had on average 12,300 kWh of savings (48% of pre-conversion usage and 91% of pre-conversion heating usage) with a relative precision of ±19%.

The following figures are based on PRISM model results. Figure 13 shows the distribution of percentage changes in the predicted electricity use between the pre- and post-conversion periods.

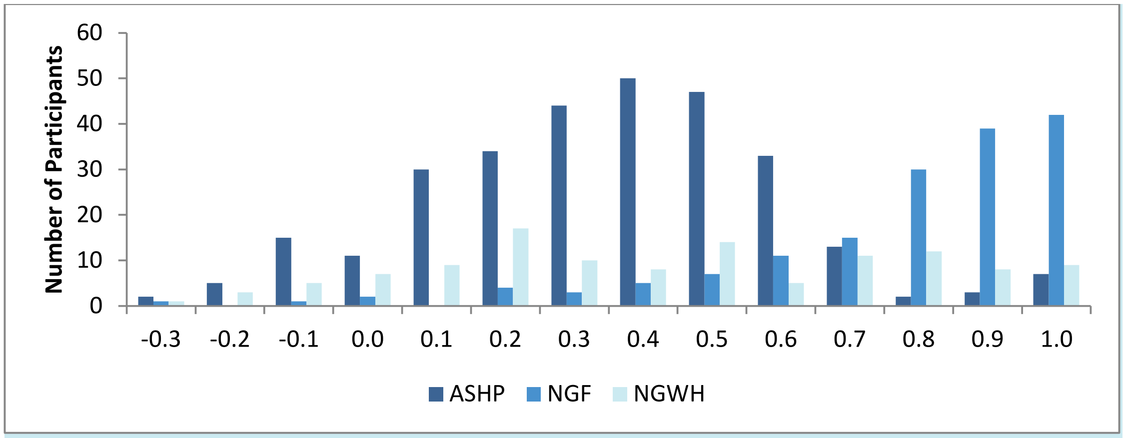
Figure 13. Distribution of Percentage Changes in Annual Electricity Savings by Conversion Group



These results show an approximate normal distribution centered around 30% reduction in electric use for ASHP conversions, 50% reduction for NGF conversions, and 35% for NGWH conversions.

Figure 14 shows the distribution of percentage changes in the predicted electricity use for heating between the pre- and post-conversion periods. The percentage changes are based on the pre-period heating load.

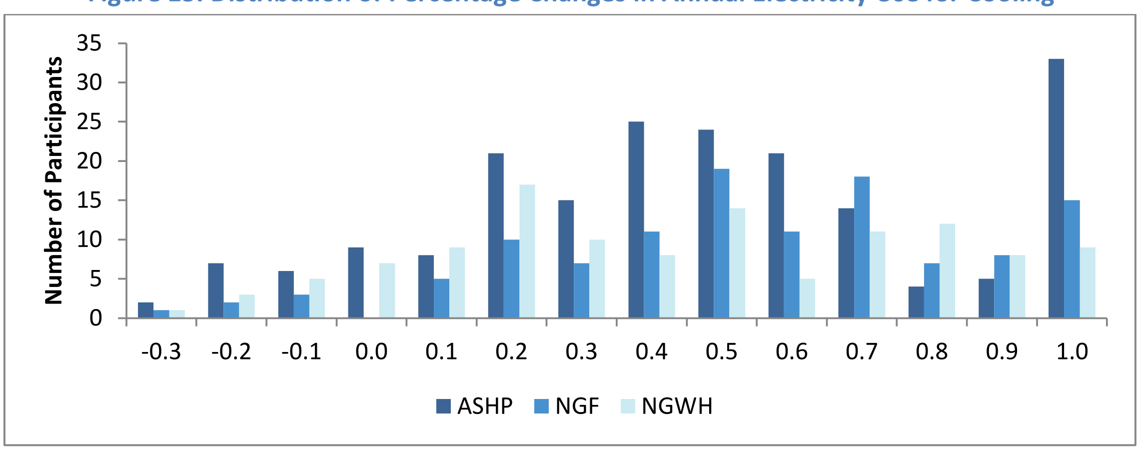
Figure 14. Distribution of Percentage Changes in Annual Electricity Use for Heating



The figure shows a more than 80% drop in the heating load for approximately 70% of electric to NGF conversion homes. For the electric to NGWH conversion homes, there is varying amounts of heat load savings across all homes. Almost 50% of savings were achieved for most ASHP conversion homes.

Figure 15 shows the distribution of percentage changes in the predicted electricity use for cooling between the pre- and post-conversion periods. The percentage changes are based on the pre-period cooling load.

Figure 15. Distribution of Percentage Changes in Annual Electricity Use for Cooling



The figure shows that customers achieved cooling efficiency, especially with ASHP conversions, followed by NGF conversions, then NGWH conversions.

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Per Home Savings Impacts (Pooled Regression Model)

Cadmus ran several specification of the panel regression model. We found that the overall savings results were fairly consistent across the PRISM and pooled regression model. In the final model, Cadmus controlled for all other measures installed by the conversion participants (except for high-efficiency variable speed motors). The results for this model are shown in Table 41. Cadmus used the coefficient estimates and standard errors from this table to calculate the savings and its relative precision.

Table 41. Electric Savings per Home (Fixed-Effects Model)

Conversion Measure	Home Type	Number of Homes	Savings (kwh)	Relative Precision on the Savings	Pre-Normalized Annual Consumption (kWh)	Savings as Percent of Pre-Period Consumption
NGF	Dual	164	10,287	9%	24,349	42%
NGWH	Dual	159	4,370	16%	16,305	27%
Multiple	Dual	23	13,643	26%	25,646	53%
ASHP	Electric Only	288	4,775	11%	24,955	19%
	Dual	33	5,309	30%	24,566	22%
	All	321	4,826	10%	24,915	19%

The results reveal that there are higher savings for each conversion group after controlling for the installation of other measures.

Table 42 provides the percentage of conversion participants in each group who had other measures installed. The regression savings analysis controls for all other measure except high-efficiency motor rebates

Table 42. Percentage of Additional Measures Installed by the Conversion Participants

Conversion Measure	Percentage of Homes With Other Measures	Percentage of Homes With High Efficiency ASHP Rebates	Percentage of Homes with Variable Speed Motor Rebates
NGF	27%	9%	45%
NGWH	26%	6%	33%
ASHP	27%	20%	52%

Results and Findings

Table 43 shows the total tracked and qualified counts, savings, and realization rates for electric Space and Water Conversion Program measures in Washington.

Table 43. Space and Water Conversion Measures and Reported and Adjusted Savings

Program Name	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
E Electric to NGF	153	1,818,068	1,463,139	100%	100%	1,463,139	80%
E Electric to NGWH	130	512,143	567,710	100%	100%	567,710	111%
E Electric to ASHP	129	840,551	570,051	100%	100%	570,051	68%
Program Total	**412**	**3,170,761**	**2,600,900**	**100%**	**100%**	**2,600,900**	**82%**

The program achieved an 82% realized adjusted gross savings rate, which is reduced slightly from the previous evaluation due to qualifications and billing analysis findings.

1.3.7. Residential Weatherization

Program Description

Avista offered the Residential Weatherization Program, for which it incented four measures available to residential electric and gas customers who heat their homes with fuel provided by Avista:

- Fireplace Dampers
- Insulation—Ceiling/Attic
- Insulation—Floor
- Insulation—Wall

Avista customers primarily heating with electric or natural gas and having a wood burning fireplace could receive up to $100 for installing a rooftop damper. This measure was removed for the 2012 program year. The two participants are a legacy from the previous program year.

Qualifying ceiling and attic insulation (both fitted/batt and blown-in), which increased the R-value by 10 or more, 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), which increased the R-value by 10 or more, 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 electric weatherization in PY 2011, PY 2012, and PY 2013. The previous billing analysis primarily included PY 2010 customers, although we extrapolated the realization rates to PY 2011. We included PY 2011 customers in the billing analysis since they now have complete post-period billing data. This increased the sample sizes and improved the precision of the weatherization savings estimates. Results only including PY 2012 and PY 2013 are also presented. To increase the accuracy of our 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 CSA and PRISM approach. We calculated overall electric model savings estimates for each measure bundle. We also attempted to estimate the detailed measure-specific savings impacts.

Billing Analysis Methodology

Avista provided Cadmus with monthly electric 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 electricity billing data. We obtained Washington daily average temperature weather data from January 2009 through January 2014 for nine National Oceanic and Atmospheric Administration (NOAA) weather stations, representing all ZIP codes in Avista's Washington service territory. From daily temperatures, we determined base 65 HDDs and CDDs for each station. Using 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 and CDDs from the associated stations.

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

1. ***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.
2. ***The Fixed Dates:*** For this specification, the earliest and latest dates of available billing data are selected. In effect, we used the period of January 2010 through December 2010 as the pre-installation period, before any installations occurred. We defined the post-installation period as the latest period with complete billing data: February 2013 through January 2014.

Table 44 shows an example of the specification of the pre- and post-installation periods under the two specifications. In this analysis, Cadmus used a combination of the two pre-post specifications. While the first specification allows for 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 the attrition, we used the Customer Specific Measure Install Date specification when possible where there was insufficient billing data to use Fixed Dates.

Table 44. Example of Pre- and Post-Installation Period Under the Two Specifications

Specification of Pre- and Post-Installation 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-installation period, which could have skewed the weatherization savings estimates.

PRISM Modeling Screens

As a second step of the data screening process, Cadmus ran PRISM models for pre- and post-installation billing data. These models provided weather-normalized pre- and post-installation annual usage for each account, and provided an alternate check of the savings obtained from the CSA model. Details on the model specifications can be found in Appendix A.

After running the three models, we dropped any models with negative heating or cooling slopes. The best of the remaining models for each customer in either the pre- or post-installation period was the model with the highest R-square that still had positive heating and/or cooling slopes.

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

- ***Accounts where the post-installation weather-normalized (POSTNAC) usage was 70% higher or lower than the pre-installation weather-normalized (PRENAC) usage.*** Such large changes could indicate property vacancies or adding or removing other electric equipment that is unrelated to weatherization (such as pools or spas).
- ***Accounts with negative intercepts (base load).*** These negative intercepts indicate a negative base load, for example lighting, refrigerators, plug loads, etc. In electric homes, the base load is never expected to be negative.

- ***Accounts where the pre- and post-installation billing data had anomalies including: vacancies, seasonal usage, outliers, and equipment changes.***

The Washington weatherization population included 356 participants. Once we placed these screens on the data, 159 Washington weatherization participants (45%) remained for use in the CSA model, outlined below, for determining overall savings.

Table 45 summarizes the attrition from each step listed above. Each row in the table indicates the accounts remaining after attrition. We dropped approximately 36% of the participant accounts because they did not have sufficient pre- and post-installation billing data. We dropped another 20% based on PRISM screenings and the presence of vacancies, seasonal usage, outliers, or equipment changes in the billing data.

Table 45. Weatherization Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Total Washington weatherization accounts	356	100%	0	0%
Matched to billing data provided	353	99%	3	1%
Less than 10 months of pre- or post- billing data	230	65%	123	35%
PRISM screening*	212	60%	18	5%
vacancies, seasonal usage, equipment changes	159	45%	53	15%
Final analysis group	**159**	**45%**	**197**	**55%**

* 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 modeling method, using pooled monthly time-series (panel) billing data. This fixed-effects modeling approach corrected for differences between pre- and post-installation weather conditions, as well as for differences in usage consumption between participants through the inclusion of a separate intercept for each participant. This modeling approach ensured model savings estimates would not be skewed by unusually high-usage or low-usage participants. Details on the model specifications can be found in Appendix A.

Program Impact Evaluation Findings

Overall Savings Impacts (Fixed Effects)

Table 46 summarizes the usage and savings associated with the weatherization measures installed in electrically heated homes.[21] The results show the annual savings, relative precision on these savings, the pre-installation heating usage NAC for each level, and the savings as a percentage of the pre-heating usage NAC. The table also shows *ex ante* savings estimates and the achieved realization rates for the weatherization measures.

Table 46. Washington Weatherization Electric Savings per Home (Fixed-Effects Model)

Program Years	Number of Homes	Model Savings (kWh)	Relative Precision on the Savings	Pre-Normalized Annual Consumption (kWh)	Pre-Normalized Heating Annual Consumption (kWh)	Savings as Percent of Pre-Period Heating Consumption
2011-2013	159	2,444	19%	19,628	11,239	12.5%
2012-2013	39	3,170	24%	23,007	14,088	13.8%
2011	120	2,187	26%	18,529	10,314	11.8%

Table 47 shows the realization rates for the three analysis groups.

Table 47. Washington Weatherization Electric Savings Realization Rates (Fixed-Effects Model)

Program Years	Model Savings (kWh)	Relative Precision on the Savings	Annual *Ex Ante* Savings (kWh)	Realization Rate
2011-2013	2,444	19%	2,540	96%
2012-2013	3,170	24%	2,083	152%
2011	2,187	26%	2,689	81%

Overall, the PY 2011-PY 2013 weatherization measures achieved savings of 2,444 kWh, or 12.5% relative to the pre-installation period heating NAC. With an average weatherization measure *ex ante* savings estimate of 2,540 kWh, the weatherization measures realized 96% of the expected savings.

If the billing analysis is limited to only 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 PY 2012 and PY 2013, in which only homes with

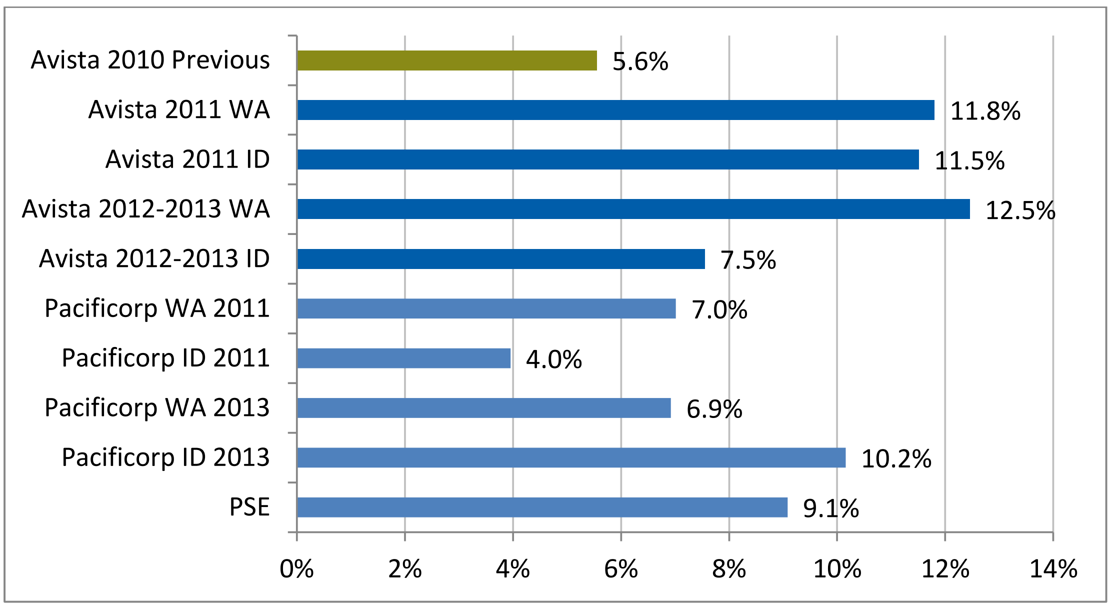
[21] Cadmus also estimated measure-level models for PY 2012 and PY 2013 that contain the most recent *ex ante* estimates. For Washington, these revealed that the attic insulation model savings were generally higher than the current *ex ante* values. The wall insulation model savings were similar to the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

very low initial R-value insulation levels qualified for the program. The PY 2012 and PY 2013 weatherization participants achieved savings of 3,170 kWh, or 13.8% savings relative to the pre-installation period heating NAC. With an average weatherization measure *ex ante* savings estimate of 2,083 kWh, the weatherization measures realized 152% of the expected savings.

Cadmus also estimated the savings for only PY 2011 participants. PY 2011 represents the predominant sample of the billing analysis; however, the *ex ante* estimates are considerably higher than in other years. The PY 2011 weatherization participants achieved savings of 2,187 kWh, or 11.8% relative to the pre-installation period heating NAC. With an average weatherization measure *ex ante* savings estimate of 2,689 kWh, the weatherization measures realized 81% of the expected savings.[22]

Figure 22 shows a comparison of the weatherization percentage savings to similar electric weatherization evaluations. Avista's PY 2011 PY 2012 and PY 2013 percent savings have improved significantly since the PY 2010 program year. The Washington weatherization percentage of savings also compare favorably with the Idaho savings.

Figure 16. Electric Weatherization Percent Savings Benchmarking



Cadmus did not include fireplace dampers in the billing analysis, but retaining the deemed savings value that Cadmus developed for the PY 2012 Avista Technical Reference Manual (TRM).

[22] The weatherization savings estimate from the previous PY 2010 and PY 2011 report was 953 kWh and the combined Washington and Idaho realization rate was 35%. For the evaluation outlined in the previous report, Cadmus relied primarily on PY 2010 participants. PY 2011 savings and realization rate are higher than the PY 2010 estimates.

Table 48 shows the total reported and qualified counts, savings, and realization rates of electric weatherization program measures.

Table 48. Weatherization Program Results

Program Name	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
E Attic Insulation with Electric Heat	102	60,310	91,671	100%	100%	91,671	152%
E Floor Insulation with Electric Heat	27	39,048	59,353	100%	100%	59,353	152%
E Wall Insulation with Electric Heat	52	83,131	126,360	100%	100%	126,360	152%
E Fireplace Damper With Electric Heat	2	326	326	100%	100%	326	100%
Program Total	**183**	**182,816**	**277,710**	**100%**	**100%**	**277,710**	**152%**

1.3.8. Water Heater Efficiency

Program Description

The Water Heater Efficiency Program represented one measure: electric high-efficiency water heaters.

Through this program, Avista offered a $50 incentive to residential electric customers who installed an eligible high-efficiency water heater. Electric water heaters with a tank had to have a 0.93 EF or greater to qualify for the program.

Analysis

The PY 2010-PY 2011 electric impact evaluation report[23] documented the analysis Cadmus performed to determine the change in energy consumption resulting from installation of this measure. As that analysis continued to provide the best information on this measure, we used those results for PY 2012.

Results and Findings

Table 49 shows the total tracked and qualified counts, savings, and realization rate.

[23] Cadmus. *Avista 2010–2011 Multi-Sector Electric Impact Evaluation Report*. May 2012.

Table 49. Water Heater Efficiency Measure and Reported and Adjusted Savings

Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
314	37,311	37,397	100%	100%	37,397	100%

1.3.9. ENERGY STAR Homes

Program Description

Avista offered incentives through the ENERYG STAR Homes Program for builders constructing single-family or multifamily homes complying with ENERGY STAR criteria and certified as ENERGY STAR Homes. Avista provided a $900 incentive for homes using electric or electric and natural gas service from Avista for space and water heating.

Analysis

In the PY 2010-PY 2011 electric impact evaluation report, Cadmus documented the simulation modeling we performed to determine energy savings achieved by ENERGY STAR Homes. As the simulation results continued to provide accurate estimates of savings, we used those results for PY 2012-PY 2013.

Results and Findings

Table 50 shows total tracked and adjusted counts, savings, and realization rates for measures offered through the ENERGY STAR Homes Program. Avista funded both electric and gas measures for participating Avista homes.

Table 50. ENERGY STAR Home Program Results

Program Name	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
Home-Electric Only	19	62,603	47,690	100%	100%	47,690	76%
Home-Electric/Gas	11	11,608	11,594	100%	100%	11,594	100%
Program Total	**30**	**74,211**	**59,284**	**100%**	**100%**	**59,284**	**80%**

1.3.10. Manufactured Home Duct Sealing

Program Description

Through the Manufactured Home Duct Sealing Program, contractors performed one of three levels of duct inspection and sealing on manufactured homes in Washington. In addition to the duct sealing, the inspectors also installed CFLs and low-flow showerheads. Avista offered the program from October 2012 through June 2013.

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 in Washington. Three out of every four customers, or 1,636, used electricity to heat their homes, while the remaining 580 used gas to heat their homes.

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

- Level 1 – 1,550 kWh
- Level 2 – 1,950 kWh
- Level 3 – 2,350 kWh

In gas-heated homes, the duct sealing measures were expected to save 50, 65, and 80 therms, respectively for the three levels. Secondarily, CFLs were installed in 83% of the homes. The *ex ante* estimate was 23 kWh per CFL, and most homes received five CFLs. Showerheads were also installed in two out of every three homes. The showerheads were expected to save 310 kWh in homes with electric water heating, and 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 levels in electrically heated homes. Secondarily, we used billing analysis to obtain the electric savings of all the lighting and the water heating measures.

More specifically, Cadmus' evaluation of the Manufactured Home Duct Sealing Program consisted of the following three tasks:

- Data collection, review, and preparation.
- Billing analysis.
- Energy-savings estimation.

Data Collection, Review, and Preparation

To perform the billing and uplift analysis, Cadmus collected the following data.

Monthly Customer Bills

Avista supplied Cadmus with monthly gas and electricity bills between January 2010 and February 2014. These billing data included: account numbers, read dates, and energy use during the monthly billing cycle.

Program Information

Cadmus obtained program measure data from Avista. The measure data included account numbers, measures installed, measure level *ex ante* savings, heating type, and dates of participation in the program.

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 program homes in the Avista territory.

Data Preparation

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

- Reformatting and merging the raw billing data in 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-installation periods for each customer account:
  - ***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 2011 through December 2011 as the pre-period, before any installations occurred. We defined the post-installation period as the latest period of complete billing data: March 2013 through February 2014.

Table 51 shows an example of the pre- and post-installation 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

the attrition, we used the Customer Specific Measure Install Date specification when possible where there was insufficient billing data to use Fixed Dates.

Table 51. 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 2011 - December 2011	March 2013 - February 2014

Cadmus used daily average temperature and billing cycle information to estimate CDDs and HDDs for each home during each billing cycle. To calculate HDDs and CDDs exactly matching the energy use in the customer's bill, this required using a base temperature of 65 degrees and billing cycle start and end dates

Data Attrition

Cadmus performed the billing analysis on the population of program homes, with a few exceptions where we excluded homes from the estimation sample if they 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- annual usage.

Table 52 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-installation billing data in the analysis. Another 9% were dropped based on PRISM screening, percent change screening, or the presence of vacancies, seasonal usage, outliers, and equipment changes in the billing data.

Table 52. 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 customers who 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-installation 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. Details on the model specifications can be found in Appendix A.

Energy-Savings Estimation

Overall Savings Impacts (Fixed Effects)

Table 53 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-NAC for each group, and the savings as a percentage of the pre-NAC. The table also reports *ex ante* savings estimates and the achieved realization rates for the measures.

Table 53. Overall Electric Savings per Home (Fixed-Effects Model)

Duct Sealing Level	Number of Homes	Model Savings (kwh)	Relative Precision on the Savings	Pre-Normalized Annual Consumption (kWh)	Savings as Percent of Pre-Period Consumption	Annual *Ex Ante* Savings (kWh)	Realization Rate
Level 1	171	1,474	16%	19,532	7.5%	1,869	79%
Level 2	555	1,588	8%	19,928	8.0%	2,321	68%
Level 3	106	2,335	16%	21,045	11.1%	2,704	86%
Overall	**832**	**1,661**	**7%**	**19,989**	**8.3%**	**2,277**	**73%**

Duct Sealing Level 1 homes achieved savings of 1,474 kWh, or 7.5% relative to the pre-period NAC. With an average *ex ante* savings estimate of 1,869 kWh, these homes realized 79% of their expected savings.

Duct Sealing Level 2 homes achieved savings of 1,588 kWh, or 8.0% relative to the pre-period NAC. With an average *ex ante* savings estimate of 2,321 kWh, these homes realized 68% of their expected savings.

Duct Sealing Level 3 homes achieved savings of 2,335 kWh, or 11.1% relative to the pre-period NAC. With an average *ex ante* savings estimate of 2,704 kWh, these homes realized 86% of their expected savings.

Overall in the billing analysis sample, manufactured homes averaged achieved savings of 1,661 kWh, or 8.3% relative to the pre-period NAC. With an average *ex ante* savings estimate of 2,277 kWh, these homes realized 73% of their expected savings.

Duct Sealing Savings Impacts (Fixed Effects)

Table 54 summarizes savings specifically for the key duct sealing measures installed in electrically heated homes.[24] The results show the annual savings, relative precision of these savings, the pre-heating NAC for each level, and the savings as a percentage of the pre-heating NAC. The table also reports *ex ante* savings estimates and the achieved realization rates for the duct sealing measures.

[24] Cadmus determined the duct sealing savings by subtracting out the savings for CFLs and showerheads from the total *ex ante* and *ex post* savings. The resulting savings are for the duct sealing measures only.

Table 54. 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 Annual Heating 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%**

The Duct Sealing Level 1 measure achieved savings of 1,155 kWh, or 8.5% relative to the pre-period heating NAC. With an average duct sealing measure ex ante savings estimate of 1,550 kWh, this measure realized 75% of the expected savings.

The Duct Sealing Level 2 measure achieved savings of 1,218 kWh, or 9.2% relative to the pre-period heating NAC. With an average duct sealing measure *ex ante* savings estimate of 1,950 kWh, this measure realized 62% of the expected savings.

The Duct Sealing Level 3 measure achieved savings of 1,980 kWh, or 13.9% relative to the pre-period heating NAC. With an average duct sealing measure *ex ante* savings estimate of 2,350 kWh, this measure realized 84% of the expected savings.

Overall, customers who received the duct sealing measures in the billing analysis sample achieved savings of 1,303 kWh, or 9.7% relative to the pre-period heating NAC. With an average duct sealing measure *ex ante* savings estimate of 1,919 kWh, this measure realized 68% of the expected savings.

Results and Findings

Table 55 shows total tracked and adjusted counts, savings, and realization rates for measures offered through the Manufactured Home Duct Sealing Program.

Table 55. Manufactured Home Duct Sealing Program Results

Measure	Reported Measure Count	Reported Savings (kWh)	Adjusted Savings (kWh)	Qualification Rate	Verification Rate	Adjusted Gross (kWh)	Realization Rate
Duct Sealing Level 1	401	621,550	463,155	100%	100%	463,155	75%
Duct Sealing Level 2	1,061	2,068,950	1,292,298	100%	100%	1,292,298	62%
Duct Sealing Level 3	194	455,900	384,120	100%	100%	384,120	84%
Direct Install CFL	9,184	211,232	211,232	100%	100%	211,232	100%
Direct Install Showerhead	1,500	465,000	465,000	100%	100%	465,000	100%
Program Total	**12,340**	**3,822,632**	**2,815,805**	**100%**	**100%**	**2,815,805**	**74%**

1.3.11. Geographic CFL Giveaway Events

Avista gives CFLs out to customers at events throughout the year. The number of bulbs distributed is tracked by Avista outside of their database and other CFL programs. Avista estimates the energy savings achieved by these bulbs at 15 kWh per bulb. This value is conservative compared to estimates currently in use by the RTF. Cadmus accepts the energy savings estimated by this effort at 15 kWh per bulb. No further evaluation activities were completed.

Table 56. Geographic CFL Giveaway Events, Evaluated Savings

Program	PY	Reported Measure Count	Evaluated Savings (kWh)
Residential Giveaways	2012	4,729	70,935
	2013	1,262	18,930
Home Energy Audits	2012	6,480	97,200
	2013	0	0
Low Income & Senior Citizen	2012	803	12,045
	2013	4,128	61,920
Program Total		**17,402**	**261,030**

1.4. Residential Conclusions

For PY 2012 and PY 2013, Avista's residential electric programs produced 23,167,742 kWh in savings, which yielded an overall realization rate of 91%. Table 57 shows reported and evaluated gross savings and realization rates per program.

Table 57. Total Program Reported and Evaluated Gross Savings and Realization Rates

Program	Reported Savings (kWh)	Adjusted Gross Savings (kWh)	Realization Rate
Simple Steps, Smart Savings™	16,095,035	16,059,081	100%
Second Refrigerator and Freezer Recycling	1,360,068	983,369	72%
ENERGY STAR® Products	818,582	156,087	19%
Heating and Cooling Efficiency	833,270	819,515	98%
Space and Water Conversions	3,170,761	2,600,900	82%
Weatherization/Shell	182,816	277,710	152%
Water Heater Efficiency	37,311	37,397	100%
ENERGY STAR® Homes	74,211	59,284	80%
Geographic CFL Giveaway	261,030	261,030	100%
Manufactured Home Duct Sealing	3,822,632	2,815,805	74%
Program Total	**26,607,743**	**23,888,639**	**90%**

1.5. Residential Recommendations

Cadmus recommends the following changes to Avista's residential electric programs:

- Avista should consider updating its per-unit assumptions of recycled equipment to reflect this evaluation in order to ensure that planning estimates of program savings are in line with evaluated savings.
- If clothes washer rebates are ever reinstated, Avista should track them all within the electric program unless there is a large penetration of gas dryers.
- Increase measure level detail capture on applications and include in the database. Specific additional information should include energy factors or model numbers for appliances, baseline information for insulation, and home square footage, particularly for the ENERGY STAR Homes program.
- Consider tiered incentives by SEER rating as higher SEER systems generally require ECM fan motors to achieve certain SEER ratings.

Future Research Areas

The following are recommended future research areas for this program. These research recommendations are based on the results of this impact evaluation and known future changes to program requirements.

- Avista should consider completing a lighting logger study within its territory if Avista believes the results of the forthcoming RBSA study do not accurately represent usage in their territory.
- Avista should consider researching the percentage of Simple Steps, Smart Savings bulb purchase that are installed in commercial settings. This could increase the average installed hours of use and increase program savings.

- Perform a billing analysis on ENERGY STAR homes using a non-participant comparison group once enough homes have participated under the new requirements to justify performing the work. This research could be used to demonstrate the achieved savings through energy efficiency construction practices.
- Consider researching the current variable speed motor market activity to determine if this measure should continue as a stand-alone rebate or be packaged with other equipment purchases.

2. Residential Behavior Program

2.1. Program Description

For the Residential Behavioral Program, Avista sends home energy reports to residential customers. The reports educate customers about their electricity use and suggest opportunities for saving electricity. Each report contains:

- An analysis of the home's current and past electricity use;
- A comparison of the home's electricity use to the electricity use of its similar neighbors (known as the neighbor comparison); and
- Electricity-savings tips, including promotions of other Avista energy-efficiency programs.

The program seeks to achieve electricity savings by increasing awareness of energy efficiency and by encouraging lasting changes in energy-use behaviors and in the adoption of energy-efficiency measures. Opower implements the program. It was expected that the program would save about 1% of energy use in PY 2013.

The program targeted single-family homes and units in multifamily buildings with above-average electricity use.[25] Although the program is focused on saving electricity, homes that receive electricity and natural gas service from Avista are eligible to participate. Each home will receive six reports during the first 12 months of the program.

2.1.1. Program Details

The program began in June 2013, when Opower sent the first energy reports to homes in Avista's Washington service territory by U.S. mail. Approximately 48,000 Avista Washington residential electric customers received one or more reports in 2013. Most program homes received their first report in June or July 2013, although a small number received their first report in a later month.

To be eligible, homes had to meet the following criteria:

- Have above-average electricity use;
- Have an adequate electricity billing history (12 or more months of continuous bills at the same premise);
- Have a sufficient number of similar neighboring homes (for the neighbor comparison);
- Have home occupants who are responsible for paying electricity bills;
- Be a primary residence;
- Not be master-metered; and

[25] The average annual electricity use per program home was 17,509 kWh in 2012. Median annual energy use was 15,950 kWh and the 25th and 75th percentiles were, respectively, 13,340 kWh and 20,170 kWh.

- Have a valid mailing address.

By contacting Avista, a homeowner could stop delivery of the reports at any time; these homes are referred to as opt-outs. During PY 2013, there were 486 opt-out customers in Washington, for a rate of 1.05%, a very small share of customers that received reports.

Opower implemented the program as a randomized control trial (RCT), in which Opower identified homes in Avista's service territory eligible to receive the reports and Cadmus independently randomly assigned each home to the program treatment or control group.[26] Homes in the treatment group received the home energy reports while homes in the control group did not receive reports and were not informed of the program.[27] With random assignment, the treatment and control groups are expected to be equivalent except for the treatment group having received the energy reports, so it is therefore possible to attribute any difference in average energy use during the program between the groups to the receipt of the reports. RCT is the gold standard in program evaluation, because it yields unbiased and robust estimates of the program treatment effects. RCT is the recommended by both the DOE's forthcoming Uniform Methods Project for Evaluating Behavior-Based Programs (2014) and by SEE Action guidelines for evaluating residential behavior-based programs (2012).[28] This approach was also employed in evaluation of other large-scale, home energy reports programs of Washington investor-owned utilities.[29]

Table 58 shows the number of Avista residential customers in Washington assigned to the treatment group and the number receiving one or more energy reports in PY 2013. Not every treatment customer received energy reports because after Cadmus created the random assignments, Opower determined that some customers did not have a valid mailing address or information required to generate a report. The table also shows the number of customers in the control group and the number of customers in the

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26 Using standard statistical tests, Cadmus verified that the treatment and control groups were balanced in terms of their annual, summer, and winter ADCs.

27 Opower could not deliver reports to a small number of homes assigned to the treatment group, as discussed later in this report. Opower also identified control homes for which it would have been impossible to send a home energy report.

28 See the State and Local Energy Efficiency Action Nework (2012). Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. http://behavioranalytics.lbl.gov. Also, the draft UMP protocols for behavior-based programs are available here: *http://energy.gov/eere/about-us/initiatives-and-projects/uniform-methods-project-determining-energy-efficiency-program*

29 See the 2012 impact evaluation of Puget Sound Energy's Home Energy Reports Program: *https://conduitnw.org/_layouts/Conduit/FileHandler.ashx?RID=849*

control group who would have received reports if they had instead been assigned to the treatment group.

Table 58. Number of Treatment and Control Homes in PY 2013

	Washington		
	Treatment	Control	Total
Randomly assigned	48,299	13,000	61,299
Randomly assigned and received a report (treatment) or could have received a report (control)*	46,474	12,583	59,057

* This row excludes treatment homes that did not receive a report and control homes that could not have received a report due to an invalid mailing address or unavailable information required to generate a report.

2.2. Residential Behavior Program Impact Evaluation Methodology

For the impact evaluation, Cadmus sought to estimate the program energy savings in PY 2013 and quantify the program impact on participation in Avista's other residential efficiency programs. Cadmus used a panel regression analysis of customer monthly bills to estimate the program's electricity savings between mailing of the first reports in June 2013 and December 2013. Cadmus analyzed Avista efficiency program participation and measure savings data to estimate the program's effects on participation in other Avista efficiency programs, as well as to estimate savings that were counted towards other efficiency programs.

More specifically, Cadmus' evaluation of the Residential Behavior Program savings and efficiency program uplift consisted of the following four tasks:

1. Data collection, review, and preparation.
2. Equivalency analysis (checks on treatment and control groups).
3. Billing analysis.
4. Energy-efficiency program uplift and savings analysis.

2.2.1. Data Collection, Review, and Preparation

To perform the billing and uplift analyses, Cadmus collected the data outlined below.

Monthly Customer Bills

Avista supplied Cadmus with monthly electricity and gas bills (for dual-fuel customers) between June 2012 and January 2014. The data included approximately 12 months of bills prior to and six months of bills after the program began for homes in the treatment and control groups. These billing data included: account numbers, energy use during the monthly billing cycle, number of days in the billing cycle, and the first and last days of the billing cycle.

Program Information

Cadmus obtained program enrollment information from Opower. These data included the following fields for each home in the treatment and control groups:

- Address of residence;
- Assignment to treatment or control group;
- First report date;[30]
- Opt-out date for homes in the treatment group choosing not to participate in the program;
- Inactive date for homes that closed their gas or electric account; and
- Account numbers for linking to billing data.

Weather

Cadmus collected daily average temperature data for weather stations in the program region from the National Climate Data Center (NCDC). For a small number of stations where the NCDC data were incomplete, Cadmus was able to interpolate daily average temperature as an average of the preceding and following day. In cases where a string of days were missing data, Cadmus used temperature data from the next-nearest weather station. Then we used temperatures to calculate the number of HDDs and CDDS for each customer billing cycle.

Residential Energy-Efficiency Program Tracking Data

Avista provided Cadmus with participant and measure savings data for PY 2013 residential energy-efficiency programs in which the behavior program could have influenced participation. These programs included appliance recycling and residential rebates for HVAC equipment, conversions to natural gas, and insulation. For each program and measure, the data included: the account number; the number and description of measures installed; measure installation dates; and verified gross savings. Cadmus used this information to estimate the behavior-based program's participation and savings effects on other efficiency programs.

[30] Opower assigned a pseudo first report date to control homes, representing the date the first energy report would have been mailed.

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Data Cleaning

Cadmus conducted a number of steps to inspect and clean the data provided by Opower. The steps are described in Appendix B: Residential Behavior Program Data Cleaning Procedures. Cadmus did not identify any significant issues with the Opower data.

Cadmus requested monthly billing data from Avista for Washington customers from June 2012 through February 2014. Avista provided bills for all but a few customers in the program treatment and control groups.[31] Cadmus then followed a number of steps to clean the billing data. These steps are also described in Appendix B: Residential Behavior Program Data Cleaning Procedures.

Data Preparation

Using the number of days in the billing cycle, Cadmus expressed each month's energy use and weather in average daily terms, then merged the billing, weather, and program information data, including information about the approximate delivery date of the first home energy report.

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

- The home was in the treatment group but did not receive a home energy report or was in the control group but would not have received a home energy report (indicated by missing the first report date in the customer information data).[32]
- Opower flagged the home as receiving a home energy report, but the home had not been randomly assigned to the treatment group.[33]
- The home did not have a complete or near-complete billing history for the 12 months before the start of the program. Cadmus dropped homes from the analysis that had fewer than 11 bills between June 2012 and May 2013.

Applying these filters resulted in a group containing 54,324 customers: 11,579 in the control group and 42,745 in the treatment group. Although the billing analysis excluded homes with fewer than 11 bills in the year before the program, the savings estimate includes savings from these homes.[34]

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[31] Avista provided billing data for all but 868 customers. While we did not use these customers' bills in the savings analysis, we did count the savings from these customers in our estimated PY 2013 total program savings.

[32] A home in the treatment group may have been missing a first report date because either the account became inactive before the first report was generated, or Opower did not have a valid mailing address. An approximately equal number of control homes were not assigned a first report date and were left out of the analysis for the same reasons.

[33] For example, this group included utility employees who requested to participate in the program.

2.2.2. Equivalency Analysis

Per an agreement between Avista, Cadmus, and Opower, Cadmus performed the random assignments of eligible residential customers to the program treatment or control groups. At the time, Cadmus verified that the random assignment resulted in treatment and control groups that were balanced in terms of their annual, winter, and summer electricity use. Cadmus provided these random assignments to Opower, who additionally analyzed the random assignments using proprietary home and demographic characteristic data and verified that the groups were balanced.

Cadmus also performed an equivalency check of homes in the analysis sample treatment and control groups after applying the filters described in the preceding section. As Table 59 shows, the difference between the two groups' annual consumption is not statistically significant.

Table 59. Equivalency of Analysis Sample Treatment and Control Group Homes

	Average Annual Consumption
Treatment	17,786
Control	17,807
t value	0.32
P value	0.75

As described below, any time-invariant differences in energy use between the treatment and control groups after filtering are absorbed with customer fixed effects.[35]

2.2.3. Billing Analysis

To estimate Residential Behavioral Program electricity savings, Cadmus used difference-in-differences (D-in-D) regression. D-in-D regression uses the energy use of treatment and control group homes before and after the first energy reports to account for any naturally occurring efficiency that might have been correlated with Residential Behavior Program activity.

The D-in-D approach requires monthly energy use from before and during the program in the treatment and control group homes. Using Avista billing data, Cadmus conducted panel regression analysis of the electricity consumption in Washington to estimate the average program savings per home per day in PY 2013.

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[34] Cadmus followed the guidelines in the SEE Action's report *EM&V of Residential Behavior-Based Energy Efficiency Programs* (2012) to drop homes with less than 10 months of billing data from the analysis.

[35] A home fixed effect represents the portion of a home's energy use that does not vary over time. This energy use is captured in the regression analysis by the inclusion of a separate intercept for each customer or by equivalently transforming all the variables by subtracting home-specific means.

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Model Specification

Assume ADC of electricity of home 'i' in month 't' is given by:

$$ADC_{it} = \beta_1 \, POST_{it} + \beta_2 \, PART_i \times POST_{it} + W'\gamma + \alpha_i + \tau_t + \varepsilon_{it}$$

Where:

β_1	=	Coefficient representing the impact of non-program factors on consumption between pre- program and program months.[36]
POST	=	An indicator variable for whether the month is pre- or post-treatment. This variable equals 1 in months following the first report date and 0 otherwise. The variable is defined with a short lag to allow for time between the report's generation and delivery of the report to the home.[37]
β_2	=	Coefficient representing the conditional average treatment effect (ATE) of the program on electricity use (kWh per home per day).
PART	=	An indicator variable for program participation (which equals 1 if the home was in the treatment group, and 0 otherwise).
W	=	A vector using both HDD and CDD variables to control for the impacts of weather on energy use.
γ	=	Vector of coefficients representing the average impact of weather variables on energy use.
α_i	=	Average energy use in home 'i' that is not sensitive to weather or time. Analysis controlled for non-weather-sensitive and time-invariant energy use with home fixed effects.
τ_t	=	Average energy use in month 't' reflecting unobservable factors specific to the month. The analysis controls for these effects with month-by-year fixed effects.[38]
ε_{it}	=	Error term for home 'i' in month 't.'

[36] In addition to naturally occurring efficiency, this term captures differences in average consumption between pre-program and program months due to having 12 months of pre-program bills and only 7 months of program bills.

[37] Specifically, we defined the first report date as 14 days after the report was generated. This allowed for time between generating and delivering the report.

[38] It was possible to include month-by-year fixed effects and POST in the same model because there was variation between customers in the month of the first report date.

Program Energy Savings

Cadmus estimated the total Residential Behavioral Program energy savings in PY 2013 by multiplying the total number of program days across treated homes by the average savings per home per day, β_2. To illustrate, let i=1, 2, …, N index the number of homes receiving a home energy report; and D(x) return the number of the days in 2013 from January 1 for a given date x (e.g., D(February 1)=32).

The net program savings then equaled:

$$\text{Net Savings} = -\beta_2 * \left(\sum_{i=1}^{N} \text{ProgDays}_i\right)$$

Where:

i	=	1, 2, …, N; indexes the number of homes in the treatment group.
ProgDays_i	=	365 – D(first report date_i), if the billing account for home ‘i' was still active on December 31, 2013; and,
	=	D(inactive date_i) - D(first report date_i), if the billing account for home ‘i' became inactive before December 31, 2013.

As the definition of $ProgDays_i$ shows, Cadmus counted savings in treated homes whose accounts became inactive up until the accounts closed.

2.2.4. Energy-Efficiency Program Uplift Analysis

The Residential Behavioral Program could have increased participation in Avista’s other efficiency programs in two ways:

- First, energy reports directly educated customers about some of Avista’s efficiency programs and encouraged them to take advantage of program offerings and incentives.
- Second, the reports could have raised customer awareness and knowledge of energy efficiency, which may cause some to participate in Avista’s efficiency programs.

Analysis of efficiency program uplift is important for two reasons:

- First, Avista sought to learn whether and to what extent the Residential Behavior Program caused participation in its other efficiency programs.
- Second, to the extent the Residential Behavioral Program caused participation in other efficiency programs, energy savings resulting from this participation will have be counted twice: in the regression estimate of Residential Behavior Program savings; and in the other programs’ savings. (Thus, Avista will want to subtract the double-counted savings from its portfolio savings.)

The uplift analysis described here yields estimates of the effect of the Residential Behavioral Program on other efficiency program participation and the double-counted savings. The analysis was limited, however, to program measures that Avista tracked at the customer level, and thus did not include residential upstream programs promoting CFLs through store discounts. However, analysis of Opower home energy report programs in other service territories suggests that CFLs only account for a small percentage of total program savings.[39]

Methodology

As with the energy-savings analysis, the uplift analysis follows the logic of the program's experimental design. Cadmus collected Avista electric efficiency program participation and savings data for PY 2013, matched the data to the program treatment and control homes, and estimated uplift as a simple difference in participation rates and savings between treatment and control groups. As customers in the treatment and control groups are expected to be similar, except for having participated in the behavior program, the difference between treatment and control groups in other efficiency program participation is expected to equal the true Residential Behavior Program uplift. In matching treatment and control homes to the PY 2013 efficiency program data, Cadmus excluded measures installed after an account became inactive or before the first energy report date.

Let ρ_m be the participation rate (defined as the number of efficiency program participants to the number of potential participants) in a PY 2013 program for group m (as before, m=1 for treated homes, and m=0 for control homes). Then:

$$\text{Participation uplift} = \rho_1 - \rho_0$$

Expressing participation uplift relative to the participation rate of control homes in PY 2013 yields an estimate of the percentage of uplift:

$$\%\text{Participation Uplift} = \text{Program Uplift}/\rho_0$$

Residential Behavior Program savings from participation in other efficiency programs can be estimated the same way, by replacing the program participation rate with the program net savings per home:

$$\text{Net savings per home from participation uplift} = \sigma_1 - \sigma_0.$$ [40]

Multiplying net savings per home by the number of program homes yielded an estimate for a customer segment and wave of total Residential Behavioral Program net savings counted in Avista's other efficiency programs.

39 See impact evaluation of PG&E Home Energy Reports Program, 2010-2012. Available at *http://www.calmac.org/publications/2012_PGE_OPOWER_Home_Energy_Reports__4-25-2013_CALMAC_ID_PGE0329.01.pdf*

40 Cadmus obtained net savings by multiplying measure-verified gross savings by the estimated measure net-to-gross ratio.

Cadmus performed participation and savings uplift analyses for the following Avista residential efficiency programs:

- Appliance Recycling
- Residential rebate programs, including:
  - Residential conversions (conversion from electric to NGF or NGWH)
  - Residential HVAC (ASHP (including conversions), variable frequency drives (VFDs), and electric water heaters)
  - Residential shell (floor and attic insulation)

Cadmus did not perform uplift analyses for the following residential electricity efficiency programs:

- Upstream Lighting. Though the Residential Behavior Program may have influenced CFL and other high-efficiency lighting purchases, such purchases were tracked at the store level.
- ENERGY STAR Homes. This program targeted builders of new homes, which the Residential Behavior Program did not target.
- Low-Income Weatherization. The typical time lag between the application for a retrofit and installation of measures exceeded the number of program months (which was six or seven) in PY 2013, making it unlikely that the energy reports would have resulted in any savings for this program.

2.3. Program Results and Findings

2.3.1. Electricity Savings per Home Estimates

Table 60 shows the average daily energy savings per home or, equivalently, the conditional average program treatment effect (ATE) per home of Avista's Residential Behavioral Program. The savings are represented by the coefficient on the interaction variable between $PART_{it}$ x $POST_{it}$. On average, homes saved 0.764 kWh (1.61%) per day.[41] This savings estimate was statistically significant at the 1% level.

For perspective, these savings could be achieved by turning off a 75-watt incandescent lamp for 10 hours per day or by replacing ten 100-watt incandescent lamps used for one hour each day with ten 25-watt CFLs.

[41] Average savings of 1.61% during the first seven months is slightly greater than the average savings over the same period estimated for other utility home energy reports programs. See Allcott, H. (2011). Social Norms and Energy Conservation. Journal of Public Economics, 95(2), 1082-1095. Also, Rosenberg, Mitchell, G. Kennedy Agnew, and Kathleen Gaffney. Causality, Sustainability, and Scalability – What We Still Do and Do Not Know about the Impacts of Comparative Feedback Programs. Paper prepared for 2013 International Energy Program Evaluation Conference, Chicago.

Table 60. Conditional Average Treatment Effects*

	kWh/day
PARTit x POSTit – Year 1 (Year 1 savings per day per home)	0.764 (0.100)
Customer fixed effects	Yes
Month-by-year fixed effects	Yes
Weather polynomials	Yes
N (homes)	58,535

* The dependent variable is average daily electricity use in the month for a treatment or control group home. The model estimated this by ordinary least squares using monthly bills between June 2012 and January 2014. Huber-White estimated standard errors (shown in parentheses) are clustered on homes.

Cadmus ran several other model specifications to check the robustness of the savings estimates with the inclusion or omission of different variables. For example, we estimated models with and without different combinations of home-fixed effects, time-fixed effects, and the weather variables. Appendix C: Residential Behavior Program Regression Model Estimates includes complete results from these other regression specifications. Little or no difference occurred in the estimated savings between specifications—an expected result, as estimates of treatment effects in large RCTs typically prove robust to changes in model specifications.

Table 61 shows the average savings per Residential Behavior Program home in PY 2013. Cadmus obtained this estimate by multiplying the estimated savings per home per day in Table 60 by the average number of program days for treated homes in PY 2013. We defined the program days for a home as the number of days between the first report date and December 31, 2013.

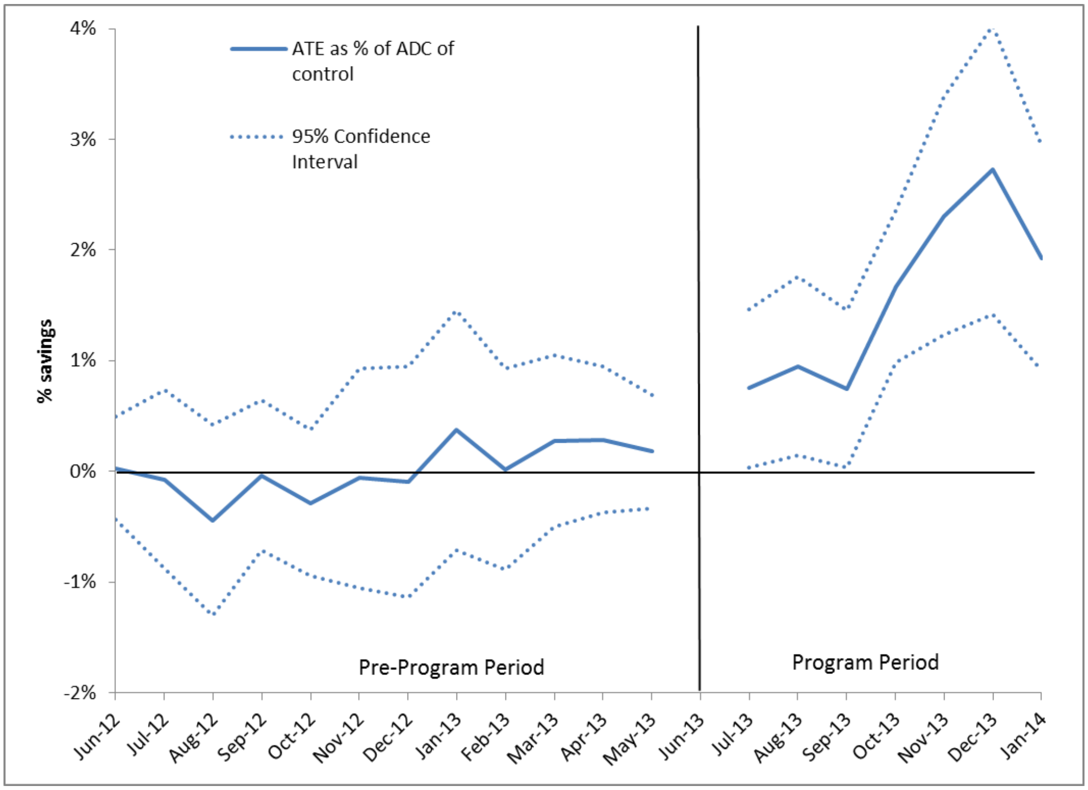
Table 61. Average Savings (kWh) Per Home for PY 2013*

Savings (kWh)	90% CI Lower Bound	90% CI Upper Bound
135	106	164

* Cadmus estimated these savings per home based on Table 61and the average number of program days per home in PY 2013.

Figure 17 shows estimates of average savings per month from June 2012 to January 2014. Cadmus obtained savings via a regression that estimated the difference in energy use between treatment and control group homes, conditional on home fixed effects. The ATE is shown as a percentage of the ADC of control group homes.

Figure 17. Average Savings Per Month*



* Cadmus obtained the savings estimates in this figure Figure 17 from a regression of ADC on home fixed effects, month-by-year fixed effects, and month-by-year fixed effects interacted with an indicator of whether that home was in the treatment group. As the model also includes home fixed effects, it was necessary to omit one month-by-year fixed effect.

As expected, there were not significant differences in average energy use between treatment and control group homes before Opower sent the first energy reports in June 2013. The 90% confidence interval includes zero in each month. The approximate equality of energy use before treatment means that we cannot reject the identifying assumption of the savings analysis: that receiving a home energy report was random and uncorrelated with expected energy use.

Treated homes started saving energy after receiving the first reports. In July and August, percentage savings were below 1% but still substantial. Percent savings increased in subsequent months. The ramping of savings in the first six months of the program is evident in Figure 17, which is typical of home energy report programs.

2.3.2. Program Savings Estimates

Table 62 reports the total program savings for Avista's Washington service territory. Cadmus estimated savings by multiplying the estimate of average daily savings per home by the total number of program days for treated homes.

Table 62. Residential Behavioral Program Energy Savings in PY 2013

Service Area	*Ex Ante* Percent Net Electricity Savings*	Evaluated Percent Net Electricity Savings	Evaluated Annual Net Electricity Savings (kWh)	90% CI Lower Bound	90% CI Upper Bound	Realization Rate
Washington	1.2%	1.61%	6,283,477	4,927,294	7,639,600	134%

* Cadmus obtained *ex ante* percent electricity savings from the 2013 *Avista Energy Efficiency Business Plan*. Avista expected electric savings from the program to be 1.4% in the first year, and Avista assumed that 40% of the first-year energy savings would occur in the first six months of the program in 2013. Given the 2013 consumption data for the control group, it follows that the savings expected for the first six months of the program are 1.2% Evaluated annual net electricity savings are based on the savings estimate shown in Table 60.

Avista expected net savings of 1.2% from the Residential Behavioral Program in PY 2013. Based on the regression analysis of monthly energy use, Cadmus determined that the program achieved net savings of 1.61%. Cadmus estimated net savings of 6,283,477 kWh in PY 2013, with a 90% confidence interval of [4,927,294 kWh, 7,639,600 kWh] or relative precision of ±21%. The program realized 134% of the expected savings.

2.3.3. Uplift Analysis

This section reports estimates of the Residential Behavioral Program's effect on participation in Avista's other efficiency programs (the uplift), as well as savings resulting from additional participation. To avoid double-counting savings, behavior program savings from participation in other efficiency programs must be subtracted from the residential portfolio savings. In estimating participation uplift and savings from uplift, Cadmus considered only those measures installed after the first reports were received.

Participant Uplift

Table 63 shows the percentage uplift estimates for each program. As noted in the methodology, uplift equals the absolute effect on the participation rate, and the percentage uplift equals the participation rate effect divided by the participation rate of control homes in PY 2013.

Table 63. Residential Behavioral Program Participation Uplift*

Program	Participation Uplift	% Participation Uplift
Appliance Recycling	0.02%	4%
Residential Rebate Programs		
Residential Conversions	0.03%	96%
Residential HVAC	-0.02%	-7%
Residential Shell	0.001%	8%

* Participation uplift derives from the estimate of change in the rate of program participation attributable to the Residential Behavior Program. The percent of participation uplift is the change in the participation rate relative to the program participation rate of control homes in PY 2013. The text below provides estimation details and data sources.

The Residential Behavioral Program increased the rate of participation of homes in the Appliance recycling, residential conversions, and residential shell programs. The behavior program increased the participation rate in these other programs by less than 1%, but because the baseline rate of participation was relatively low, the percentage uplift effect was higher, especially for residential conversion programs. Appliance recycling presented 4% uplift, residential conversion programs presented 96% uplift, and residential shell programs presented 8% uplift. This means, for example, that treatment homes were 4% more likely to participate in the ARP than control homes.[42] The behavior program did not increase participation in the Residential HVAC Rebate Program: the negative uplift occurred because control group homes participated in the program at a higher rate than treatment group homes. The difference in participation rates was not statistically significant, however.

Savings Analysis

Table 64 shows electricity savings from lift in participation in the ARP and residential rebate programs in PY 2013. The savings reflect the behavior program's effects both on participation rates and on the numbers and/or kinds of measures installed.[43] The savings from program uplift reported in Table 64 should be subtracted from the PY 2013 residential portfolio savings.

42 Percent uplift for the residential conversion program was large because the increase in the conversion rate was large relative to the baseline rate.

43 The methodology called for using net savings of efficiency measures in calculating Residential Behavioral Program savings from efficiency program uplift; however, except for the ARP, Cadmus did not derive net-to-gross values for program measures. Instead, we used adjusted gross savings estimates based on field estimates of utilization and installation rates to calculate uplift savings. For consistency across programs, we used the adjusted gross savings for the APR.

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Table 64. Residential Behavior Program Electricity Savings from Program Uplift

Program	Washington PY 2013	
	Home (kWh)	Total Savings (kWh)
Appliance Recycling	0.16	7,416
Residential Rebate Programs		
Residential Conversions	1.48	56,702
Residential HVAC	-0.06	-2,799
Residential Shell	0.03	1,635
Total	**1.61**	**62,954**

Participation in the Appliance Recycling and Residential Rebate programs resulted in savings of 62,954 kWh. The majority of uplift savings derived from residential conversions of electricity to gas. To avoid double counting, the savings from uplift must be subtracted from evaluated savings for the electricity efficiency portfolio, the behavior program, or other efficiency programs from PY 2013.

2.3.4. Evaluated Net Savings Adjustment

shows the Residential Behavioral Program adjusted net savings for PY 2013. The adjusted savings are the difference between the program evaluated net savings and estimated savings from program uplift. The adjusted net program savings in PY 2013 were 6,220,493 kWh.

Table 65 shows the Residential Behavioral Program adjusted net savings for PY 2013. The adjusted savings are the difference between the program evaluated net savings and estimated savings from program uplift. The adjusted net program savings in PY 2013 were 6,220,493 kWh.

Table 65. Residential Behavioral Program Adjusted Net Savings in PY 2013

Service Area	Evaluated Net Electricity Savings (kWh/yr)	Adjusted Net Electricity Savings (kWh/yr)
Washington	6,283,447	6,220,493

2.4. *Behavior Program Conclusions*

Analysis of the monthly electric bills of treatment and control homes during the first seven months of the program led to the following findings about Residential Behavior Program savings in PY 2013:

- Homes in Washington saved on average 0.764 kWh (1.61%) per day. The percentage savings were significantly higher than expected (1.2%).
- The program achieved total electricity savings of 6,283,447 kWh. The relative precision of the electricity savings estimate was ±21% with 90% confidence.
- The program generated percentage savings at a slightly higher rate than the normal range for energy reports programs.

Analysis of Avista's energy-efficiency program data resulted in the following findings about the Residential Behavior Program effects on other efficiency program participation and savings:

- The Residential Behavior Program lifted the rate of participation in the ARP, residential conversions, and residential shell programs. Percent uplift for conversion was large because of the low baseline rate of conversions.
- The total Residential Behavior Program electricity savings from efficiency program uplift was 62,954 kWh, or 1.0%.
- Savings from efficiency program uplift are counted in the Residential Behavior Program regression-based estimate of savings and the savings of the other programs. To avoid double counting, the uplift savings must be subtracted from the evaluated savings for the electric portfolio or for the Residential Behavior Program.
- After adjusting net electricity savings for program uplift, the program saved 6,220,493 kWh.

2.5. Behavior Program Recommendations

Based on the analysis, Cadmus makes the following recommendations:

- Avista should continue to promote its efficiency programs in the energy reports, as the reports increase both the rate of efficiency program participation and savings.
- Avista should consider performing additional research about the peak-coincident demand savings from the behavior program to determine whether it is cost-effective relative to existing residential load control programs.[44]

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[44] Research would require analysis of high frequency (15 minute or one hour interval) energy use data for a large number of treatment group and control group homes. For an example of such an analysis, see Stewart, James, 2013. Peak-Coincident Demand Savings from Residential Behavior-Based Programs: Evidence from PPL Electric's Behavior and Education Program. Available at *http://escholarship.org/uc/item/3cc9b30t*.

3. Nonresidential Impact Evaluation

3.1. Introduction

Through its nonresidential portfolio of programs, Avista promotes the purchase of high-efficiency equipment for commercial utility customers. Avista provides rebates to partially offset the difference in cost between high-efficiency equipment and standard equipment.

The nonresidential electric portfolio has 11 programs in three major categories: prescriptive, Energy Smart Grocer, and Site-Specific (custom). The programs are described below.

Prescriptive Commercial Clothes Washer

To encourage customers to select high-efficiency clothes washers, this program is targeted to nonresidential electric and natural gas customers in multifamily or commercial laundromat facilities. Avista streamlined the prescriptive program approach to reach customers quickly and effectively and to promote ENERGY STAR or Consortium for Energy Efficiency (CEE)-listed units.

Prescriptive Commercial Windows and Insulation

Beginning in January 2011, Avista has processed the installation of commercial insulation through a prescriptive program in addition to the site-specific program. Projects are eligible for the Prescriptive Commercial Windows and Insulation Program when they have:

- Wall insulation of less than R-4 that is improved to R-11 or better
- Attic insulation of less than R-11 that is improved to R-30 or better
- Roof insulation of less than R-11 that is improved to R-30 or better

Prescriptive Food Service

Applicable to nonresidential electric and gas customers with commercial kitchens, Avista provides direct incentives to customers who choose high-efficiency kitchen equipment though this program. The equipment must meet either ENERGY STAR or CEE tier levels (depending on the unit) to qualify for an incentive.

Prescriptive Green Motors Initiative

Operated in partnership with The Green Motors Practices Group[45], Avista provides education through this program to foster the organization and promotion of member motor service centers' commitment to energy-saving shop rewind practices for motors ranging from 15 HP to 500 HP.

Prescriptive Lighting

Since there is a significant opportunity for lighting improvements in commercial facilities, Avista offers direct financial incentives to customers who increase the efficiency of their lighting equipment through this program. The rebate is available to existing commercial and industrial electric customers whose

[45] http://www.greenmotors.org/

facilities on rate schedules 11 or above. Avista provides pre-determined incentive amounts for 38 measures, including:

- T12 fluorescent to T8 fluorescent lighting
- High bay, high-intensity discharge lighting to T5 fluorescent or T8 fluorescent
- High bay, high-intensity discharge lighting to induction fluorescent
- Incandescent to CFL or cold cathode fluorescent
- Incandescent to LED
- Incandescent exit signs to LED exit signs

Prescriptive Motor Controls HVAC

The use of single-speed motors to drive fans or pumps often provides the opportunity to save energy through the use of a VFD. A VFD can convert a single-speed motor to variable speed motor with no modification to the motor itself. This can be an efficient way to convert constant volume air systems into variable volume systems, for example. VFDs are readily available for motors from 1 HP to 300 HP and are easily installed directly into the power line leading to the motor, replacing the existing motor starter. Avista provides incentives for the installation of VFDs.

Many fan and pump systems have a cost-effective application for VFDs. Quite often these systems have a variable flow rate through the use of throttling devices, such as valves and dampers that vary the flow. Throttling devices essentially waste excess energy to maintain a given pressure or flow, and the use of a VFD can be very cost-effective in these situations. Typical examples of systems using throttling devices are: booster pumps for domestic water, process chilled or condenser water systems, and fan discharge dampers.

Other variable flow systems use mechanical or electrical methods such as inlet vanes, outlet dampers, eddy current clutches, hydraulic couplings, or variable pitch pulleys to vary the speed of the fan or pump. These are more efficient than throttling devices, but not as efficient as VFDs. Some fan and pump systems that currently have a constant flow may be converted to variable flow systems through modifications to the system.

Prescriptive PC Network Controls

Computers that remain in a full-power state when idle can waste significant energy, especially for customers with numerous PCs. Through this program, available to nonresidential electric customers, Avista provides an incentive for the installation of a network-based power management software solution that manages the power of networked PCs.

Prescriptive Standby Generator Block Heater

Most block heating technology employs natural convection within the engine block system to drive circulation—more commonly known as thermosiphon. Avista promotes the replacement of thermosiphon-style engine block heaters with pump driven circulation units, which reduces the overall block temperature. Because this replacement also decreases the heat transfer rate from the block to the environment, it can reduce overall block heater energy consumption, which is tied to the circulation method.

Because thermosiphon heaters require temperature variation to drive circulation, warmer coolant rises to the top of the block and colder coolant descends to the lower sections of the block. The coolant in the lower portions of the block must meet the minimum block temperature requirements, which means the coolant in the upper parts of the block will exceed the minimum temperature requirements. A pump driven heater does not require a temperature difference to drive flow, leading to a more uniform coolant temperature throughout the block. This reduces the overall average block temperature and minimizes the driving force affecting heat transfer.

Renewables

Avista provides prescriptive incentives for residential and nonresidential projects where photovoltaic (solar electric) systems and/or wind turbines are installed.

Energy Smart Grocer

Refrigeration has high potential for energy savings, but is 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 also providing guidance as to the amount of savings they can achieve. A field energy analyst offers technical assistance to customers, produces a detailed report of the potential energy savings at their facility, and guides them through the program process from inception through the payment of incentives for qualifying equipment.

Site Specific

The Site-Specific Program is for nonresidential measures that are not addressed by any of the prescriptive applications, but must be considered based on their project-specific information. For a measure to be considered, it must have demonstrable kWh and/or therm savings. These measures are available to all commercial, industrial, or pumping customers that receive electric or natural gas service from Avista.

Electric and saving measures included in the program are:

- Site-Specific HVAC
  - HVAC Combined
  - HVAC Cooling
  - HVAC Heating
  - Multifamily Measures
- Site-Specific Lighting
  - Lighting Exterior
  - Lighting Interior
- Site-Specific Other

- Appliances
- Compressed Air
- Green Motors Rewind
- Industrial Process
- Motor Controls Industrial
- Standby Generator Block Heater

- Site-Specific Shell

Avista implements the Site-Specific Program and prescriptive programs, while PECI implements the Energy Smart Grocer Program. 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. Throughout the program, Avista manages projects by reviewing and approving applications at all stages of the process, calculating project savings, and populating the database with relevant information.

3.2. Methodology

Cadmus designed the impact evaluation to verify reported program participation and estimate energy savings. In the impact evaluation, we determined gross savings through engineering calculations, verification site visits, metering, and some project-level billing analysis.

We reviewed Avista's reported gross energy savings and available documentation, such as audit reports and savings calculation work papers, for a sample of sites, giving particular attention to the calculation procedures and documentation for savings estimates. We also verified the appropriateness of Avista's analyses to calculate savings, as well as the operating and structural parameters of the analyses. We then determined gross evaluated energy savings through site visits and engineering calculations for a sample of projects.

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 any changes to the operating parameters since the measures were first installed. We also interviewed facility staff about their experiences and any additional benefits or shortcomings of the installed system. We used the savings realization rates from site visits to estimate savings and develop recommendations for future studies.

3.2.1. 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 shown in Table 66. We used preliminary program population data provided by Avista, and determined we needed to conduct measurement and verification on 107 sites. We anticipated achieving 90/10 precision at the overall nonresidential portfolio level through the targets for each stratum.

Cadmus selected both a census and random sample for each stratum. The census projects represented a small number of participants with large savings impacts in the stratum. The cutoff for the census savings for each stratum is shown in Table 67. We visited all sites with reported savings above this census level. In each stratum, we also randomly selected additional participants from the remaining population of projects.

Table 66. Proposed PY 2012-PY 2013 Nonresidential Evaluation Activities

Stratum	Precision Target	Proposed Site Visits
Prescriptive	90/20	26
Energy Smart Grocer	90/20	13
Site-Specific HVAC	90/20	25
Site-Specific Lighting	90/20	21
Site-Specific Other	90/20	15
Site-Specific Shell	90/20	7
Total	**90/10**	**107**

Table 67. Census-Level Cutoff by Stratum

Stratum	Reported Savings (kWh)
Prescriptive	300,000
Energy Smart Grocer	300,000
Site-Specific HVAC	500,000
Site-Specific Lighting	500,000
Site-Specific Other	500,000
Site-Specific Shell	N/A

In Table 68, we show the precision achieved for the actual number of evaluation activities for electric measures. 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 68. Final PY 2012-PY 2013 Electric Evaluation Activity Sample

Stratum	Achieved Precision	Completed Metering Projects	Completed Site Visits
Prescriptive	90/17	7	25
Energy Smart Grocer	90/5	2	23
Site-Specific HVAC	90/6	1	29
Site-Specific Lighting	90/11	5	20
Site-Specific Other	90/3	7	13

Site-Specific Shell	90/11	0	10
Total	**90/9**	**22**	**120**

As explained above, we selected projects with large reported savings (census-level) to use in our analysis. In selecting the rest of our sample, we found that the extract from Avista's database did not include addresses that would enable us to identify if projects performed for the same company were at different sites, nor did it include information on the specific measures installed. Therefore, the sampling process was iterative. From the extract, we completed the final primary and backup samples by selecting projects of interest and asking Avista for additional data that we received and used to determine how many and what types of projects were at various locations.

We also found that the database extract provided program-level data, but not measure-level information. Therefore, we attempted to verify savings for every incented measure at each site, regardless of whether it achieved gas or electric savings. We were unable to determine whether we evaluated an accurate distribution of measure types within each program. That type of distribution would have required an exhaustive review of project files, which was not within the scope of the evaluation.

3.2.2. Data Collection

Cadmus collected data from 22 metering sites and 120 on-site verifications. For each, we first conducted a document review to determine measure type, quantity, operational parameters, and calculation methodology.

Document Review

Avista provided Cadmus with documentation of the energy-efficiency projects undertaken at the sample sites. We reviewed program forms, the tracking database, audit reports, and savings calculation work papers for each rebated measure. In our review of calculation spreadsheets and energy simulation models relevant to the evaluation effort, we paid particular attention to calculation procedures and documentation for savings estimates.

Cadmus reviewed each application for the following information:

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

Short-Term and Long-Term Metering

Cadmus performed short-term (two weeks) metering for projects within the nonresidential electric portfolio. We installed power meters and light loggers to obtain operational data to inform energy-savings estimates. The metering and analysis requirements were specific to the measure category.

Site Visits

Cadmus performed on-site visits to verify measure installations, collect primary data to calculate savings impacts, and interview facility staff.

We accomplished three primary tasks during the on-site visits:

1. We verified the implementation status of all measures for which customers received incentives. We verified that the energy-efficiency measures were installed correctly and still functioned properly, and also verified the operational characteristics of the installed equipment, such as temperature setpoints and operating hours.
2. We collected the physical data, such as cooling capacity or horsepower, and analyzed the energy savings realized from the installed improvements and measures.
3. We conducted interviews with facility personnel to obtain additional information on the installed system to supplement data from other sources.

3.2.3. Engineering Analysis

The prescriptive programs and the Site-Specific Program required significantly different methods of analysis.

Overview

Our procedures for verifying savings through an engineering analysis depended on the type of measure being analyzed. The analytical methods included in this evaluation are listed below and described in the following sections:

- Prescriptive deemed savings
- Short-term metering
- Billing analysis
- Calculation spreadsheets
- Energy simulation modeling

Prescriptive Deemed Savings

For most prescriptive measures, Cadmus verified the deemed savings estimates that Avista used. We focused our verification activities on the installed quantity and equipment nameplate data and on the proper installation of equipment and operating hours. Where appropriate, we used data from site verification visits to re-analyze prescriptive measure savings using Avista's Microsoft Excel® calculation tools, ENERGY STAR calculation tools, RTF deemed savings, and other secondary sources.

Short-Term Metering

Depending on the site and measure, Cadmus determined whether short-term metering (over a period of two weeks) or long-term metering (over a period of several months) would be most effective for achieving precision in that particular project's energy-saving calculations. Specific metering details for each measure category are discussed in the Results and Findings section. The installed metering equipment encompassed:

- HOBO light loggers for 12 lighting projects.
- Energy Logger Pros for metering two Energy Smart Grocer projects: anti-sweat heater controls and refrigeration compressors.
- Energy Logger Pros for metering fan usage for one site-specific HVAC cooling project.
- Energy Logger Pros for metering energy use for seven compressed air and industrial process motor projects.

The analysis for each project varied by the measure and metering data obtained.

Billing Analysis

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

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

We followed a modified PRISM approach when developing the analysis models, which normalized all dependent and independent variables for the days in each billing period and allowed for model coefficients to be interpreted as average daily values. We used this methodology to account for differences in the length of billing periods. For each project, we modeled the ADC in kWh as a function of some combination of average standing base load, HDDs, and (where appropriate) daily consumption.

For each site, Cadmus estimated two demand models: one for the pre-period and one for the post-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.

Cadmus calculated three scenarios after estimating model coefficients for each site. First, we estimated a reference load for the previous 12 billing cycles using the pre-installation period model. This scenario extrapolated the counterfactual consumption, which is what the consumption would have been in absent the program. We calculated the energy savings as the difference between the counterfactual scenario and the actual consumption.

Cadmus then estimated two normalized scenarios: one using the pre-model, and one using the post-model. We used 15-year TMY3 data in both scenarios as the annual HDD and mean annual values for the usage data. The difference between these two scenarios represents the long-term expected annual savings.

Calculation Spreadsheets

Avista developed calculation spreadsheets to analyze energy savings for a variety of measures, including building envelope measures such as ceiling and wall insulation. Calculation spreadsheets require input of relevant parameters such as square footage, efficiency value, HVAC system details, and location details. Avista programmed algorithms that estimate energy savings from these data. For each spreadsheet, we reviewed the input requirements and output estimates and determined if the approach was reasonable.

Energy Simulation Modeling

Avista determined savings for many site-specific HVAC and shell projects with energy simulation modeling, choosing eQuest software because of 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 measure. We updated the models as necessary based on our site verification data.

3.3. Results and Findings

3.3.1. Overview

Cadmus adjusted gross savings estimates based on our evaluated findings. Further details by program are discussed in the following sections.

For most projects, the documentation was readily available and the measures performed close to expectations. However, some project files contained excessive 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. Cadmus contacted the participants regarding these measures, but the lack of clarity sometimes caused them to be confused and dismayed.

3.3.2. Prescriptive

Cadmus evaluated savings for a sample of sites across eight prescriptive programs and the Renewables program. Table 69 and Table 70 show our evaluated results by program. Specific evaluation details are described in each program subsection below.

Table 69. Evaluated Results for Nonresidential Prescriptive Sample - Combined States

Program	Number of Measure Installations	Evaluated Sample	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Prescriptive Commercial Clothes Washer	2	0	N/A	N/A	N/A
Prescriptive Commercial Windows and Insulation	97	3	1,866	1,168	63%
Prescriptive Food Service	154	3	11,136	16,470	148%
Prescriptive Green Motors Rewind	35	1	2,254	1,376	61%
Prescriptive Lighting	4,784	19	3,150,101	2,582,336	82%
Prescriptive Motor Controls HVAC	24	3	1,069,027	1,035,447	97%
Prescriptive PC Network Controls	3	1	21,000	0	0%
Prescriptive Standby Generator Block Heater	42	1	1,849	1,849	100%
Renewables	11	0	N/A	N/A	N/A
Total	**5,827**	**31**	**4,257,233**	**3,638,646**	**85%**

Table 70. Evaluated Results for Nonresidential Prescriptive Sample – Washington Only

Program	Number of Measure Installations	Evaluated Sample	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Prescriptive Commercial Clothes Washer	2	0	N/A	N/A	N/A
Prescriptive Commercial Windows and Insulation	74	1	207	207	100%
Prescriptive Food Service	114	3	11,136	16,470	148%
Prescriptive Green Motors Initiative	6	0	N/A	N/A	N/A
Prescriptive Lighting	2,978	12	375,747	363,106	97%
Prescriptive Motor Controls HVAC	18	3	1,069,027	1,035,447	97%
Prescriptive PC Network Controls	2	0	N/A	N/A	N/A
Prescriptive Standby Generator Block Heater	36	1	1,849	1,849	100%
Renewables	8	0	N/A	N/A	N/A
Total	**3,238**	**20**	**1,457,966**	**1,417,079**	**97%**

Overall, the prescriptive programs' analysis achieved a level of 90/17 confidence and precision. Cadmus identified several necessary adjustments to the reported savings for the prescriptive programs. We note that these calculations often rely on reported equipment and operations data, which may vary from the parameters identified during on-site verification visits and metering.

Our adjustments decreased savings by 10%. Typical adjustments were to correct equipment efficiency, fuel type, operating schedules, and/or operating parameters as described below:

- Cadmus used lighting logging and verification data to confirm or adjust operating hours for lighting projects. These adjustments, in addition to those made from verified fixture counts, reduced or increased energy savings by varying amounts.
- Avista implementation staff made a data entry error on one census-level lighting project. The calculation workbook listed 646 baseline fixtures listed instead of 64. This data entry error significantly overestimated baseline consumption, and the resulting realization rate was 3%. However, Avista paid the correct incentive for the project.
- One motor controls HVAC project was provided with incentives for two pump VFDs. One of the pumps was redundant, as only one is operating at any given time. The realization rate for this project was 50%.
- One food service equipment refrigerator had a larger volume than reported, which increased savings. The resulting realization rate was 157%.
- Cadmus evaluated one PC network controls project. The participant installed the system in 2009 and applied for an incentive in December 2009. The project files show that Avista was still attempting to obtain output reports from the control system to verify savings during 2011 and 2012. The incentive was approved in early 2012. Cadmus contacted the facility in October 2012, but learned the participant had deactivated the PC network control system. As a result, we did not assign any savings for this project.

3.3.3. Energy Smart Grocer

Cadmus performed on-site or metering visits at 26 Energy Smart Grocer Program projects, which represented a mixture of refrigeration case lighting and refrigeration equipment measures. We calculated an overall realization rate for all projects in Idaho and Washington, then we applied the resulting realization rate to the savings for each state. Table 71 lists the two measure types we evaluated and the number of projects and reported savings. Table 72 shows our evaluated results for the program.

Table 71. Energy Smart Grocer Program Measure Types and Projects Evaluated

Measure Type	Idaho		Washington		Total	
	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)
Case Lighting	2	88,535	9	24,012	11	112,547
Industrial Process	6	477,441	8	972,020	14	1,449,461
Total	**8**	**565,976**	**17**	**996,032**	**25**	**1,562,008**

Table 72. Evaluated Results for Nonresidential Energy Smart Grocer Program Sample

State	Total FY12-13 Measure Installations	Evaluated Sample	Gross Reported Sample Savings (kWh)	Gross Evaluated Sample Savings (kWh)	Sample Realization Rate
Idaho	191	8	565,976	503,604	89%
Washington	485	17	996,032	1,012,166	102%
Total	**676**	**25**	**1,562,008**	**1,515,770**	**97%**

Overall, the Energy Smart Grocer analysis achieved a level of 90/5 confidence and precision. Cadmus identified several necessary adjustments to the reported savings for the Energy Smart Grocer Program. We note that these calculations often rely on reported equipment and operations data, which may vary from the parameters identified during on-site verification visits and metering.

Our adjustments decreased savings by 5%. Typical adjustments were to correct equipment efficiency, operating schedules, and/or operating parameters as described below:

- At one large site, we found that floating head pressure controls were not enabled on the medium temperature rack. Energy management system (EMS) data showed the controls had not been in operation for at least three weeks, the limit of the EMS trending history. The reduction in energy savings resulted in a 51% realization rate.
- Cadmus applied a PECI benchmarking work paper[46] to evaluate savings for several doors added to medium temperature walk-in cases. The adjustment resulted in a decrease in electricity savings, for a realization rate of 50%.
- Cadmus found variation in actual installed LED case lighting quantities during site visits at two retail chain stores. The stores installed fewer low output LED case lights and more high output LED case lights than reported. This increased savings, and the resulting realization rate was 112%.

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

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3.3.4. Site Specific

Cadmus performed site visits for 84 projects, which represent a variety of measure types. Cadmus calculated an overall realization rate for all projects in Idaho and Washington, then we applied the resulting realization rate to the savings for each state. Table 73 lists the different measure types we evaluated, as well as the number of projects and reported savings. Table 74 shows our evaluated results for the program.

Table 73. Site-Specific Measure Types and Projects Evaluated

Measure Type	Idaho		Washington		Total	
	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)
Site-Specific HVAC	10	1,345,068	20	4,708,338	30	6,053,406
Site-Specific Lighting	8	1,990,605	17	6,766,338	25	8,756,943
Site-Specific Other	4	3,460,866	16	2,864,862	20	6,325,728
Site-Specific Shell	5	149,317	5	359,772	10	509,089
Total	**27**	**6,945,856**	**58**	**14,699,310**	**85**	**21,645,166**

Table 74. Evaluated Results for Nonresidential Site-Specific Sample

State	Total FY12-13 Measure Installations	Evaluated Sample	Gross Reported Sample Savings (kWh)	Gross Evaluated Sample Savings (kWh)	Sample Realization Rate
Idaho	214	27	6,945,856	7,401,914	107%
Washington	434	58	14,699,310	14,024,358	95%
Total	**648**	**85**	**21,645,166**	**21,426,272**	**99%**

Overall, the Site-Specific Program achieved a level of 90/10 confidence and precision. Cadmus identified many adjustments to Site-Specific Program project reported savings. Site-specific projects tend to be more complex, with energy savings parameters and impacts that are more difficult to estimate. In addition, the calculations often rely on participant-supplied building, equipment, and operations data, which may vary from parameters identified during an on-site verification visit.

In aggregate, the adjustments noted by Cadmus increased savings by 1.5%, driven primarily by the high realization rate for lighting projects.

Typical adjustments made to the savings values included corrections to equipment efficiency, operating schedules, temperature setpoints, and building parameters. Cadmus also identified errors in simulation models and calculation estimates, which resulted in adjustments. Specific adjustments are identified by major measure category below.

Site-Specific HVAC Adjustments

- Cadmus determined that Avista overestimated cooling savings for one project. We applied an equivalent full load hours algorithm supported by RTF analysis. This resulted in lower savings, for a realization rate of 41%.
- Avista adjusted the furnace calculator on a project to calculate heat pump savings, but resulting values were too high. The result appears to account for the per-unit consumption instead of energy savings. Cadmus benchmarked results against ENERGY STAR, and used the more conservative value. This led to a 14% realization rate.
- Cadmus conducted a utility billing analysis on one small heat pump project, which revealed no electricity savings resulting from the project and resulted in a realization rate of 0%.
- The heating load appeared to have been overestimated on two large, partially-occupied, multifamily new construction projects. The utility billing data showed an average 65% of expected consumption when normalized to full occupancy.
- Cadmus engineers found issues with simulation modeling by one contractor on four projects. The models had an excessive portion of simulation hours outside of the throttling range. The unmet load hours outside the throttling range indicate zones in the model, which do not receive sufficient heating or cooling. This value should be less than 5% (as recommended by the U.S. Green Building Council's Leadership in Energy and Environmental Design). Larger values call the integrity of the model into question. These four evaluated projects had unmet load hour issues ranging from 10.36% to 99.9% for any system zone outside throttling range. However, the contractor had calibrated the models to the utility billing data. Overall, the energy savings and model energy consumption appeared to be within a reasonable range. An example of the issue from an eQuest simulation output file is shown in Figure 18.

Figure 18. eQuest Output File Showing Throttling Range Issue

```
Sloan Part 2                                                        DOE-2.2-47d   12/08/2010    9:10:30  BDL RUN  1

REPORT- BEPS Building Energy Performance                                    WEATHER FILE- Spokane      WA TMY2
---------------------------------------------------------------------------------------------------------------------

                      TASK     MISC    SPACE    SPACE    HEAT    PUMPS    VENT    REFRIG  HT PUMP  DOMEST    EXT
            LIGHTS   LIGHTS   EQUIP   HEATING  COOLING  REJECT   & AUX    FANS   DISPLAY  SUPPLEM  HOT WTR  USAGE    TOTAL
           -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  --------

EM1  ELECTRICITY
     MBTU   1152.2      0.0   1353.1     17.2    321.6      0.0     58.6   1426.4      0.0      0.0      0.0      0.0   4329.2

FM1  NATURAL-GAS
     MBTU      0.0      0.0      0.0   5509.6      0.0      0.0      0.0      0.0      0.0      0.0    156.4      0.0   5666.1
           =======  =======  =======  =======  =======  =======  =======  =======  =======  =======  =======  =======  ========

     MBTU   1152.2      0.0   1353.1   5526.9    321.6      0.0     58.6   1426.4      0.0      0.0    156.4      0.0   9995.3


              TOTAL SITE ENERGY      9995.27 MBTU     92.0 KBTU/SQFT-YR GROSS-AREA     92.0 KBTU/SQFT-YR NET-AREA
              TOTAL SOURCE ENERGY   18653.63 MBTU    171.7 KBTU/SQFT-YR GROSS-AREA    171.7 KBTU/SQFT-YR NET-AREA

              PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 54.1
              PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

              NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
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Site-Specific Lighting Adjustments

Cadmus evaluated a non-census sample of site-specific lighting projects using a combination of light logging and verification data. On average, the results indicated reasonable reported values, and the measure category had a realization rate of 98%.

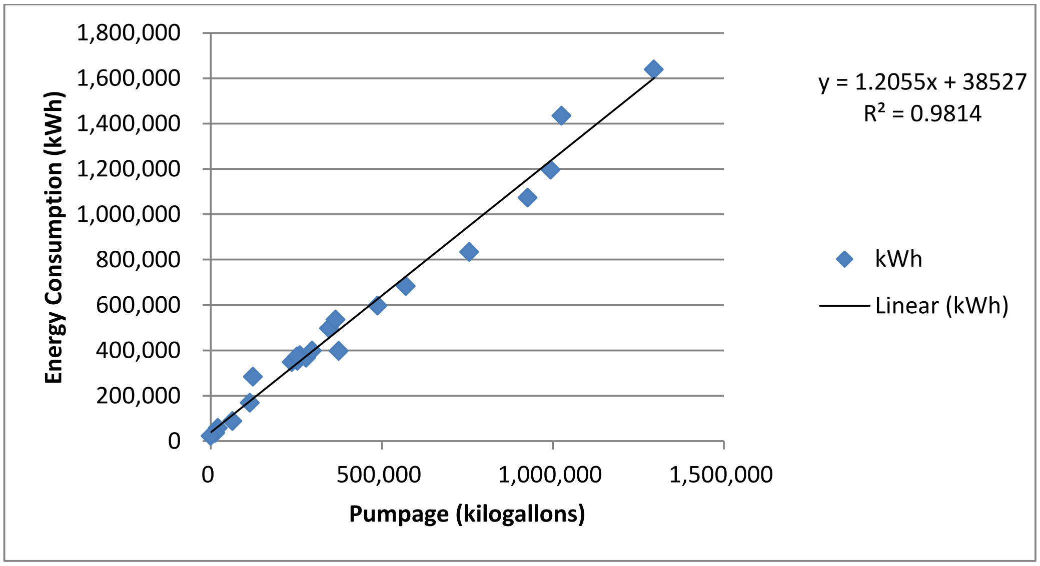
- Cadmus evaluated the largest project (with 2,857,210 kWh of reported savings) through extensive verification and light logging. The evaluated results were nearly identical to Avista's reported values, resulting in a 100.5% realization rate.
- On one hotel project, Avista assumed 25 operating hours per week for wall sconces. Light logging revealed that the fixtures were never turned off. This increased the baseline and retrofit energy consumption. Therefore, it also increased energy savings, resulting in a 306% realization rate.
- On one small new construction project, the installed lighting power density exceeded code requirements, therefore no savings could be achieved and the realization rate was 0%.

Site-Specific Other Adjustments

- Cadmus found that Avista applied an incorrect baseline for a refrigerated dryer on a compressed air application. The baseline listed a desiccant dryer, which would actually consume far more energy than Avista estimated. The refrigerated dryer is the industry standard, and typically represents the baseline. Thus, no savings were achieved for this project.

We identified issues with the calculations for a census-level project for a water pump replacement at one station. The participant reported savings using the change in efficacy (kilogallons pumped per kWh) across four stations. The baseline was difficult to define because the retrofit station shares its Avista utility meter with another station. However, that station's impact was not included in efficacy calculation. Each station's pumpage varied considerably between baseline and retrofit conditions. The retrofit station pumped much more during the post-installation period than the baseline period. A linear regression (Figure 19) showed a strong correlation between retrofit pumpage and energy consumption. Based on our analysis, we determined the project should achieve at least the reported level of savings, and evaluated the savings at the reported level for a 100% realization rate.

Figure 19. PY 2011-PY 2012 Retrofit Monthly Pumpage vs. Electric Consumption



- Cadmus metered two industrial process motor projects and one compressed air project, and accepted Avista's metering data for baseline energy consumption. Our metering data indicated lower retrofit energy consumption than Avista's retrofit data. This would increase energy savings. We compared the production data for both periods, and could not reconcile the difference in energy consumption based on that data. We therefore combined the Avista and Cadmus retrofit metering data to establish the normalized retrofit energy consumption. The realization rate for these three projects was 86%.
- Cadmus adjusted savings for a small refrigeration circulation pump project to match actual operating hours. This resulted in a reduction in energy savings, with a realization rate of 33%.
- Cadmus evaluated the remaining site-specific other projects using a combination of utility billing and verification data. On average, the results indicated the achieved energy savings were slightly less than the reported values.

Site-Specific Shell Adjustments

- One shell project had low evaluated savings based on the initial calculation methods. Avista funded the switch from electric resistance to natural gas heating, but did not update the shell calculator with new fuel, and calculated shell savings in terms of electricity. The resulting realization rate was 35%.
- Cadmus performed a site visit at one school with two site-specific shell projects. We found that the site turned off their HVAC system completely during the summer months when school was not in session. The Avista energy-savings estimate relied on the assumption that air conditioning would operate during the summer months. The required an adjustment to reduced energy savings, with a resulting realization rate of 34% for both projects combined.

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Cadmus evaluated the remaining site-specific shell projects using verification data with the applicable Avista savings calculators. In general, Cadmus found the reported shell quantities and properties did not vary much from verified values, and the savings calculators produced reasonable results. The remaining results indicated that the achieved energy savings were equal to the reported values.

3.3.5. Extrapolation to Program Population

For our evaluation of the nonresidential electric programs, we selected sites that could provide the most impactful information. 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 claimed-to-verified 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:

$$RR_{ij} = \frac{Verified_{ij}}{Claimed_{ij}};\ for\ measure\ j\ at\ site\ i$$

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 verified savings to the sum of claimed savings from the randomly selected sample for each measure type:

$$RR_j = \frac{\sum_i Verified_i}{\sum_i Claimed_i};\ for\ measure\ j\ across\ all\ sample\ sites$$

We calculated the population verified savings for non-census projects by multiplying the measure type realization rate from the random sample by the claimed savings for the non-census population of each measure type:

$$\sum_k Verified_k = RR_j\, x \sum_k Claimed_k;\ for\ measure\ j\ across\ all\ sites\ in\ measure\ population$$

Where:

k	=	total population for measure type 'j'

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

$$RR_l = \frac{\sum_k Verified_k}{\sum_k Claimed_k}; \; for\ the\ population\ (all\ sites\ and\ measures)$$

Where:

l = total program population

Cadmus summed these values to determine the total adjusted evaluated savings and program-level realization rates for the programs as a whole and for Idaho and Washington, as shown in Table 75 and Table 76. The overall portfolio gross realization rate was 97%.

Table 75. PY 2012-PY 2013 Electric Gross Program Realization Rates – Combined States

Program	Gross Sample Reported Savings (kWh)	Gross Sample Evaluated Savings (kWh)	Realization Rate*	Gross Program Reported Savings (kWh)	Gross Program Evaluated Savings (kWh)
Prescriptive	4,257,233	3,638,646	95%	6,791,118	6,448,089
Energy Smart Grocer	1,562,008	1,515,770	92%	22,560,559	20,652,917
Site-Specific HVAC	6,053,406	5,229,048	91%	3,367,537	3,053,079
Site-Specific Lighting	8,756,943	9,141,338	110%	9,596,933	10,589,164
Site-Specific Other	6,325,728	6,659,011	100%	4,693,462	4,696,253
Site-Specific Shell	509,089	396,875	78%	82,037	63,954
Total	**27,464,407**	**26,580,688**	**97%**	**47,091,646**	**45,503,456**

* Realization rates vary from the ratio of evaluated to reported savings due to the impact of census-level projects.

Table 76. PY 2012-PY 2013 Electric Gross Program Realization Rates – Washington

Program	Gross Sample Reported Savings (kWh)	Gross Sample Evaluated Savings (kWh)	Realization Rate*	Gross Program Reported Savings (kWh)	Gross Program Evaluated Savings (kWh)
Prescriptive	1,457,966	1,417,079	91%	36,327,974	32,985,879
Energy Smart Grocer	996,032	1,012,166	95%	7,745,984	7,339,802
Site-Specific HVAC	4,708,338	3,976,437	86%	6,749,168	5,786,311
Site-Specific Lighting	6,766,338	6,709,814	110%	14,646,188	16,067,671
Site-Specific Other	2,864,862	3,044,525	104%	4,961,496	5,174,412
Site-Specific Shell	359,772	293,582	78%	379,131	295,562
Total	**17,153,308**	**16,453,603**	**96%**	**70,809,941**	**67,649,637**

* Realization rates vary from the ratio of evaluated to reported savings due to the impact of census-level projects.

3.4. Nonresidential Conclusions

Cadmus evaluated 142 of 6,476 measures installed through the programs, representing 16% of reported savings.

In general, Cadmus determined that Avista implemented the programs well. The overall portfolio achieved a 96% realization rate when comparing gross evaluated savings to gross reported savings.

Cadmus identified the following key issues that led to adjusted energy savings:

- Metering on several industrial process measures indicated that post-installation power consumption was lower or higher than expected, which increased or decreased energy savings respectively.
- Some participants did not operate the incented equipment correctly or did not complete the improvements expected for the measure.
- Some participant post-installation heating or cooling loads did not achieve the level of projected consumption.
- Simulation models sometimes did not accurately represent the actual as-built building or system operation.
- Avista implementation staff sometimes may not have conducted a thorough analysis of energy-savings calculations provided by participants or third-party contractors for all projects.
- Avista implementation staff sometimes made errors on some projects in entering data to characterize building or measure performance.

Cadmus also found one implementation issue that affected the impact evaluation. One PC network controls project was installed in 2009, but did not provide the final data demonstrating a reduction in consumption until 2012. Avista paid the incentive in 2012, but the participant reported deactivating the system soon after.

3.5. Nonresidential Recommendations

Cadmus recommends that Avista continue to offer incentives for measure installation through the evaluated programs. We have the following recommendations for improving program energy-savings impacts and evaluation effectiveness:

- Create a quality control system to double-check all projects with savings over 300,000 kWh.
- Consider working with participants to accelerate the process of claiming energy savings and paying the project incentive. Preferably this should happen within one year of measure installation, depending on Avista's requirements for post-installation data on the particular project.
- Continue working with participants to conduct metering on baseline conditions in cases of high uncertainty.
- Avista may want to consider tracking and reporting demand reduction to better understand measure load profiles and peak demand reduction opportunities.
- Update prescriptive measure assumptions and sources on a regular basis.
- Streamline its file structure to enable reviewers more easily identify the latest documentation.
- 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 when the paid invoice does not include installation labor.
- Avista may consider adding a flag to their tracking database to automatically calculate the unit of energy savings per dollar (kWh/$ or therm/$) to provide a quick check to identify extreme outliers.
- In the case of redundancy, Avista may want to consider incenting pump projects through the Site-Specific Program to more accurately characterize the equipment operating hours.
- Avista may want to adopt modeling design guidelines to set minimum standards. The Energy Trust of Oregon provides an example on their website: http://energytrust.org/commercial/incentives/construction-renovation-improvements/custom/modeled-savings.

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4. Low Income Impact Evaluation

4.1. Introduction

Cadmus conducted a statistical billing analysis to determine evaluated savings and realization rates for energy-efficient measures installed through the low-income weatherization program in 2012. We examined energy savings at the household or participant level, rather than at the measure level. Cadmus performed billing analysis on 2012 participants who had full years of energy consumption data, before (2011) and after (2013) the weatherization period. Then we applied 2012 billing analysis results to 2013 participants to report evaluated savings across both program years.

To estimate energy savings resulting from the program, Cadmus used a pre- and post-installation, combined CSA and a 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, ensuring households have a sufficient amount of billing data, and conducting a graphical outlier analysis. A detailed discussion of the regression model used for this billing analysis is outlined below, accompanied by resulting savings.

4.1.1. Program Description

Five components, listed in Table 77, are included in the low-income weatherization Program. Local Community Action Partners (CAPs) within Avista's Washington service territory implement the 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 77. Low-Income Weatherization: 2012-2013 Electric-Efficiency Installations by Component*

Low-Income Program Component	Measure Description	Measure Installations
Shell/Weatherization	Insulation, window/door, air infiltration, programmable thermostat	309
Fuel Conversion*	Electric furnace, heat pump or water heater replacement	289
Hot Water Efficiency	High-efficiency water heater replacement	20
ENERGY STAR Appliance	High-efficiency refrigerator replacement	90
HVAC Efficiency	High-efficiency heat pump replacement, variable speed motor	7

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

4.2. 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 the reported savings from each completed installation. The data did not, however, include the quantity of measures installed (such as the total 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 NOAA for six representative stations, drawn for the corresponding time period.

4.2.1. Sampling

Cadmus began the analysis with a census of 2012 program participants. We then screened the 2012 program participant data by specific criteria (e.g., had sufficient monthly billing data, was not classified as an outlier) for use in the final analysis. In all, 82 Washington participants were included in the billing analysis: 43 non-conversion and 39 conversion participants. Cadmus defined a conversion customer as any participant who received a new gas furnace or water heater.

4.2.2. 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, detailing all gas and electric measures installed per home by CAPs.

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

To estimate energy savings from this program, Cadmus used a pre/post CSA fixed-effects modeling method using pooled monthly time-series (panel) billing data. This modeling approach corrected for differences between pre- and post-installation weather conditions, as well as for differences in usage consumption between participants (as the model included a separate intercept for each participant). The modeling approach ensured that model savings estimates would not be skewed by unusually high-usage or low-usage participants.

4.3. Data Screening and Modeling Approach

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

4.3.1. General Screens

Cadmus used the following screens to remove 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 in either the pre- or post-period (less than 1,000 kWh or more than 50,000 kWh).
- Accounts that change electric usage from the pre- or post- period by more than 90% (unless for a conversion project).[47]

4.3.2. Weather Normalization Screens

To screen the data, Cadmus used PRISM-like models for weather-normalizing pre- and post-billing data for each account, and to provide an alternate check on measure savings obtained from the CSA model. For more detail on the model specification, see Appendix E: Low-Income Weatherization – Billing Analysis Model Specification.

Table 78 and Table 79 summarize non-conversion and conversion account attrition, respectively, from the screens listed above.

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[47] 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 not expected to be attributed to program effects and can confound the analysis of consumption.

Table 78. Low-Income Weatherization: Non-Conversion Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Electric Accounts	89	100%	0	0%
Overlap Participation within Pre- or Post- Periods	69	78%	20	22%
Matched to Billing Data Provided	69	78%	0	0%
Insufficient Pre- and/or Post-Period Months	54	61%	15	17%
Insufficient Pre- and/or Post-Period Days	53	60%	1	1%
Low or High Usage in Pre- or Post-Period	53	60%	0	0%
Changed Usage Between Pre- to Post-Periods (> 90%)	52	58%	1	1%
PRISM Screen: Low R-Squared, Low Heating Usage	52	58%	0	0%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	43	48%	9	10%
Final Analysis Group	**43**	**48%**	**46**	**52%**

Table 79. Low-Income Weatherization: Conversion Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Electric Accounts	72	100%	0	0%
Overlap Participation within Pre- or Post- Periods	49	68%	23	32%
Matched to Billing Data Provided	49	68%	0	0%
Insufficient Pre- and/or Post-Period Months	44	61%	5	7%
Insufficient Pre- and/or Post-Period Days	44	61%	0	0%
Low or High Usage in Pre- or Post-Period	44	61%	0	0%
Changed Usage Between Pre- to Post-Periods (> 90%)	43	60%	1	1%
PRISM Screen: Low R-Squared, Low Heating Usage	43	60%	0	0%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	39	54%	4	6%
Final Analysis Group	**39**	**54%**	**33**	**46%**

4.3.3. Conditional Savings Analysis Modeling Approach

To estimate energy savings from this program, Cadmus used a pre/post CSA fixed-effects modeling method, 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 a separate intercept for each participant. This modeling approach ensured that model savings estimates are not skewed by unusually high usage or low usage participants. We used the following model specification to determine program-level savings. For more detail on the model specification, see Appendix E: Low-Income Weatherization – Billing Analysis Model Specification.

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4.4. Results and Findings

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

4.4.1. Billing Analysis Results

Table 80 summarizes model savings results for electric non-conversion and conversion participants of the low-income weatherization program.

Table 80. Electric Model Savings Summary

Participant Type	n	PRENAC	Change in Consumption (kWh)	Savings as Percent of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Non-Conversion	43	15,865	3,504	22%	±37%	2,223	4,785
Conversion	39	18,951	10,397	55%	±13%	9,034	11,760

The model savings averaged 3,504 kWh for each non-conversion participant and 10,397 kWh for each conversion participants. In this analysis, Cadmus determined an overall conversion estimate instead of equipment-specific estimates due to the small sample size of furnace-only and water heater-only participants at the state level. The precision estimates are 37% and 13% for non-conversion and conversion models, respectively.

Table 81 provides a distribution of the electric measures in the final model that Avista funded for participants. This distribution reveals a slightly different mix of measures for the two participant groups. Specifically, non-conversion participants had slightly higher percentages of refrigerator replacement and shell measures (e.g., doors, windows, wall insulation). Conversion participants had slightly higher percentages of air infiltration.

Table 81. Measure Distribution of Final Model Sample by Participant Type

Measures	Non-Conversion		Conversion	
	Count	Percent	Count	Percent
Air infiltration controls	30	70%	32	82%
Windows	14	33%	7	18%
Doors	17	40%	7	18%
Floor Insulation	23	53%	23	59%
Attic Insulation	19	44%	16	41%
Duct Insulation	1	2%	2	5%
Water heater replacement	4	9%	1	3%
Wall Insulation	8	19%	4	10%
T-stat (No AC)	0	0%	4	10%
Refrigerator replacement	16	37%	8	21%
Furnace conversion	0	0%	35	90%
Water heater conversion	0	0%	35	90%
Sample (n)	**43**	**100%**	**39**	**100%**

Statistical billing analysis results encompass all measure installations made at participant households, including those not paid for through Avista's program. Since local CAP agencies use a variety of funding sources to implement the low-income program, it is possible that participant homes received measures paid for by federal, state, and/or other utility dollars. Specifically, Avista does not fund CFLs offered through the program, which likely had a significant impact on the electric savings in participant homes.

4.4.2. Overall Program Results

Table 82 shows the realization rates for Washington low-income weatherization program participants.

Table 82. Low-income Weatherization: Electric Model Realization Rate Summary

Participant Type	n	PRENAC	Model Savings (kWh)	Per Participant Reported Savings (kWh)	Realization Rate	Model Savings as Percent of Pre-Usage	Expected Savings as Percent of Pre-Usage
Non-Conversion	43	15,865	3,504	2,860	123%	22%	18%
Conversion	39	18,951	10,397	7,181	145%	55%	38%

Both participant groups exceeded their expected savings and had realization rates above 100%. There were nine participants during 2013 who received electric resistance to electric heat pump conversions, which were not represented in the billing analysis sample. Cadmus used Avista's listed database savings for the heat pump conversion measures and additional non-conversion measures for these customers. Table 83 presents the overall program population savings separated by participant type and program year.

Table 83. Low-Income Weatherization: Total 2012-2013 Evaluated Program Savings

Participant Type	Year	Total Participants	Model Savings per Participant	Total Evaluated Savings (kWh)	Total Reported Savings (kWh)	Realization Rate
Non-Conversion	2012	89	3,504	250,797	204,701	123%
	2013	83	3,504	155,726	127,104	123%
Conversion	2012	72	10,397	575,332	397,361	145%
	2013	97	10,397	490,673	338,890	145%
Heat Pump Replacement*	2012	1	N/A	5,360	5,360	N/A
	2013	8	N/A	38,350	38,350	N/A
Overall		**350**	**N/A**	**1,516,238**	**1,111,766**	**136%**

* Avista funded high-efficiency electric heat pump replacements that were not included in the billing analysis participant sample (i.e., the one participant from 2012 was removed through screening process). For these measures, Cadmus used the claimed savings values listed in the Avista database.

Cadmus calculated the total program savings by multiplying the modeled realization rates by the claimed *ex ante* savings.

4.5. Comparison to Previous Billing Analysis

The results from the 2012 billing analysis indicate greater energy savings than results from the 2010 billing analysis. Table 84 compares the model results from Cadmus' 2010 and 2012 billing analyses. Both participant groups show increased energy savings and have realization rates greater than 100%.

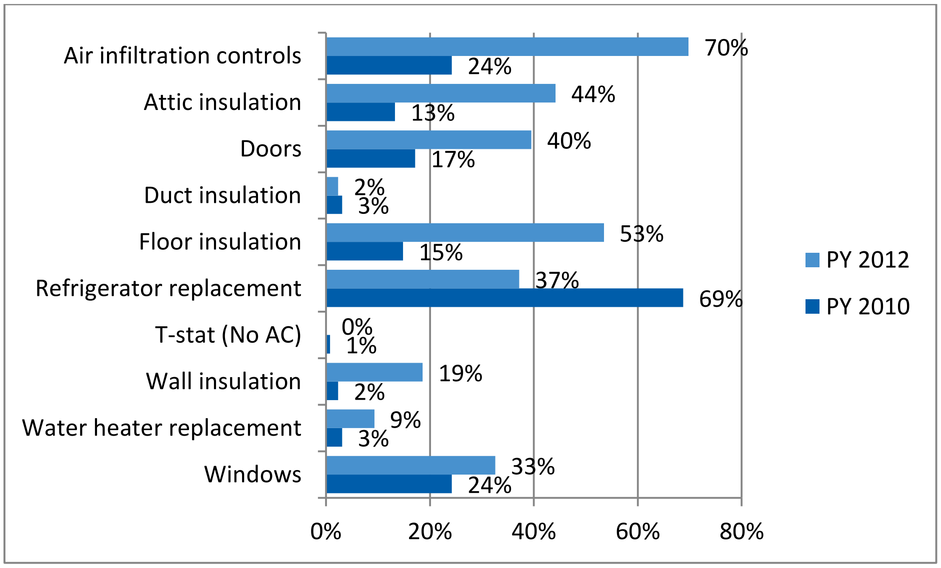
Table 84. Low-Income Weatherization: Comparison of Model Results by Participant Group and Year

Participant Type	Program Year	n	PRENAC	Model Savings (kWh)*	Average Reported Savings Per Participant (kWh)	Realization Rate	Model Savings as Percent of Pre-Usage	Reported Savings as Percent of Pre-Usage
Non-Conversion	2010	128	14,608	2,099	2,256	93%	14%	15%
	2012	43	15,865	3,504	2,860	123%	22%	18%
Conversion	2010	137	16,449	8,394	10,511	80%	51%	64%
	2012	39	18,951	10,397	7,181	145%	55%	38%

* The models results are not statistically different.

One factor contributing to increased energy savings between the 2010 and 2012 program years is a change in the distribution of electric-saving measures that Avista funded. With the exception of refrigerator replacements, Avista funded a greater number of high energy-saving measures in 2012 than in 2010 for non-conversion participants. Figure 20 shows the percentage of Avista-funded measures for non-conversion participants for both program years.

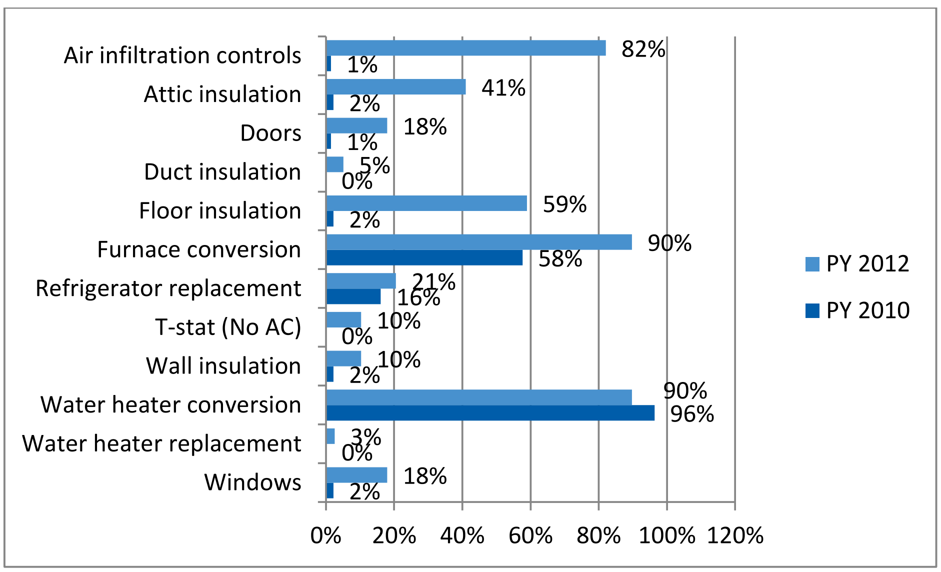
Figure 20. Percent of Installed Measures for Non-Conversion Model Participants by Program Year



The PY 2012 program reveals higher frequencies of shell measures (i.e., insulation, air sealing, doors, and windows) being installed in participant homes than during PY 2010.

A similar trend is observed for conversion participants, as shown in Figure 21.

Figure 21. Percent of Installed Measures for Conversion Model Participants by Program Year



A larger percentage of conversion participants received a furnace conversion in 2012 than in 2010. Additionally, a greater percentage of 2012 conversion participants received a non-conversion shell measures than 2010 conversion participants. For example, 82% of 2012 conversion customers received air infiltration controls, compared to only 1% in 2010.

The realization rates are also substantially higher in 2012 than in previous years. As explained above, there was an increase in the installation of building shell measures during 2012. The difference in realization rates is also partially due to the reported measure-level savings. Table 85 presents a comparison of the average kWh savings between PY 2011 and PY 2012-2013.

Table 85. Comparison of Average Reported Measure-Level Savings Between Program Years*

Measures	PY 2011 (kWh)	PY 2012-2013 (kWh)
Attic insulation	3,329	562
Door	287	333
Duct insulation	760	1,511
Floor insulation	4,137	2,132
Air infiltration controls	1,456	431
Refrigerator replacement	691	533
Wall insulation	3,447	1,694
Water heater replacement	299	115
Window	1,205	1,275
Furnace replacement (conversion)	8,655	3,496
ASHP replacement	N/A	3,645
Water heater replacement (conversion)	5,567	1,586

* These savings values reflect full program years, not the analysis sample

All but three measures experienced a decrease in average reported savings between PY 2011 and PY 2012-2013. The measures with the largest change in reported savings were attic insulation, wall insulation, and both of the conversion measures (furnace replacement and water heater replacement).

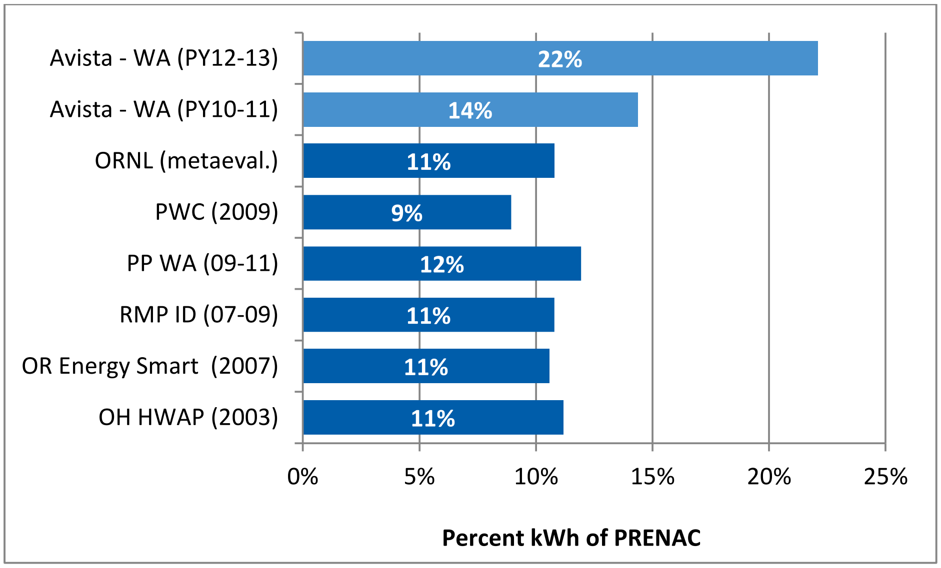
An additional factor may account for changes in modeled savings: (1) non-Avista funded measures installed by agencies through the program.

4.6. Benchmarking

To place Avista program savings estimates in context, we compared billing analysis results from other low-income program efforts across the country.[48] This section provides two metrics for comparing Avista's program savings to other similar programs. First, Figure 22 compares the percentage of energy savings, relative to PRENAC, of Avista's program and a number of other low-income weatherization programs, based on electric billing analyses. This metric allows for comparing programs given variation in weather, costs, program delivery, and measure offerings.

48 The comparable studies include Oak Ridge National Laboratory Meta-evaluation of Low-Income Weatherization Programs, Ohio Home Weatherization Assistance Program, People Working Cooperatively Low-Income Weatherization Program in Ohio, Pacific Power Low-Income Weatherization Program in Washington, Rocky Mountain Power Low-Income Weatherization Program in Idaho, Energy Smart low-income program in Oregon, and the Ohio Home Weatherization Assistance Program.

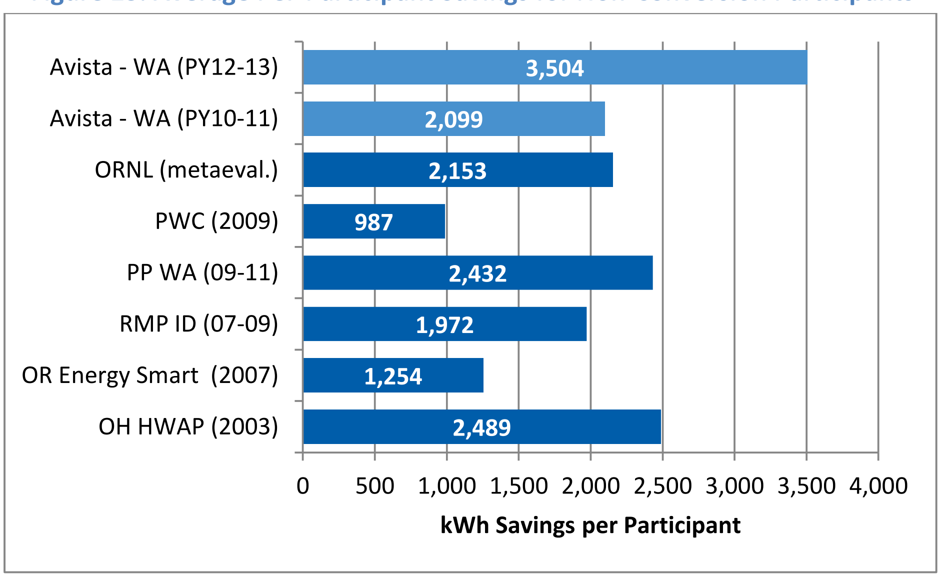
Figure 22. Savings Percentage of Pre-Period Consumption*



*This chart reflects savings for non-conversion participants

Figure 23 presents the absolute energy savings from low-income programs; this is a second metric for comparing Avista's non-conversion results to other programs. Absolute estimates do not use PRENAC, but rather show savings that are directly attributable to the program.

Figure 23. Average Per-Participant Savings for Non-Conversion Participants



4.7. Low Income Conclusions

Compared to PY2010, Avista's low-income program demonstrated an increase in average electric savings per participant, in addition to an increase in overall program realization rate (from 78% to

136%). Several factors may have contributed to the increase in participant savings, including: (1) an increased frequency of installation of high-saving measures (e.g., shell) in the evaluation period, (2) changes in agency delivery protocols or energy-saving installation made with non-utility funding, and (3) exogenous effect (e.g., economic, rate changes) that may have occurred simultaneous to program activity. One factor contributing to higher realization rates are lower average reported savings occurring in the evaluation period compared to previous years.

4.8. Low Income Recommendations

Cadmus recommends the following enhancements in order 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 options for increasing analysis sample sizes (such as using combined models with participation of both state programs).*** 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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5. CFL Contingency Program

5.1. Introduction

In our previous evaluation,[49] Cadmus estimated the percentage of bulbs installed by the end of calendar year 2011 and provided the savings associated with only these bulbs. This report provides total energy savings achieved by the program in the first year and calculates energy savings for measures installed in 2012 as the difference between the total program savings and evaluated PY 2011 savings.

5.1.1. Program Description

The CFL Contingency Program design was intended to deliver cost-effective, energy-efficiency resources to Avista's residential and small commercial customers, while simultaneously maintaining the flexibility to meet anticipated energy acquisition targets at a lower ratepayer cost.

Starting in July 2011 and continuing through November 2011, Avista sent residences and small businesses within the territory a box of eight ENERGY STAR CFLs of varying sizes, accompanied by literature on the benefits of their use and instructions on proper disposal and bulb placement. Avista also sent customers information about returning the CFLs, at no cost, should they decide not to keep them, and about requesting additional bulbs.

5.2. Methodology

For evaluating the savings achieved by the CFL Contingency Program, Cadmus completed an engineering review, which was based on the previous evaluation analysis, but updated to include recent evaluation results and expected regional decisions.

Six parameters informed the calculation of gross savings for the lighting component:

$$\text{CFL Watts} \times \text{DWM} \times \text{HOU} \times \text{DAYS} \times \text{WHF} \times \text{ISR} = \text{Annual Energy Savings}$$

Where:

CFL Watts = Wattage of the mailed ENERGY STAR CFL

DWM = The difference in wattage between baseline bulb and the CFL, divided by the wattage of the CFL

HOU = Daily lighting operating hours

DAYS = Days per year (365)

49 Cadmus. *Avista 2010–2011 Multi-Sector Electric Impact Evaluation Report*. May 2012.

WHF	=	An adjustment representing the interactive effects of lighting measures on heating and cooling equipment operations
ISR	=	The percentage of units installed

The annual savings algorithm derived from industry-standard engineering practices, consistent with the methodology used by the Northwest RTF. Discussions of each input follow.

5.2.1. CFL Wattage

This assumption did not change from the previous analysis. The program delivered over 2.3 million CFLs to residential and commercial customers in Avista's territory, with the distribution shown in Table 86. The CFL wattage derived from the weighted average of units delivered to each sector. The residential sector had an average delivered CFL wattage of 18.30, and the commercial sector had an average delivered CFL wattage of 18.25.

Table 86. Total Units of Delivered CFLs by Sector Type

CFL Wattage	Residential	Commercial
13	389,006	18,960
19	55,116	-
20	1,056,786	56,880
23	55,116	-
Total	**1,556,024**	**75,840**

5.2.2. DWM

The DWM assumption did not change from the previous evaluation. Cadmus relied on the RTF (for residential) and the 6th Power Plan (for commercial) to determine the DWM. Adjusting the RTF's residential DWM allowed incorporation of Avista's survey results for the room distribution of installed bulbs. Thus, the DWM for residential installation was updated from the RTF's 2.60 to 2.63.[50] The commercial DWM was 2.70, based on the 6th Power Plan lighting workbook.

This analysis did not account for EISA's potential impact. EISA could only impact the baseline for the 55,116 23-watt CFLs mailed to residential customers in the first round of packages. Survey results suggest that these bulbs achieved the maximum ISR by the end of 2011.

5.2.3. HOU

Cadmus updated the residential HOU assumption to 1.93 for bulbs installed in 2012. This aligns with the current RTF assumptions and with the Simple Steps Smart Savings analysis completed for this evaluation.

[50] The RTF DWM represents the 2011 baseline, and does not include federal EISA impacts that started in 2012.

To determine commercial HOU, Cadmus used the 6th Power Plan's documented lighting hours of operating for each building. After gathering building type information from Avista's survey of commercial participants, Cadmus weighted the 10.16 lighting hours from the 6th Power Plan to calculate 10.02 for Avista's commercial HOU. The assumed commercial HOU did not change from the previous analysis.

5.2.4. WHF

The WHF assumption did not change from the previous evaluation. The WHF accounts for changes in annual HVAC energy (lost or gained) due to reductions in facility lighting energy. Cadmus based the WHF on SEEM building models, developed by the Northwest Power and Conservation Council. We used these SEEM building models to estimate the change in HVAC equipment energy use due to a change in lighting technology (e.g., incandescent lamps to CFLs). In general, the models accounted for interactions using load-shape profiles of the HVAC and lighting equipment, based on dwelling occupancy.

The Northwest Power and Conservation Council uses an inherently conservative method that assumes a closed shell (i.e., all interior lamps, including ceiling recessed cans, would be contained in a closed system, hence any heat generated by the bulbs would go into the building). In reality, waste heat could transfer out of the conditioned space.

Cadmus based the residential WHF calculation on Avista's share of electric heating equipment,[51] along with its associated efficiencies and its surveys of interior and exterior distribution. We determined a residential WHF of 89.8%.[52]

Cadmus used the commercial WHF of 85.5% provided in the 6th Power Plan.

5.2.5. ISR

Cadmus updated the ISR assumption. The ISR used in this analysis represents the percentage of bulbs believed to be installed and operating within one calendar year of receiving the CFL package.

In October 2013, the RTF approved an updated *Residential: Lighting — CFLs* workbook.[53] Based on the NEEA RBSA results, the approved workbook assumes a 24% storage rate and 2% removal rate for residential, unsolicited mailed CFLs. The overall first-year ISR is therefore now assumed to be 74.48%.

5.3. Overall Program Savings

Cadmus calculated PY 2012 savings by subtracting the PY 2011 evaluated savings, calculated in the previous evaluation, from the total program savings calculated in this evaluation. Table 87 shows achieved annual savings by year and sector.

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[51] Saturations of Avista equipment types are based on the 2011 CFL Contingency Program participant surveys.

[52] The RTF WHF is 86.4%; the adjusted Avista WHF is 89.8%.

[53] http://rtf.nwcouncil.org//measures/measure.asp?id=141.

Table 87. CFL Contingency Program Evaluated and Expected Savings by Year

Sector	Total Program Savings (kWh)	PY 2011 Evaluated (kWh)	PY 2012 Evaluated (kWh)
Residential	39,637,362	23,347,564	16,289,799
Commercial	8,715,798	3,826,229	4,889,569
Total	**48,353,160**	**27,173,793**	**21,179,368**

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6. Portfolio Savings and Goals

6.1. Gross Portfolio Savings

The PY 2012-PY 2013 Washington electric portfolio consisted of several sectors and many program delivery streams. In total, the programs achieved a 97.0% gross realization rate and total evaluated savings of 120,635,914 kWh (Table 88).

Table 88. PY 2012-PY 2013 Washington Gross Savings

Segment*	Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Residential	26,655,717	24,070,178	90.3%
Nonresidential	70,809,941	67,649,637	95.5%
Low Income	1,111,766	1,516,238	136.4%
CFL Contingency**	21,179,368	21,179,368	100.0%
Residential Behavior	4,636,392	6,220,493	134.2%
Total	**124,393,184**	**120,635,914**	**97.0%**

* Note that residential Behavior Program and Second Refrigerator and Freezer Recycling Program savings are inherently calculated as net, not gross.
** Program did not have reported savings, so the verified savings are duplicated as reported savings, thus giving the 100% realization rate.

6.2. Gross and Net Savings Designation

The 2012-2013 biennium yielded many uncertainties on savings definitions, and what would be allowable for different goal requirements. The following are terms and definitions as Cadmus understands them to apply to various programs and individual measures when assessing gross and net savings.

Gross Savings – Gross savings have not been subjected to an evaluated net-to-gross (NTG) value, and that use the traditional method of code baseline for savings calculation.

RTF Based Savings – We are terming savings to be an RTF based value if the measure uses the market adjusted baseline determined by the RTF, or similarly uses the RTF savings calculation methodology.

Net Savings – Net savings are have either been decremented by an evaluated customer self-reported NTG, or that produces a true net savings value in the way a measure is analyzed.

Another important element to distinguish between gross, RTF based, and net savings is the application of freeridership and spillover. True gross savings do not have freeridership (the actions customers would have taken in the absence of the program) or spillover (additional actions customers have taken because of the self-stated influence of Avista's programs) applied, while net savings include both. The RTF's modified gross definition accounts for freeridership but not spillover. Therefore, when appropriate, we have included evaluated spillover savings to RTF-based measures.

Table 89 outlines Avista's programs and type of savings methodology applied.

Table 89. Avista's DSM Programs' NTG Methodology

Program	Designation	Reasoning
Low Income	Gross	Traditionally free from NTG modifications (i.e., NTG assumed 1)
Nonresidential programs	Gross	The CPA included nonresidential savings free from NTG modification
CFL Contingency	RTF Based	Using the methodology and inputs from the RTF
Residential Behavior Program	Net	The results from the billing analysis are net because of the control group, but do not include any spillover
Manufactured Homes Duct Sealing	Gross	Direct install measure, free to customers (i.e., NTG assumed 1)
ENERGY STAR Products	RTF Based	RTF deemed savings values with the addition of spillover
ENERGY STAR Homes	RTF Based	RTF deemed savings values with the addition of spillover
Appliance Recycling	Net	The analysis methodology produces a net value
Geographic CFL Giveaway	RTF Based	Using the methodology and inputs from the RTF
Simple Steps, Smart Savings	RTF Based	Using the methodology and inputs from the RTF
Weatherization/Shell	Gross	Measure not available in RTF; savings calculated by billing analysis, yielding gross savings
Heating and Cooling Efficiency	Gross	Measure not available in RTF; some measure savings calculated by billing analysis, yielding gross savings
Water Heater Efficiency	RTF Based	RTF deemed savings values with the addition of spillover
Space and Water Conversions	Gross	Measure not available in RTF; savings calculated by billing analysis, yielding gross savings

6.3. Goals Achievement

Evaluation of the 2012-2013 portfolio was challenging due to:

- Multiple statements and sources of goals (I-937, Avista's Integrated Resource Plan, and Avista Business Plan).
- Varying definitions of savings (e.g., gross versus net, Regional Technical Forum versus evaluation based estimates).
- Different means of achieving the goals (e.g., fuel conversion counts toward the IRP electric savings but not toward I-937).
- Different programs are not included under certain goals (e.g., Avista Business Plan does not include Contingency CFL savings).

Table 90 through Table 92 show achieved savings toward each of the three goals: the DSM portion of I-937, IRP, and Avista Business Plan. All goals were exceeded. The goals are portfolio-level targets, so in order to conduct sector-level comparisons, Cadmus adopted the Avista Business Plan goals by sector, and applied those proportions to the I-937 and IRP targets. The tables also show saving achievements for the portfolio excluding the CFL Contingency and residential Behavior programs. I-937 and IRP goals are still met, but the more aggressive Business Plan goal falls slightly short.

Table 90. PY 2012-PY 2013 I-937 DSM End-Use Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	22,596,781	44,586,457	197.3%
Nonresidential	51,209,063	70,993,666	138.6%
Low Income	2,396,157	450,233	18.8%
Total	**76,202,000**	**116,030,356**	**152.3%**
Excluding CFL Contingency and Behavior Programs	**76,202,000**	**88,630,495**	**116.3%**

* Achieved savings do not include fuel switching measures.

Table 91. PY 2012-PY 2013 IRP Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	22,483,207	46,617,306	207.3%
Nonresidential	50,951,680	72,539,206	142.4%
Low Income	2,384,113	1,516,238	63.6%
Total	**75,819,000**	**120,672,750**	**159.2%**
Excluding CFL Contingency and Behavior Programs	**75,819,000**	**93,272,889**	**123.0%**

* Achieved savings includes all savings.

Table 92. PY 2012-PY 2013 Avista Business Plan Goals and Achieved Savings

Sector	Savings Goal (kWh)	Achieved (kWh)*	Achievement Rate
Residential	28,391,942	30,327,507	106.8%
Nonresidential	64,342,119	67,649,637	105.1%
Low Income	3,010,674	1,516,238	50.4%
Total	**95,744,735**	**99,493,382**	**103.9%**
Excluding Behavior Program	**95,744,735**	**93,272,889**	**97.4%**

* Achieved savings do not include CFL Contingency.

Appendix A: Residential Billing Analysis Model Specifications

Overview of the PRISM Approach

A site-level modeling approach was originally developed for the PRISM software (Fels et al. 1995). In this model, the NAC is estimated separately for each customer account, for both the pre- and post-installation periods. The weather normalization for each account and period relies on a longitudinal regression analysis. The difference between the pre- and post-program NAC represents the program-related change in the consumption plus exogenous changes in consumption. Without a non-participants group this exogenous change is not eliminated, but it is expected to be small for consumption over the three year evaluation period, especially with respect to the larger change in consumption from conversion.

Model Specification

Cadmus fitted each account with specific degree-day regression models, separately for the pre- and post-installation periods. We first normalized the monthly bills by the number of days in each billing period to obtain the average daily consumption (ADC). Then we calculated the average temperature during each utility billing period.

This degree-day regression for each account is modeled as:

$$\mathrm{ADC_{it}} = \alpha_\mathrm{i} + \beta_i \mathrm{AVGHDD_{it}} + \gamma_i \mathrm{AVGCDD_{it}} + \epsilon_\mathrm{it}$$

Where:

ADC_{it}	=	Average daily kWh or therm consumption for each customer ‘i' during billing month ‘t’
α_i	=	participant intercept; represents the average daily kwh or therm base load or the energy use for non-space heating or cooling purposes
β_i	=	participant slope; represents the change in the energy use for a unit change in the HDDs
$AVGHDD_{it}$	=	base 65 average daily HDDs for customer ‘i' in period ‘t’
γ_i	=	participant slope; represents the change in energy use for a unit change in the CDDs
$AVGCDD_{it}$	=	base 65 average daily CDDs for customer ‘i' in period ‘t’

Cadmus used the results from the above estimation to compute the NAC for electricity:

$$\mathrm{NAC_i} = \widehat{\alpha}_\mathrm{i} * 365 + \widehat{\beta}_i \mathrm{NORMHDD_i} + \widehat{\gamma}_i \mathrm{NORMCDD_t}$$

Where:

NAC_i	=	Normalized annual kWh or therm consumption for each customer ‘i'
$\widehat{\alpha}_\mathrm{i}$	=	The participant intercept; estimated from the above model

$\hat{\beta}_i$	=	The participant heating slope; estimated from the above model
$NORMHDD_i$	=	Annual normal-year HDDs (base 65) for customer 'i' in period 't'
$\hat{\gamma}_i$	=	The participant cooling slope; estimated from the above model
$NORMCDD_i$	=	Annual normal-year CDDs (base 65) for customer 'i' in period 't'

Overview of the Regression Approach

Cadmus specified a conditional savings regression model with paired pre- and post-participation months. This is a pooled regression approach that combines all participants and time intervals for a single measure group into a single regression analysis. The observations vary across both time and individual accounts. This pooled approach is recommended for cases like this, where there is no separate comparison group and where other energy-efficiency measures are installed in homes.

Model Specification

Cadmus estimated a separate regression model for each of the groups. The model determined ADC of electricity of home 'i' in month 't' as:

$$\mathrm{ADC_{it}} = \alpha_i + \tau_t + \beta_1\mathrm{HDD_{it}} + \beta_2\mathrm{CDD_{it}} + \beta_3\mathrm{HDD_{it}} * Other_{it} + \beta_4\mathrm{CDD_{it}} * Other_{it} + \beta_5\mathrm{POST_{it}} + \beta_6\mathrm{POST_{it}} * \mathrm{HDD_{it}} + \beta_7\mathrm{POST_{it}} * \mathrm{CDD_{it}} + \beta_8\mathrm{POST_{it}} * Other_{it} + \varepsilon_{it}$$

Where:

α_i	=	Average daily base load energy use in home 'i' that is not sensitive to weather or time. This analysis controlled for non-weather-sensitive and time-invariant energy use with home fixed effects.
τ_t	=	Average energy use in month 't' reflecting unobservable factors specific to the month. This analysis controlled for these effects with month-by-year fixed effects.
β_1, β_2	=	Average daily usage per HDD and CDD (kWh or therm/degree day) in the pre-conversion period.
HDD	=	Average daily HDDs (heating load) during the billing cycle.
CDD	=	Average daily CDDs (cooling load) during the billing cycle.
β_3, β_4	=	Coefficients for HDD and CDD (kWh or therm/degree day) interacted with the installation of other measures.
Other	=	An indicator variable for whether the month is pre- or post-installation of other measure. 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.
$\beta_5 - \beta_8$	=	Coefficients used to estimate the conversion program effect on electricity usage (as shown in next equation).

POST	=	An indicator variable for whether the month is pre- or post-conversion. This variable equals 1 in the months and years following the conversion date, and 0 otherwise. The variable is defined using a combination of Customer Specific Measure Install Date and Full Year specifications.
ε_{it}	=	Error term for home ‘i’ in month ‘t.’

Cadmus used the mean differences approach to estimate the above model. This approach removes the customer-specific constant term, α_i, and controls for the variation in electricity use between customers and between months.

Cadmus estimated the fuel conversion program savings for each conversion group using estimated coefficients on all the post-installation period dummy variable components in the above fixed-effects regression model. For a home in conversion group ‘j,’ the gross savings are given by:

$$\text{Savings}_j = \hat{\beta}_5 * 365 + \hat{\beta}_6 \text{AnnualHDD}_j + \hat{\beta}_7 \text{AnnualHDD}_j + \hat{\beta}_8 * 365$$

Where:

AnnualHDD_j	=	Average annual HDDs for all customers in conversion group ‘j’
AnnualCDD_j	=	Average annual CDDs for all customers in conversion group ‘j’

Appendix B: Residential Behavior Program Data Cleaning Procedures

Cadmus conducted the following steps to inspect and clean the data provided by Opower:

1. Removal of one customer from the Opower data that appeared in both the control and treatment groups
2. Verification that customer assignments to treatment and control groups in the Opower data corresponded to the assignments that Cadmus made. No discrepancies were found.
3. Removal of customers flagged by Opower for exclusion from analysis. Customers were flagged because it was not possible to generate an energy report or they received a report but were not randomly assigned.[54]
4. Checks for duplicate records. None were found.

One participant originally selected by Cadmus for the control group was missing from Opower's list of participants. The Opower data also included 12 extra participants in the treatment group that were not present in Cadmus' original sample, but these were all flagged to be excluded from the analysis. After cleaning the data, there were 99,495 customers on Opower's list.

Cadmus conducted the following steps to clean the billing data provided by Avista:

1. Verification that customer account numbers were unique to addresses.
2. Removal of billing data for customers not in the Opower control or treatment groups and for billing records ending before June 1st, 2012 or beginning after December 31st, 2013.
3. Removal of gas bills
4. Removal of customers whose maximum daily average consumption in any billing period was greater than 1,000 kWh per day. There were less than ten such customers, and Cadmus assumed their large bills were likely due to meter misreads, billing errors, or significant commercial, industrial, or agricultural activity which would make them ineligible for analysis. Cadmus also noted that there were 185 customers who regularly consumed more than 240 kWh-per-day on average, but Cadmus did not remove these customers from the analysis.
5. Removal of duplicate bills. One of the additional billing data files that Avista provided included many duplicate records; Cadmus did not include these in the analysis.
6. Removal of $0.00 bills. Cadmus noticed that there were many duplicate bills of this type. Cadmus only removed these bills when either:
    a. The service amount was $0.00 and the usage quantity (kWh) was non-zero, or
    b. Both the service amount and the usage quantity were zero, but there was another non-zero bill in the same period
7. Removal of bills from August 2012 that ended on the 27th of August, when there were multiple bills for that month. Cadmus noticed that many customers had two partially-overlapping records

[54] For example, some Avista staff requested to receive energy reports from Opower. There were 12 customers who received reports but were not assigned to the treatment group.

in August 2012. These two bills had the same start dates. The first always ended on August 15th or 16th, and the second on August 27th. Cadmus noted that the next bill started on the 15th or 16th of August, not the 27th, so to ensure that there would be no double-counting of kWh Cadmus removed the longer, partially-overlapping bill.

8. Manual data cleaning of partially-overlapping bills. In less than 20 instances, Cadmus manually removed problematic partially-overlapping bills, so that there would be no double-counting of kWh when the bills were summarized for analysis.

Appendix C: Residential Behavior Program Regression Model Estimates

Table 93 shows results from different panel regressions of home average daily electricity use. Model 4 was used to estimate savings as shown in the report. There were only small differences between models 1-4 in the estimated savings.

Table 93. Regression Estimates of Home Energy Report Effects on Energy Use

Conditional Average Treatment Effects				
	Model 1	**Model 2**	**Model 3**	**Model 4**
Post	3.0979	1.7691	-0.9085	0.741
	(0.09)	(0.18)	(0.09)	(0.18)
Participant x Post	-0.6586	-0.7612	-0.7642	-0.7637
	(0.10)	(0.10)	(0.10)	(0.10)
Customer fixed effects	Yes	Yes	Yes	Yes
Month by year fixed effects	No	Yes	No	Yes
Weather	No	No	Yes	Yes
N homes	54,324	54,324	54,324	54,324
Number of Observations	1,022,886	1,022,886	1,022,886	1,022,886

Notes: Dependent variable is the home's average daily electricity use for a month. Estimates based on difference-in differences OLS regression of average daily consumption between June 2012 and December 2013. Huber-White estimated standard errors in parentheses are clustered on homes.

Appendix D: Low Income Weatherization Participant Survey

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

Table 94 provides details regarding the telephone survey planned and achieved completes.

Table 94. Participant Telephone Survey Sampling Plan

	Quantity
Total Participants	434
Screened out due to a change in occupancy or incorrect phone number	78
Eligible participants on 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 as available in April 2013 (434 participants). Cadmus aimed for and achieved 150 completed survey responses, which provided results with 90% confidence and ±5.1% precision at the program level. The survey achieved a high fielding response rate, as we used only 75% the sample frame to accomplish the 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 24 presents all ways survey respondents heard about the program.

Figure 24. How Respondents Heard About the Program (n=125)

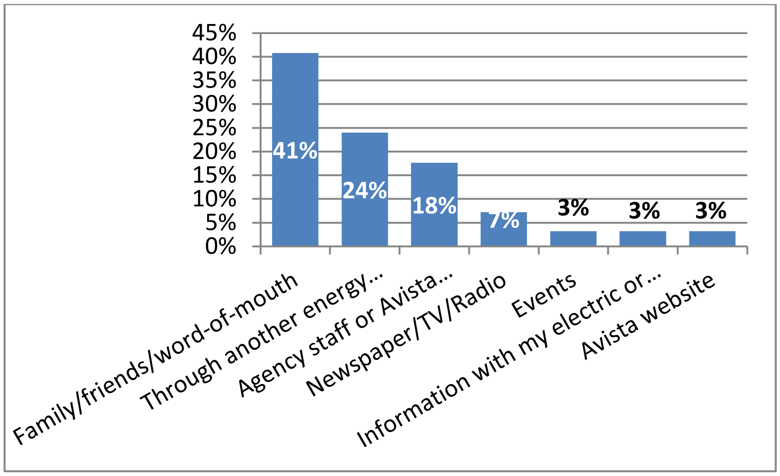
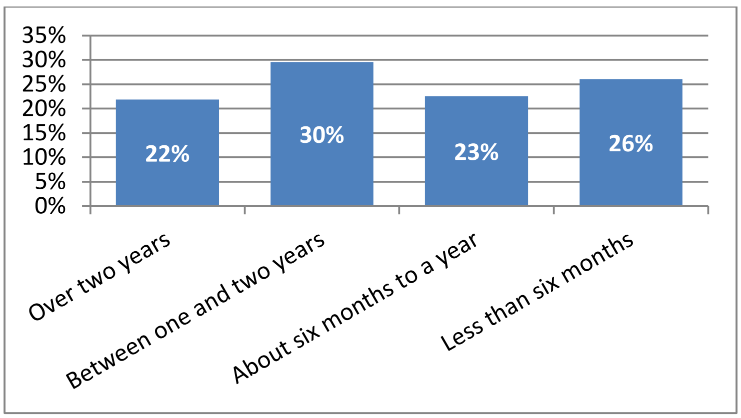


Figure 25 shows how long respondents were on the waiting list for the program.

Figure 25. How Long Respondents Were on the Program Waiting List (n=142)



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

Previous and New Equipment

Table 95 shows the distribution of installed equipment and the condition of the replaced equipment. For respondents who received programmable thermostats, the table also indicates whether the installer programmed the thermostat, the participants just received education on how to install it, or received neither programming nor education.

Table 95. 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 96 shows how long the equipment was experiencing those issues.

Table 96. 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 97 details the fuel type of old and replaced furnaces and water heaters for respondents who received this new equipment.

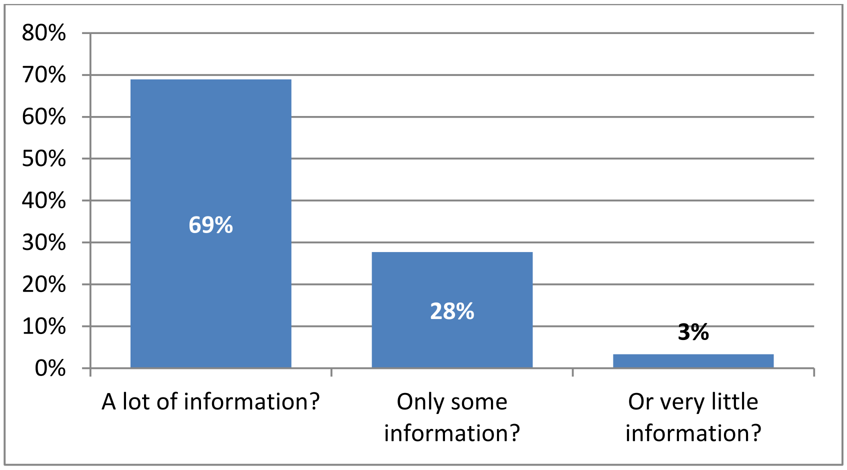
Table 97. Furnace and Water Heater Fuel

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 3% of respondents said they received little information, while over two-thirds said they received a lot of information, as shown in Figure 26.

Figure 26. Amount of Much Information Respondents Received (n=119)



As shown in Table 98, 89% of respondents said they received educational pamphlets, and 97% of those respondents said they read them.

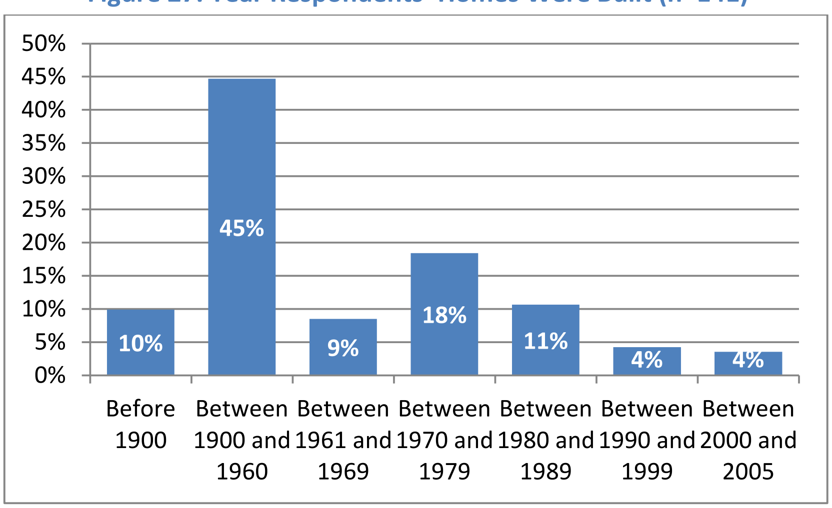
Table 98. How Many Respondents Received and Read Pamphlets

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

Home Characteristics

Figure 27 shows the distribution of years that the respondents' homes were built.

Figure 27. Year Respondents' Homes Were Built (n=141)



Most respondents live in a single-family home or a mobile home or trailer, as shown in Figure 28.

Figure 28. Home Types (n=147)

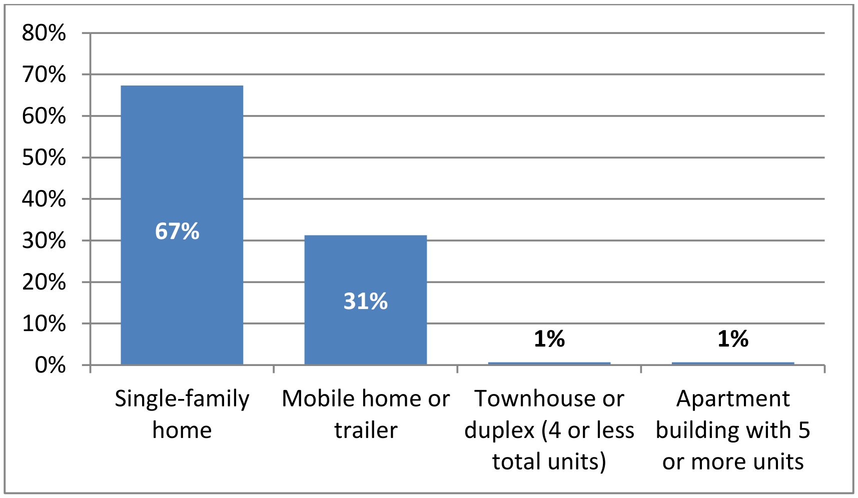


Figure 29 shows that most respondents heat their home by natural gas, followed by electricity.

Figure 29. Heating Fuel (n=147)

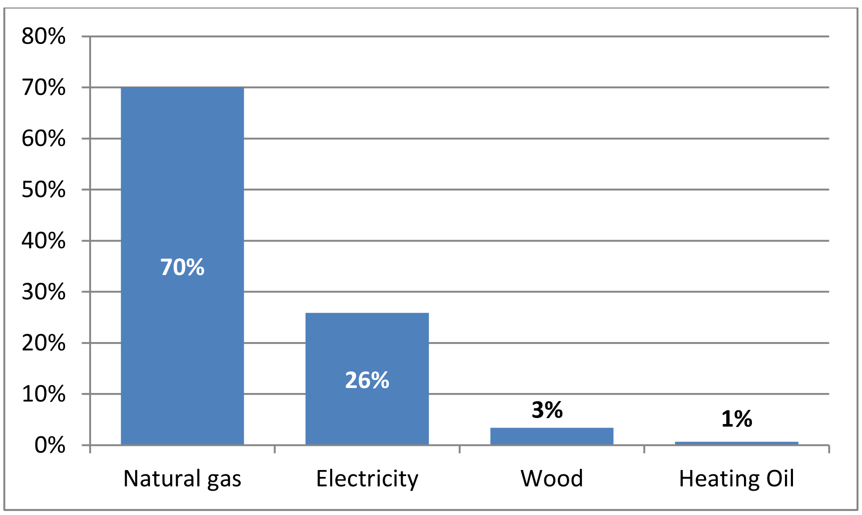
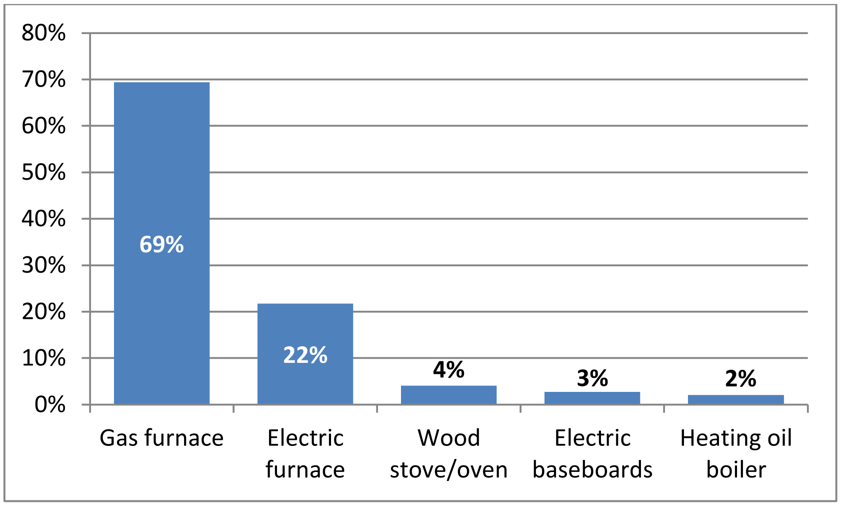


Figure 30 presents the distribution of respondents' primary heating equipment. Most respondents (69%) said their primary heater is a natural gas furnace, followed by an electric furnace (22%).

Figure 30. 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 31.

Figure 31. Post-Installation Thermostat Changes (n=135)

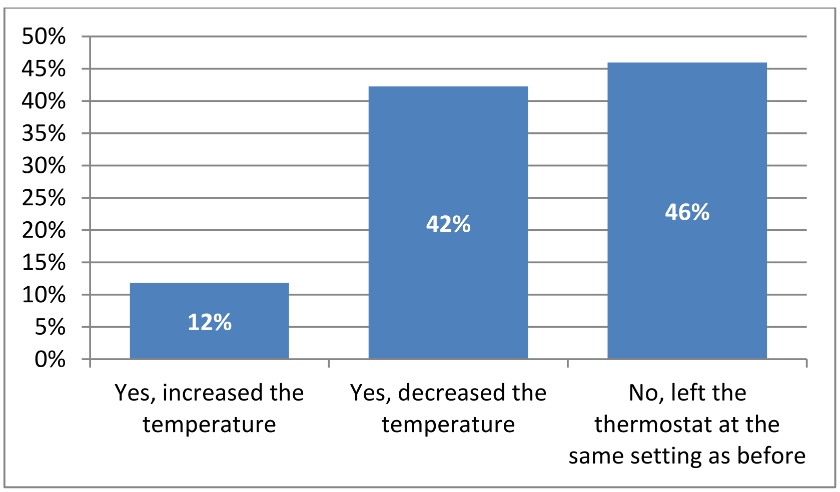
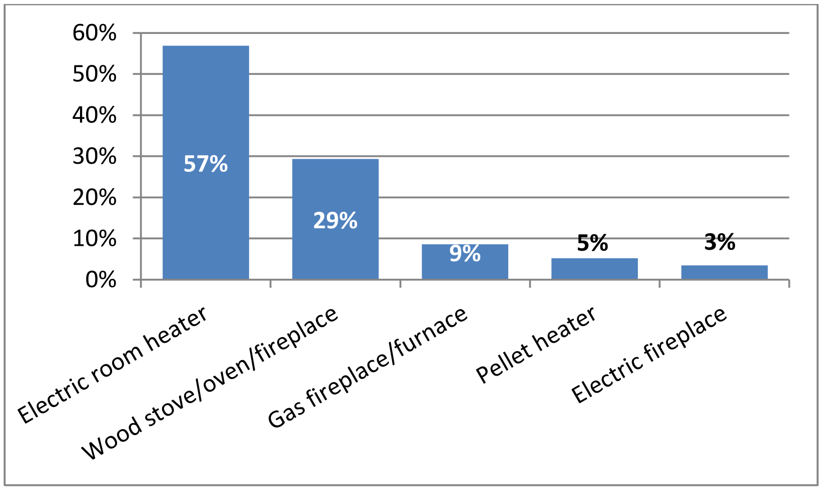


Figure 32 shows what respondents use as a supplemental heating source. Most indicated using an electric room heater or a wood burning device.

Figure 32. 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 33.

Figure 33. Post-Installation Supplemental Heater Use (n=56)

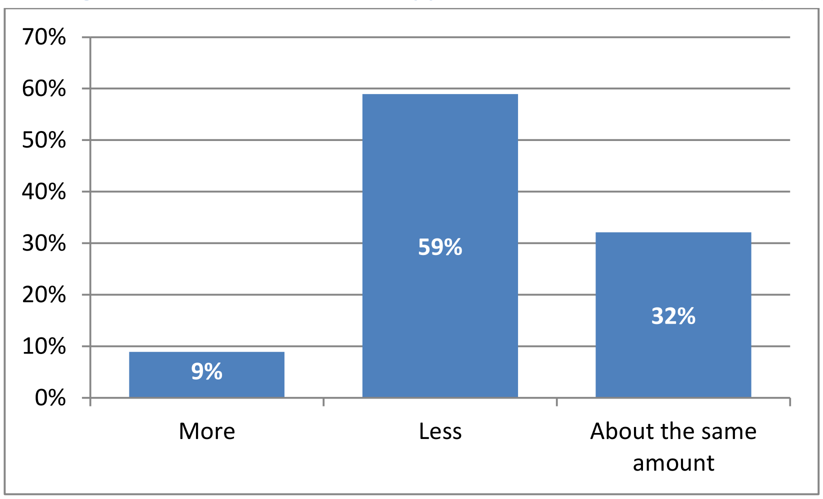


Figure 34 presents the distribution of equipment used to cool respondent's homes. When asked if they would change the way they cool their home after participating in the program, only 8% responded affirmatively.

Figure 34. Summer Cooling Equipment Types (n=140)

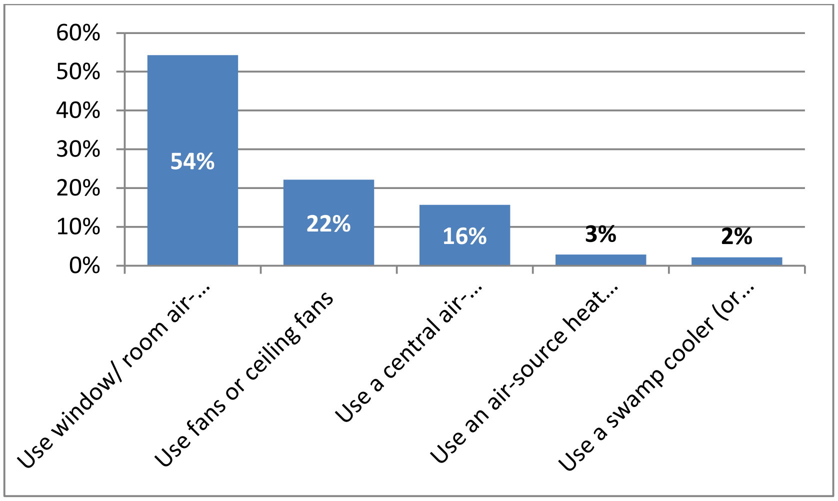
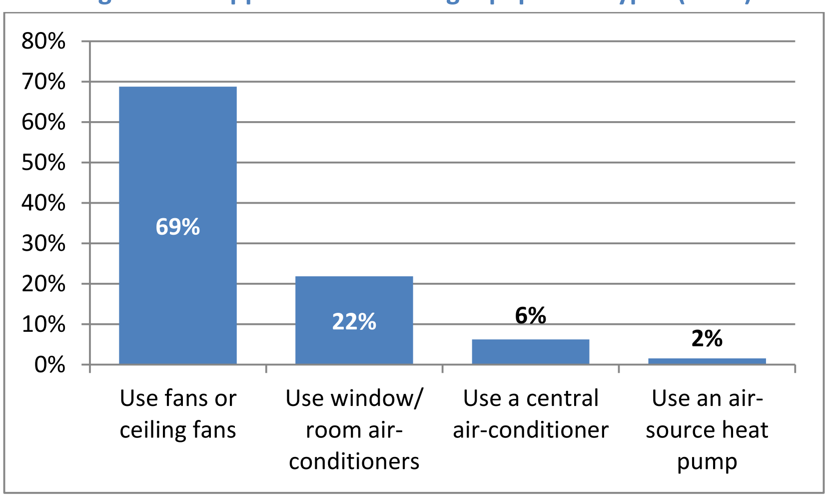


Figure 35 shows what type of supplemental equipment respondents use to cool their home.

Figure 35. Supplemental Cooling Equipment Types (n=64)



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

For each participant home, Cadmus estimated three models in both the pre- and post-periods in order to weather-normalize raw billing data:

- Heating and cooling,
- Heating only, and
- Cooling only.

The heating and cooling PRISM model specification was:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer ‘i’ and calendar month ‘t’:

ADC_{it}	=	The average daily kWh consumption in the pre- or post-program period
α_i	=	The participant intercept; represents the average daily kWh base load
β_1	=	The model space heating slope (used in the heating only and heating + cooling models)
$AVGHDD_{it}$	=	The base 65 average daily HDDs for the specific location (used in the heating only and heating + cooling models)
β_2	=	The model space cooling slope (used in the cooling only and heating + cooling models)
$AVGCDD_{it}$	=	The base 65 average daily CDDs for the specific location (used in the cooling only and heating + cooling models)
ε_{it}	=	The error term

From the model above, we computed the NAC as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \beta_2 LRCDD_i + \varepsilon_i$$

Where, for each customer ‘i’:

NAC_i	=	Normalized annual kWh 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 kWh usage (non-weather sensitive)
β_1	=	The heating slope; in effect, usage per heating degree from the model
$LRHDD_i$	=	The annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location

$\beta_1 * LRHDD_i$	=	Weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC
β_2	=	The cooling slope; in effect, the usage per cooling degree from the model
$LRCDD_i$	=	The annual, long-term CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location
$\beta_2 * LRCDD_i$	=	The weather-normalized annual weather sensitive (cooling) usage, also known as COOLNAC
ε_i	=	The error term

Although we used the same specification for both electric (non-conversion) and conversion participants, Cadmus estimated separate fixed-effects CSA models for each group to determine program-level savings:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST_{it} + \beta_{4\ldots14} M_t + \varepsilon_{it}$$

Where, for customer ‘i’ and monthly billing period ‘t’:

ADC_{it}	=	Average daily kWh consumption during the pre- and post-program periods
α_i	=	The average daily kWh 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 HDDs, based on home location
β_2	=	The model space cooling slope
$AVGCDD_{it}$	=	The average daily base-65 CDDs, based on home location
β_3	=	The kWh change in usage per day
$POST_{it}$	=	An indicator variable that is 1 in the post-period (after measure installations) and 0 in the pre-period
M_t	=	An array of bill month dummy variables (Feb, Mar, …, Dec), 0 otherwise[55]
ε_{it}	=	The modeling estimation error

Cadmus estimated the above model for Washington non-conversion and conversion participants separately. The model coefficient, β_3, is an estimate of the kWh savings per day in each model.

[55] We excluded the January dummy variable from the independent variables, otherwise the 12 monthly indicators would form perfect co-linearity with the intercepts; thus, the intercepts include the seasonality from January.